National Seminar

on

STRATEGIES FOR CONSERVATION, IMPROVEMENT AND UTILIZATION OF UNDERUTILIZED FRUITS

November 25-27, 2014

Organized jointly by

CENTRAL HORTICULTURAL EXPERIMENT STATION

Indian Institute of Horticultural Research

Chettalli

and

SOCIETY FOR PROMOTION OF HORTICULTURE

Indian Institute of Horticultural Research

Bangalore

(www.sphindia.org)

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Dr. Priti Sonavane, Scientist, CHES, Chettalli

Background Information

India is the centre of origin of several tropical fruit tree species, most of them though not commercially cultivated, significantly support the livelihood of many rural and tribal communities. Besides, their nutritional importance as rich sources of antioxidants, sugars, vitamins and minerals, they serve as a source of household income. Fruit tree biodiversity has a cultural and social value that contributes to the stability of ecosystems. Many tropical fruits labelled as "underutilized species" are characterized by the fact that they are locally abundant, but restricted in their geographical dispersion and have a high use value, but their current use is limited to their economic potential. Several fruits have been identified as under-utilized fruit crops for different climatic regions. Among them Avocado, Rambutan, Durian, Mangosteen, Jack, Kokam, Dragon Fruit, Karonda, Passion Fruit, Pummelo, Jamun, Malayan Apple, Sour Sop, Longan, Mahua *etc.* are major ones identified for humid tropics and subtropics while Ber, Phalsa, Bael, Karonda, Annona, Tamarind, Amla *etc.* are identified for arid region and Pecan nut, Chest nut, Hazel nut, Pistachio nut *etc.* are identified for temperate region.

As a result of agricultural evolution process, these underutilized fruits are now being globally considered as potential fruit crops, especially due to their significant nutraceutical values and improved market demand. The market for *Garcinia,* Jamun has increased in international market due to the presence of rich health promoting compounds. Kokum also has huge export potential for its juice, powder, flakes *etc.,* due to its high nutritional value. Even though many of these fruits are being traditionally known in India since long time, the crop improvement strategy using advance scientific technologies and utilization is still meager.

With this background, Society for Promotion of Horticulture (SPH), Bangalore & Central Horticultural Experiment Station, Chettalli, a regional Research Station of Indian Institute of Horticultural Research, Bangalore is organizing a **National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits** with special emphasis on Western Ghats to bring together the knowledge base of researchers engaged in research of various underutilized fruits of tropical, subtropical, arid and temperate regions. The suggestions and recommendations of the researchers from ICAR institutions, SAUs and other institutions would be compiled, which would serve as guide for future course of research activities on these fruits. This station is in fore front in collecting several indigenous and exotic fruits in its various programmes and considerable efforts have been made for their conservation and evaluation.

The Participants

The seminar aims to create a platform for exchange of ideas and thoughts among the scientific fraternity, entrepreneurs, farmers, growers, students *etc.* from ICAR institutes, SAUs, KVKs and other Govt. and Non - Govt. organizations from different parts of the country who have been associated with underutilized fruits.

Technical Sessions

There will be seven technical sessions spanning over three days. Each session will have three to four invited lectures from the experts, followed by oral presentations & discussions. The participants from different parts of the country are expected to deliberate during the post presentation discussions to share and gain some knowledge, and to finalize the future strategies for improving production, productivity and utilization of underutilized fruits in South - East Asia in general and India in particular. The Technical Sessions are :

25th November 2014

Session I : Status of underutilized fruits and tree spices with special emphasis on Western Ghats

Session II : Genetic resources, diversity, conservation and utilization of underutilized fruits

26th November 2014

Session III : Production technology and cropping systems of major underutilized fruits/tree spices

Session IV : Biotic stress - Current scenario and management strategies

Session V : Post-harvest management and value addition

27th November 2014

Session VI : Farmers - Scientists - Entrepreneurs interaction

Session VII : Panel discussion and formulation of action plan.

Poster Presentation

The organizers invite focused research abstracts on areas in any aspect of underutilized fruits. The abstracts should be prepared in MS Word not exceeding 250 words. Posters pertaining to all the sessions will be exhibited at the designated poster sessions at the seminar venue. Space of 90 cm (height) x 70 cm (width) will be provided for each poster. Three best posters selected by the panel of judges will be awarded.

Field Visit

During the seminar, field visits will be organized to experimental blocks of Central Horticultural Experiment Station, Chettalli for showing genetic resources of various underutilized fruits like Rambutan, Mangosteen, Pummelo, Passion fruit, Avocado, Kokum, Malabar Tamarind, Litchi, Sour Sop, Karonda, Jamun etc. to encourage the scientists to take up research on some of these crops in their respective regions. The field visits would be useful for the researchers from all over the country to benefit from the on-farm discussions on various aspects of the cultivation of underutilized fruits.

Venue :

CHES, Chettalli, Madikeri, Kodagu, Karnataka

Chettalli is situated 22 km from Madikeri & 24 km from Kushalnagar. This is well connected to Mysore (110 km), Mangalore (130 km) and Bangalore (280 km).

Important Dates

Date of issue of circular	:	**15th September 2014**
Last date of submission of abstracts	:	**1st November 2014**
Last date of reservation for accommodation	:	**10th November 2014**

Registration Fee

Scientists/Researchers/Delegates	:	**Rs. 4000/-**
SPH Members	:	**Rs. 3000/-**
Students/Research Scholars	:	**Rs. 1000/-**

Demand draft/ Cheque drawn in favour of Organizing Secretary NSUF, Central Horticultural Experiment Station, Chettalli payable at State Bank of India, Madikeri, Kodagu, Karnataka along with duly filled in registration form may be sent to the Organizing Secretary NSUF, Central Horticultural Experiment Station, Chettalli-571248, Kodagu, Karnataka for registration. The participants may also directly deposit the registration fee to the **Account No. 34166049423 at State Bank of India, Madikeri (IFSC– SBIN0000876)**, Kodagu, Karnataka through RTGS and send the relevant information to the Organizing Secretary NSUF, CHES, Chettalli.

About Kodagu (Coorg)

Kodagu is a part of mountains of Western Ghats of Karnataka. It sets amidst of virtual valleys immense mountains, dense evergreen forests and grasslands. The climate of Kodagu is humid tropical with heavy rain during June-September and pleasant during remaining months. The temperature during November ranges from 12 °C to 28 °C. Kodagu is home for many perennial rivers. River Kaveri, the Ganges of South, originates from Tal Kaveri in Kodagu. Kodagu is blessed with nature. This is one of the most biodiversity hot spots in the world. There are many tourist attractions such as, Tal Kaveri, Bhagmandala Temple, Nisargadhama back water, Dubbare elephant camp, Irupu falls, Abbey falls, Golden temple, Nagarhole national sanctuary, Pushpagiri and Brahamagiri hills in this region. Kodagu is mainly a agriculture dominated district and Oranges, Coffee, Pepper, Cardamom, Paddy are the major crops. More than 25% of the coffee production of India comes from this district.

Accommodation

Many hotels are available in Madikeri and Kushalnagar. Since Kodagu is a popular tourist destination, advance booking is required. The interested participants are requested to send their request on or before 10th November, 2014. The participants may directly reserve their accommodation in following hotels under intimation to Organizing Secretary. The tariffs of some hotel are as follows:

Name of Hotel	Location	Contact Number	Tariff (Rs)
Hotel Crystal Court	Madikeri	09342342356	2000-3500
Hotel Kaveri	Madikeri	09449092459	1000-2000
Hotel Hilltown	Madikeri	09448184625	1000-2000
Hotel Mayura Valley View	Madikeri	08970650028	2000-3500
Hotel Castle International	Kushal Nagar	09480674674	1500-3000
Hotel Mist Flower Residency	Kushal Nagar	09448061066	1000-1500

For Further Details, Please Contact

Organizing Secretary, NSUF

CENTRAL HORTICULTURAL EXPERIMENT STATION (CHES)

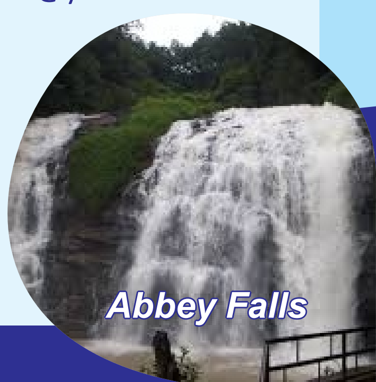
Indian Institute of Horticultural Research (IIHR)

Chettalli - 571 248, Kodagu (Coorg), Karnataka

Phone : 08276-266635, Fax : 08276-266300

Email : nsuf2014@gmail.com, cheschettalli@yahoo.co.in

Tal Kauveri



Abbey Falls

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National Seminar on

STRATEGIES FOR CONSERVATION, IMPROVEMENT AND UTILIZATION OF UNDERUTILIZED FRUITS

Organized jointly by

CHES-IIHR, Chettalli and SPH-IIHR, Bangalore

Date : November 25-27, 2014 **Venue :** CHES-IIHR, Chettalli

Name (In capital letters) :...

Designation :...

Organization :...

Mailing Address :...

....

Phone : Mobile :

Fax : e-mail :

Presenting the Paper : Yes / No Oral / Poster

Title of the papers:

(1)...

(2)...

Name of the Session ....

Whether accommodation required : Yes/No

Accommodation type : Single / Double bed

Number of persons :

Details of registration fee :

DD No.	Date	Name of the Bank	Amount*(Rs)

*SPH membership detail, if any...

(Signature)

Please Send to :

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CENTRAL HORTICULTURAL EXPERIMENT STATION (CHES)

Indian Institute of Horticultural Research (IIHR)

Chettalli - 571 248, Kodagu (Coorg), Karnataka

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STRATEGIES FOR CONSERVATION, IMPROVEMENT AND UTILIZATION OF UNDERUTILIZED FRUITS

1-3 December 2014

SOUVENIR & ABSTRACTS

Organized by

CENTRAL HORTICULTURAL EXPERIEMENT STATION
ICAR - Indian Institute of Horticultural Research
Chettalli, Kodagu

and

SOCIETY FOR PROMOTION OF HORTICULTURE
Indian Institute of Horticultural Research
Bangalore
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SOUVENIR & ABSTRACTS

National seminar on strategies for conservation, improvement and utilization of underutilized fruits

1-3 December 2014, CHES, Chettalli, Madikeri, Kodagu, Karnataka.

Organized by

Central Horticultural Experiment Station (CHES)
Society for Promotion of Horticulture (SPH)

Compiled and Edited by

P.C. Tripathi
V. Sankar
R. Senthilkumar
G. Karunakaran

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Dr. T.M. Reddy, Scientist (SS), CHES, Chettalli
Dr. Priti Sonavane, Scientist, CHES, Chettalli

सत्यमेव जयते

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

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कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

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MESSAGE

South Asia is home to a number of underutilized fruits, vegetables, tuber crops etc. since the time immemorial. These plants were once a source of food, clothing and nutritional security but now need rediscovery. These lesser known and underutilized crops can be one of the best alternatives in ensuring food and nutritional security in the era of climate change, considering their adaptation in comparison to other fruits. Some of the underutilized fruits and vegetables are a part of our culinary habit, culture and holistic diet and evolved over a period of time and contributing to fitness of the local population.

The food, neutraceutical and pharmaceutical applications of these underutilized fruits is yet to be properly understood and utilized. The ecological balance and environmental sustainability are closely entwined with the cultivation of above crops which besides supplementing the marginal society, caters to the needs of wild life and flora & fauna of the ecosystem.

The work done at the Central Horticultural Experiment Station of the IIHR, for identification of improved genetic stock and developing technologies for production and utilization of some underutilized fruits crops is commendable and in fact, a matter to reckon with. It is indeed a great pleasure to learn that a *National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits* is being organized during 1-3 December, 2014 at Kodagu, Karnataka jointly by Central Horticultural Experiment Station (ICAR-IIHR), Chettalli and the Society for Promotion of Horticulture, Bengaluru. I am sure that the participants will deliberate upon various issues and devise suitable action plan for their conservation, cultivation and utilization.

I wish the event grand success.

(S. Ayyappan)

Dated the 25th November, 2014
New Delhi

डॉ एन. के. कृष्ण कुमार
उप महानिदेशक (बाग. वि.)
Dr. N. K. Krishna Kumar
DEPUTY DIRECTOR GENERAL (HORTICULTURAL SCIENCE)

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भाकृअनुप
ICAR

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAWAN-II
PUSA, NEW DELLHI-110 012

MESSAGE

The available plant biodiversity in India can largely be credited to excellent wisdom and conservation efforts of our predecessors, more so in perennial and underutilized fruit crops. Many tropical and subtropical fruits referred to as *underutilized* are, in fact, locally abundant but restricted in their geographical distribution and utility. The potential of underutilized fruits in India through genetic improvement, production and utilization has not been tapped in scientific manner.

Realizing their potential in days to come, concerted efforts on Research and Development were made at the Central Horticultural Experiment Station (ICAR-IIHR), Chettalli, Karnataka. The efforts made so far have resulted in development of several new varieties and identification of promising genetic stock. Besides, standardization and adoption of improved crop management technologies for humid, tropical underutilized fruits have been largely helpful in popularizing these fruits over a large geographical part of Karnataka. Though, the area and production of these fruits is comparatively less, they have good potential under the climate change scenario and growing health concerns. There is need to address the challenges and harness their potential within the existing ecosystem. In addition, their cultivation can further be taken up in similar other geographical regions of the country. I am sure that well thought out deliberation upon the emerging issues on increasing the area and productivity and action plan developed for increasing production and trade of underutilized fruits in domestic and export market will be an eye opener for stakeholders in similar other regions.

I am happy to know that the Central Horticultural Experiment Station (ICAR-IIHR), Kodagu and the Society for Promotion of Horticulture (SPH), Bangalore are jointly organising ***National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits*** during 1 to 3 December, 2014 at Chettalli, Karnataka.

I compliment the organizers and participants and; wish the event grand success.

(N. K. Krishna Kumar)

भारतीय बागवानी अनुसंधान संस्थान
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ICAR- INDIAN INSTITUTE OF HORTICULTURAL RESEARCH
Hessaraghatta Lake Post, Bengaluru - 560 089

❖ Sardar Patel Outstanding ICAR Institution Award 2010 ❖

PREFACE

Central Horticultural Experiment Station Chettalli of ICAR-Indian Institute of Horticultural Research, Bengaluru was established in 1947 by then Coorg Government for research on citrus and other fruits. It was transferred to IIHR, Bengaluru in 1972. The station did a commendable job on citrus particularly on Coorg mandarin during last 65 years. Along with revival of Coorg Mandarin, crop diversification was one of the important activities the Station took up during the past two decades, as the agro-climatic conditions and crop growing situations are most suitable for many underutilized fruit crops (future fruits) and focused its work on introduction of many new crops like passion fruit, avocado, karonda, jamun, *Garcinia* species, rambutan, dragon fruit *etc.* As a result the Station made large collections of these fruits during last 15 years, evaluated and identified few varieties and promising lines. There is still a need to develop more promising varieties in these fruits and standardize production technologies and popularize in the entire belt of Western Ghats. Realizing the importance of these under utilized fruit crops, their scope as future fruits and their role in providing nutritional security, the Central Horticultural Experiment Station, Chettalli of IIHR, Bengaluru and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar on Underutilized Fruits at Chettalli during December 01-03, 2014 and create a common platform for research workers, farmers, entrepreneurs, other stake holders and interested people to discuss and deliberate on various issues of importance and emerge out with recommendations and action plan

I am immensely thankful to Dr. S. Ayyappan, Honourable Secretary, DARE & Director General, ICAR, Dr. N. K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, Dr. T. Janakiram Assistant Director General, (Hort.), ICAR, New Delhi and Dr. S.K. Malhotra, Horticulture Commissioner, Govt. of India for providing support and help to organize this seminar.

My special appreciations goes to all key note speakers, lead speakers and the scientists of CHES, Chettalli and IIHR, Bengaluru for their untiring work for making all arrangements. I also acknowledge the support rendered by all the staff member of CHES Chettalli and IIHR Bengaluru. I also thank to all Chairmen, Co-chairmen and Conveners of various committees. I would like to place my gratitude to all the public and private organization for supporting this seminar *viz.* Ministry of Agriculture, Govt. of India, ICAR, New Delhi, NHB, NABARD, Directorate of Spices Board, National Horticulture Mission, Karnataka, Tata Coffee, Pollibetta, BBTC, Siddapura and other Co-sponsors.

I wish everyone who are participating in this seminar a very happy stay and a fruitful discussions.

27.11.2014
Bengaluru

(T.Manjunatha Rao)
Director

निदेशक/Director: 080 - 28466353 / 28466471
FAX: 080 - 28466291, Email: director@iihr.ernet.in, iihrdirector@gmail.com

CONTENTS

SESSION I

STATUS OF UNDERUTILIZED FRUITS AND TREE SPICES WITH SPECIAL EMPHASIS TO WESTERN GHATS

THEME PAPERS

Unexploited fruits of Western Ghats

B.C. Uthaiah*, P.C. Tripathi, V. Sankar** and R. Senthil Kumar****

** Ex Dean, College of Forestry University of Agricultural Sciences,*
Ponnampet, Kodagu, Karnataka
*** Central Horticultural Experiment Station (IIHR), Chettalli, Karnataka*
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The Western ghats region is very rich in diversified edible fruit yielding plant species. and Western ghats hills lies in the east coast of Arabian seas and spread of border of Gujarat to Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala in southern tip of India. The region has several mountain peaks which intercept monsoon winds which results in heavy rainfall in this region. The heavy rainfall and different type of temperature conditions makes it home of several plant species. Many of them yield edible fruits and vegetables. This plant wealth is being used in various forms only by tribals and natives of the area. By an intensive survey of the area it is possible to identify and locate a few superior types cut of wide variationavailable in the region. In recent years rain fed orcharding has attracted the attention at national level. Identification of desired types among the wild edible fruit species will be of immense use for dry orcharding. These wild types gain further importance due to the fact that one or the other kind of fruit is available in ripe form during round the year and serve as a source of food and medicine to tribal's and also to animals throughout the year. There is no need to emphasis the importance of wild fruit as a source of minerals and vitamins in the diet of the rural under privileged class. For example Carissa fruits are the richest source of iron among the edible fruits. This fruit is available all over the Western Ghats. This can be used as simple remedy for the often reported iron deficiency in rural areas of the country.

The potential productivity and floristic diversity of the area has attracted the experts.In recent years survey and studies on the wealth of utility plants has yielded good results. This knowledge has been made use to collect and also produce large quantities of materials useful in agriculture, medicine and industries. Among the edible wild fruits some are even superior to the presently cultivated ones.There are more than 50 wild edible fruit species are available in Western Ghats region (Table1). It is interesting to note that at least six plant species will be in fruiting in each month of the year. The duration of fruiting period of different species ranged between two to six months. The largest numbers of species were in fruiting during the month of April - May .The availability of these fruits get reduced after October. Some of these fruits have been given emphasis in order to identify superior clones, production technologies. The efforts on some of the fruits such as Panarpuli (kokum), Panampuli (Kachampuli), another fruits have been started at various research institutes, agricultural universities and other organizations. It has beenreported that these wild edible fruits of the Western Ghats region belong to 25 families, 38 genera and 50 species, but there may be more to be identified. Out of the 25 families the important ones as a source of food to tribal's and animals are Apocynaceae, Anacardiaceae. Euphorbiaceae, Moraceae, Sapotaceae, Sapindaceae. Some the these fruits collected and analyzed at CHES Chettalli (Table 2). The detail of some of these fruits is as follows,

Baduvapuli (*Citrus penninvesiculata* Tan)

It resembles with Gajanimba and extensively grown in various parts of this region. The trees are moderately vigorous, uprightingrowth. It fruits around the year but main crop came in the month of July and August. The fruits weight range between 500 to 600 g. The fruits are greenish yellow in colour with rough and thick bark. Skin is loosely attached with flesh and can be peeled easily. The pulp colour is greenish white and there are 14 to 16 segments in fruit. The number of seeds varies from 80-100 per fruit. Fruits are acidic and titrable acidity ranges between 2.2 to 3.0 percent with total soluble solid of 8.0 to 8.5 ^{o}Brix. The juice percentage varies from 15 to 20 percent (Table 2). The fruits are used for making pickle. The fruits are essential for Onam festival for making pickles and curies in part of Kerala. The studies conducted at CHES, Chettalli that this can be used as root stock for Coorg mandarin. The Coorg mandarin budded on baduvapuli gave 1200fruit per tree after 14 years and found almost equal to rough lemon and Rangpur lime (Aiyappa *et al*, 1974 &1976).

Ballichorangi, Coorg Lime (C*itrus aurantifolia*)

This is similar to Kagzi lime. Trees are medium size with drooping type branches. It is high yielding lime which performs better under high humid conditions. The fruits are medium sized fruits and. It produces fruits round the year. Fruits are yellowish in colour skin is tight and smooth. The juice percentage varies from 25-30%. It contains 5-15 seeds and extensively used for pickle and other purposes. The plants are tolerant to citrus canker. Studies conducted at CHES Chettalli revealed that Coorg lime was found better than releasedvarieties with respect to yield (Anonymous, 2005).

Kodakithuli *(Citrus reshni* var kodakithuli*)*

Kodakithuli is a small orange extensively grown inCoorg and generally used for rootstock for Coorg mandarin. The Tree resembles with Coorg mandarin but the small of leaves is distant. Tree grows upright and may reach to 10 to 15 feet height. The fruit is similar in size and fruit weight range from 15to 20 g.The fruits are bright orange red in colour and very attractive and the skin is smooth and contains 8-15 seeds per fruit. The juice content is range from 15-25% with higher acidity (Table 2). The fruits are generally not use for consumption but this is good for rootstock for Coorg mandarin. The studies conducted at CHES Chettalli revealed that kodakithuli is a good rootstocks for Coorg mandarin and produced higher yield with quality fruits (Aiyappa et al., 1974 &1976).

Belladakithuli (*Citrus maderaspatna* Tanaka)

It is similar to Kodakithuli,but fruits are sweet in taste as a name reflect bella means jiggery in Kannada. Fruits are sweet, small size and edible. It can be used as rootstock for Coorg mandarin. The studies conducted at CHES, Chettalli that this can be used as root stock for Coorg mandarin. The Coorg mandarin budded on belladakithuli gave 1500fruit/tree after 14 years and found similar to rough lemon and Rangpur lime. The studies conducted at CHES Chettalli found that belladakithuli as one of the best rootstock for Coorg mandarin with respect to growth, yield and fruit quality parameters (Aiyappa,1974).

Lavate pan (*Allophylus serratus)*

It is a shrub of family sapotaceae. The fruits ripe in the month of February - March. The outer pulp and some time seeds are consumed in fresh state .it is frequently notice in degraded forest areas in Western Ghats. It is known to possess various therapeutic properties.

Yechi pan (*Aporosa lindleyana* WtBaill)

It is tree which grow up to 15 m height of Euphorbiaceae family. Tree bark is smooth to shallowly fissured, brownish; blaze pink. Leaves are simple, alternate, oblong - lanceolate, acute, 7.5-17 cm long. Flowers unisexual, dioecious; male flowers in axillary catkins; female flowers in condensed cymes. Fruits are smooth, globose, 1.to 1.3 cm size with, 2-4 seeds. The fruits ripe in the month of May- July. The aril is consumed in fresh state .it is frequently notice in all over the area in Western Ghats.

Aajini chakke (*Artocarpus hirsutus* Lamk)

It is a tropical evergreen tree of Moraceae which is native to western Ghats. It prefers moist, deciduous to partially evergreen forests and growsan altitude up to 1000 m msl with an annual rainfall of 1500 mm or more. The tree may reach a height of up to 35 m. The fruits ripe in the month of May- June. The mature carpels, seeds are consumed fresh .Tender fruit used in pickle. It commonly occur all over the area.

Mukkanna (*Borassus flabellifer*)

Mukkana is a robust tree of palmae family .It may reach a height of 30 metres.The leaves are green-bluish leaves. The fruit are available during December–April. The partially matured kernel is consumed in fresh form. It is found only in western side of Western Ghats but not noticed in higher elevation

Amme pan (*Canthium dicoccum* var. *umbellatum* syn. *Pelectronia parviflora*)

It is trees of family Rubiaceae which may attain up to 12 m height.The trunk is grey, smooth, irregularly fissured and flaky. Leaves are simple, opposite, decussate; stipules interpetiolar linear with broad base, to 0.9 cm long; petiole 0.6-1 cm long, glabrous; acuminate with entire margin. Flowers are born axillary cymes inflorescence. Fruit is drupe, ovoid, 1.5 cm long.The fruits ripe in the month of April - June.Whole fruit expect seed are consumed asfresh fruits are consumed in ripe stage . It commonly found at higher elevation.

Kare pan (*Canthium parviflora* Lamk syn. *Plectronia parviflora* (Lam.) Bedd.

It is also trees of family Rubiaceae which may attain up to 12 m height. The Fruit is drupe, ovoid, 1.5 cm long. The fruits ripe in the month of April - June. Whole fruit expect seed are consumed as fresh fruits are consumed in ripe stage. It commonly found throughout the Deccan Peninsula, from Gujarat and Maharashtra southwards, and in Bihar and Orissa.Leaves and fruits are astringent, antispasmodic; used against cough. A decoction of the root and leaves is given in flu. Bark is anti dysenteric. The plant contains mannitol (0.5%) and alkaloids.

Pale pan (*Chrysophyllum roxburghii)*

Pale pan is a plant of Sapotaceae family. It grows as a tree up to 30 metres tall, with a trunk diameter of up to 40 cm. The bark is grey to dark brown. Inflorescences bear up to 45 flowers. The fruit are greenish, ripening yellow, round, up to 4 cm in diameter. The fruit matures in the month of March –May. Ripe fruits are consumed when fresh .It is rarely found that too only in reserve forest area up to 700 metres altitude.

Kirkarmanji (*Carissa carandas* L)

Carissa carandas is a shrub of in the family Apocynaceae. It is a hardy, drought-tolerant plant that thrives well in a wide range of soils. Stem is multi branched thorny and strong. The Leaves are opposite, obovate to oblong, crenate base, obtuse apex and entire margin.Flowers are white in axillary and terminal clusters. It flowers in the month of January –March and fruit mature in the month of April-June. Fruits are reddish purple berries and commonly used as a fresh fruits .Immature fruits are used in pickling. The ripe fruits are used in jams, preserved in syrup and candy. It is found at only in lower elevation.

Karmanji (*Carissa gangetica* Stapt)

Karmanjiis a shrub of in the family Apocynaceae. It grows as a multi-stemmed shrub, 0.5 to 3 metres in height. The leaves are glossy green, opposite, narrow ovate to lanceolate and 1–5 cm in length. The branches bear thorns of 1–3 cm length. White, star-shaped flowers ~1 cm across are followed by ovate green berries, 1–2 cm in length, which turn black or dark purple when ripe. It flowers in the month of January –March and fruit mature in the month of June – August. Fruits are reddish purple berries. Fruits that are commonly used as a fresh fruits .Immature fruits are used in pickling. The ripe fruits are used in jams, preserved in syrup and candy. It is found at in jungles and higher elevation.

Cheslle pan (lasoda) *Cordia dichotoma*

Cheslle pan is a small to moderate-sized deciduous tree with a short bole and spreading crown. The stem bark is greyish brown, smooth or longitudinally wrinkled. Flowers are short-stalked, bisexual, white in colour which opens only at night. The fruit is a yellow or pinkish-yellow shining globose which turns black on ripening and the pulp gets viscid. The fruit mature in the month of December – February . Fruits that are commonly used as a fresh fruits .Immature fruits are used in pickling. It is rarely found in this region.

Tholiar pan,Wild olive (*Elaeagnus conferta* Roxbsyn *E.latifolia* L)

Wild Olive is a thorny climbing shrub of family *Elaeagnaceae*. Leaf blades are 5-11 mm long; elliptic to elliptic-oblong, 4-11 cm long. The lower surface with scales dense, silvery upper surface smooth. Leaf base is round .It flower in the month of October-February. Flowers greenish white or yellowish, with silvery scales.Sepal tube tubular, 4-angled, constricted above ovary; sepals ovate, 2-3 mm.The fruit mature in the month of January-March. Fruits that are commonly used as a fresh fruits .Immature fruits are used in pickling. It is not common in this region.

Kooge pan (*Elaeocarpus tuberculatus* Roxb)

It is tall tree of family Elaeocarpaceae which may grow up to 40 m tall The trunk is smooth with grey and white colour. Leaves are simple, alternate, spiral, clustered at twig ends 9-30 cm long obovate, apex round. Inflorescenceis axillaryand flowersare white .Fruits mature in September – November .Outer pulp and kernel is edible and Consumed only as ripe fruit .It is not common in this region.

Idanji pan (*Elaeocarpus munronii* (Wt.) mast)

Elaeocarpus munronii is plant in the Elaeocarpaceae family. It is found only in India. Trees growsup to 15 m tall.Trunk is greyish, smooth and blaze cream.Leavesare simple, alternate, 4-9 cm long , ovate Flowers axillary in racemes, white.Fruit is Drupe, elliptic and 2 cm long, smooth with single seed.Fruits mature in March –April.Whole fruit expect the seed is edible and Consumed only as ripe fruit .It is not common in this region.

Naikulli pan (*Epiprinus mallotiformis* (Mueller)syn *Symphylliamallotiformis*Muell)

Naikulli pan is a tree of euphorbiaceae family. The tree grows up to 12 m height.Leavesare simple, alternate, 6. 17 cm long, usually elliptic, apexacute and margin is entire.Flowersare unisexual. The maleflowersproduced numerous in clusters with few female few at the base of the inflorescence.Fruits mature in April –June .Whole fruit expect the seed is edible and consumed as ripe fruit. It is common in this regionat higher elevation.

Kakkade pan *(Flacourtia indica* syn. *Flacourtia ramontchi*) Governor's plum

Flacourtia indica is a flowering plant of family flacourtiaceae. This is a bushy shrub or tree with a spiny trunk and branches. In shrub form it grows up to 8 m The branches are drooping type and leaves areoval .Fruits mature in August- October. Whole fruit expect the seed is edible and consumed as ripe fruit. The pulp is yellow or white and sweet with an acidic tang. It is eaten raw or made in to jelly or jam. It can be fermented to make wine.The leaves and roots are used in herbal medicine. It is scattered all over the region.

Male kakkade (*Flacourtia Montana* Graham)

Male kakkade is also belongs of family flacourtiaceae which is endemic to thewestern Ghats. This is a bushy shrub or tree which grows up to 8 metre. Trunk is branched thorny, brownish and smooth. Leavesare simple, alternate, 7-18 cm long.Fruits mature in December –February. Whole fruit expect the seed is edible and consumed as ripe fruit. It is not coon but scattered all over the region.

Punarpuli, kokum (*Garcinia Indica*)

Garcinia indica, a plant in the mangosteen family, commonly known as kokum, is a fruit-bearing tree that has culinary, pharmaceutical, and industrial uses.Ripe fruits is fresh state used in preparing soft drinks and as souring agent in culinary. Edible fat is extracted from seed kernel. Immature fruit is cut , dried and used in culinary. It is found in western side of Ghats at low elevation. Kokum is a small slender evergreen tree reaching to a height of 10-15 metres with spreading branches. Mature leaves are dark green, ovate 6.3-9.0 cm. long .The tree flowers in November – February and fruits ripen in April – May or June. The fruit is a berry, 2.5-3.8 cm in diameter. Spherical or globose in shape but not furrowed and purple or red when ripe and encases 5 to 8 seeds that are compressed and embedded in pulp. It is found in western side of Ghats at low elevation.

Panapuli (*Garcinia gummigutta* (L) Roxb)

Garcinia gunmigatta (Kadumpuli or Malabar tamarind) is medium tree found in Western Ghats, The fruit rind is used as spice in curries and its juice is used for reducing fat and also prevents blood clotting by reducing triglycerides. The rind of ripe fruits are processed and used as a condiment in fish and prawn preparation to impart flavour and taste and to improve keeping quality. It has immense value in drugs production for reducing the obesity and rinsing mouth. The tree has upright growth, medium sized. The fruits ripe in the months of July- August. The fruit weight ranges between 75 to 85g. Fruits are dull yellow colored, 6-7 seeds/fruit, rind yellow, flesh white, 8 segments, juicy and acid, seeds are not attached to flesh. Whole fruit expect seed is consumed. It is found at higher elevation of the Western Ghats.

Beenakepuli (*Garcinia xanthochymus* Hook)

Beenakepuli,Yelllow mangosteen (*Garcinia xanthochymus* Hook)is evergreen tall tree. The fruit rind is used as spice in curries and its juice is used for reducing fat and also prevents stomach disorders. The tree has upright growth, medium sized. The leaves are big and drooping type.The fruits ripe in the months of November -December. The fruit weight ranges between 100-150g. Fruits are bright yellow colored, 1 seeds/fruit, rind yellow, flesh yellow, juicy and acid, seeds are not attached to flesh. Whole fruit expect seed is consumed. It is found at higher elevation of the Western Ghats.

Kurmanapan, Orange berry (*Glycosmis mauritiana*)

Orange berry is a large shrub to small tree of rutaceae family .It grow up to up to 4 m tall. Tree is trunk is brown and smooth. Leaves are compound, pinnate , alternate, spiral. Leaflets are 3-5, alternate, 9-16 cm long, oblong or elliptic. Base is pointed, margin toothed. Flowers are born in velvety panicles in leaf axils. Flowers are small, white, stalkless. Fruits mature in December –February. Whole fruit expect the seed is edible and consumed as ripe fruit. Fruits are round, pinkish, up to 2 cm diameter with 2-3 seeds. It is found in degraded forest at higher elevation throughout the Western Ghats

Thadachi pan (*Grewia tiliifolia*)

Thadachipan is a moderate-sized to large tree of family Tiliaceae. It is a very close relative ofPhalsa.Tree trunk is grey or dark brown. The leaves are stipulate, ovate with oblique base and acuminate. It flowers in April- May .The flowers are small, borne on thick axillary peduncles. The fruits ripe in May-June. The fruit are globose with 1-1.5 cm diameter, black and edible. Whole fruit expect seed are consumed at ripe stage. It is found thought out western Ghats.

Uppalipan (*Margaritaria indica* (Dalz.)

Uppalipan is a deciduous tree of family euphorbiaceae. The tree may grow up to 25m height. The tree trunk is reddish brown .The Leaves are simple, alternate, lanceolate, 5-13 cm long , with entire margin. Flowers are unisexual, dioecious, green. Fruits are small (1.0cm diameter) and globose. The fruits mature in the month of September- November. Whole fruit expect the seed is consumed at ripe stage. It is found in South and Central Sahyadris of Western Ghats.

Male Koomathi (*Nephelium stipulacum* Bedd syn *Doratoxylon stipulatum)*

Male Koomathi is plant of family sapindaceae. The fruits matures in the month of July-September. The arils of the fruit are consumed only in ripe stage. It is rarely noticed occur at higher elevation

Puli pan (*Rourea minor*)

Pulipann is a large woody climbing shrubs of family Connaraceae. Stem is black. Leaves are compound with 3-7 leaflets. Flowers in axillary panicled cymes. The fruits ripe in June –August. Whole fruit expect the rind and seed is consumed at ripe stage .It is rarely found.

Vale pan (*Rubus ellipticus)*

Vale pan is commonly known as yellow Himalayan raspberry is a thorny shrub of family rosaceae. It is an evergreen, large, spreading shrub of Rosaceae family. It has multiple stems coming out of soil from single roots system. The stem is green at young stage and purple at maturity with lot of prickles. The leaves are trifoliate. Leaflets are elliptic - obovate or ovate, green, glabrescent with bristles. The flowers are white produced in dense axillary fascicles or short terminal forming a compound inflorescence. The flowering takes place in the month of December -February. The fruits mature in month of February- April . The fruits are yellow or golden yellow and round. Whole fruit is consumed at ripe stage. It is commonly found along the banks streams and marshy areas inthis region.

More pan (*Securina leucopyrus syn. Flueggea leucopyrus***)**

More pan (Bush weed) is an erect shrub of family Euphorbiaceae. The plant grows up to 4 m tall with branches cylindrical or obtusely angular when young, gray. Final branchlets are spine-tipped, cylindrical and rigid. Leaf stalks are 2-8 mm, grooved. Leaf blade is elliptic, obovate, or round, 1.3-2.5 × 1-1.5 cm, papery to thinly leathery. Leaf margin is not toothed and the tip is rounded. Flower cymes arise in leaf axils or at leafless nodes. Flowers are tiny, yellowish. Male flowers have 5 petals, 5 stamens. Female flowers have 5 sepals, elliptic or ovate, 0.6-0.8 mm; disk annular. Fruit is a nearly spherical berry, about 4 mm in diameter, whitish when ripe. It flowers in April-July and fruits ripe in June– July. The whole fruit expect the rind and seed is consumed at ripe stage.It is raely found in this region.

Nera pan (*Syzygium cumini*)

Nera pan (jamun) is a slow growing tree. It may reach heights of up to 30 m and can live more than 100 years. The bark is rough and dark grey, becoming lighter grey and smoother higher up. The leaves are pinkish when young, changing to a leathery, glossy dark green with a yellow midrib as they mature. The trees flower from March to April. The flowers are fragrant and small. The fruits matures April- June. The fruit is oblong, ovoid, starts green and turns pink to shining crimson black as it matures. Whole fruit expect the seed is consumed at ripe stage. It is found in entire of Western Ghats.

Bolluru pan (*Syzygium gardneri*)

Bolluru pan is a large tree of Myrtaceae family .Stem is white or pale grey, usually have cracked in irregular flakes. Leaves are simple, opposite, 5-10 cm long .The trees flower from March to April. The flowers are fragrant and small. The fruits matures January-March . The fruits are oblong. Whole fruit expect the seed is consumed at ripe stage. It is found in entire of Western Ghats.

Kare pan (*Xeromphis spinosa*)

Karepan is a plant of family Rubiaceae.The fruits matures in themonth of June-July. The whole fruit expect the seed is consumed at ripe stage. It is found in entire of Western Ghats.

Kotte pan (*Zizyphus rugosa* Lamk)

Kotte pan belomgs to family Rhamnaceae. It is a tree found on hills and mountains below 1 400 m altitude. It is a small tree or shrub, spines. The leaves are simple, 5-12 cm long .and are broadly elliptic and short tips. It flowers in December-January. The fruits mature in February- March.Fruit are 5-8 mm in diameter, globose or pyriform, white when ripe. Whole fruit expect the seed is consumed at ripe stage. It is found in degraded forest areas of entire of Western Ghats.

The wild edible fruit species of the Western Ghats region serves as important component of the ecosystem of the area. Some of these have potential to commercial cultivation. There is need for more works on these plant species. There may be more species to be identified. Therefore, further study deep into the Western Ghats is necessary.

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Table 1. Wild Edible Fruits of Western Ghats region

Botanical Name	Family	Vermicular Name	Fruiting Season	Uses
Allophylus serratus	Sapindaceae	Lavate pan	February- April	Consumed in fresh stale
Aporosa lindleyana	Euphorbiaceae	Yechi pan	May- July	Consumed in fresh stale
Artocarpus hirsutus Lamk	Moraceae	Aajini chakke	May – June	Ripe carpels are consumed fresh,Tender fruit used in pickling, Seed roasted and consumed
Artocarpus lakoocha	Moraceae	Pulichakke	November-January	Picking ,Souring agent Pulp is consumed in fresh state
Borassus flabellifer L.	Palmae	Mukkanna	December -April	Consumed in fresh form
Canthium dicoccum var. *umbellatum* syn. *Pelectronia parviflora*	Rubiaceae	Amme pan	April -June	Fresh fruits are consumed in ripe stage

Canthium *parviflora* Lamk syn. *Plectronia parviflora* (Lam.) Bedd	Rubiaceae	Kare pan	April-June	Fresh fruits are consumed in ripe stage
Chrysophyllum roxburghii	Sapotaceae	Pale pan	March-May	Ripe fruits are consumed when fresh
Carissa carandas L.	Apocynaccae	Kirkarmanji	April-May	fruits are used as fresh, pickling, jams, sun dried and preserved
Carissa gangetica Stapt	Apocynaceae	Karmanji	June – August	fruits are used as fresh, pickling, jams, sun dried and preserved
Cordia dichotoma	Cordiaceae	Cheslle pan	December – February	Ripe fruits are eaten
Elaeagnus conferta	Elaeagnaceae	Tholiar pan	January-March	Ripe fruits are consumed
Elaeocarpus tuberculatus Roxb.	Elaeocarpaceae	Koogepan	September – November	ripe fruit , kernels
Elaeocarpus munronii (Wt.) mast.	Elaeocarpaceae	Idanjipan	March –April	Ripe fruits are consumed
Epiprinus mallotiformis (Mueller)	Euphorbiaccae	Naikullipan	April –June	Ripe fruits are consumed
Flacourtia indica (Burm.) Merr.	Flacourtiaceae	Kakkade pan	August-October	Ripe fruits are consumed
Flacourtia Montana Graham	Flacourtiaceae	Male kakkade	December – February	Ripe fruits are consumed
Garcinia Indica (Dupetit-Thou) Choiss .	Clusiaceae	Punarpuli	March – May	used in preparing soft drinks and s souring agent
Garcinia gummigutta (L) Roxb.	Clusiaceae	Panapulli	August-October	Dried rind &Concentrated juice used as souring agent.
Garcinia xanthochymus Hook .f.tex. T. Anders .	Clusiaceae	Beenake puli	December-March	Consumed when ripe
Glycosmis mauritiana (Lamk) Tanaka	Rutaceae	Kurmana pan	December February	Consumed at ripe stage
Grewia tiliifolia	Tiliaceae	Thadachi pann	May-June	Consumed at ripe stage

Margaritaria indica	Euphorbiaceae	Uppalipan	September-November	Consumed at ripe stage
Dimocarpus longan Lour. (*Naphalium longan* (Lamk) Camb.	Sapindaceae	Koomathi	August – November	Aril only consumed
Nephalium stipulacum Bedd.)	Sapindaceae	Male Koomathi	July-September	The arils of the fruit only eaten
Rourea minor (Gaertn.)	Connaraceae	Pulipan	June – August	Consumed at ripe stage
Rubus ellipticus J.E. Sm.	Rosaceae	Vale pan	February-April	Consumed at ripe stage
Salacia malabarica Gamb	Hippocrateaceae	Moira pan	June– July	Consumed at ripe stage
Scutia circumscissa	Rhamnaceae	Kokkarchi pann	June-August	Consumed at ripe stage
Securina leucopyrus syn. *Flueggea leucopyrus*	Euphorbiaceae	More pan	June– July	Consumed at ripe stage
Symplocos cochinchinensis ssp. Laurina (Retz.)	Symplocaceae	Padachi pan	September-November	Consumed at ripe stage
Syzygium cumini	Myrtaceae	Nerapan	April–June	Consumed at ripe stage
Syzygium gardneri	Myrtaceae	Bollurupan	January-Mar.	Consumed at ripe stage
Syzygium jambos	Myrtaceae	Jamnaripan	Nov – Jan	Consumed at ripe stage
Terminalia bellerica (Gaertn.)Roxb	Combretaceac	Kemandikai	January – April	Matured kernel is consumed
Xeromphis spinosa	Rubiaceae	Karepann	June-July	Consumed at ripe stage
Zizyphus oenoplia L	Rhamnaceae	Bellathapan	Dec.-Jan	Consumed at ripe stage
Zizyphus rugosa Lamk.	Rhamnaceae	Kottepan	Feb.- March	Consumed at ripe stage

Table 2. Fruit characteristics of some wild fruits

Vernacular Name	Botanical name	Fruit Weight (g)	Fruit volume (CC)	Fruit length (cm)	Fruit breadth (cm)	Rind colour	Flesh color	TSS (^{O}Brix)	Acid-ity (%)	No. of Seeds
Bean Puli	*Averhoa sp.*	15.6	16.0	5.6	2.2	Green	white	5.2	-	-
Undehuli	*Artocarpus lakoocha*	113.5	115.2	5.9	6.0	Green	white	6.7	-	-
Ajanchakke	*Artocarpus hirsutus*	93.55	95.0	6.45	5.3	Dull Yellow	Light yellow		-	125
Majjige hannu/ Morepan	*Securina leucopyrus*	9.33	9.51	2.34	2.47	Whitish Green	white	15.6	-	2.17
Gonne Hannu		3.11	3.2	1.27	1.61	-	-	16.3	-	31
Pale pan	*Chrysophyllum roxburghii*	34.528	34.8	13.24	12.86	Green	white	22.0	-	3
Karmanee	*Carrissa carendus*	9.04	9.15	2.53	2.46	Violet	white	15.2	-	2.3
Nar pan	*Syzygium cumini*	2.12	2.20	1.51	1.1	Violet	Reddish	11.2	-	1
Punarpuli	*Garcinia indica*	52.63	51.80	4.15	4.86	Dull Red	Red rind & white pulp	14.78	4.16	5.13
Kachampuli	*Garcinia gummigata*	60.30	56.10	5.2	5.1	Dull yellow	Yellow rind & white pulp	8.9	-	5.2
Beenakepuli	*Garcinia xanthochymus*	127.78	127.83	6.64	6.15	Bright Yellow	Yellow	12.70	7.20	1.4
Baduvapuli	*Citrus penninvesiculata*	554	545	16.5	17.0	Dull yellow	Greenish white	8.1	2.75	8.3
Ballichorangi	*Citrus aurantifolia*	28.2	29.0	-	-	Yellow	white	7.2	-	-
Kodakithuli	*Citrus reshni* var *kodakithuli*	18.37	18.2	2.64	3.49	Bright orange	orange	11.2	0.46	8.0
Belladakithuli	*Citrus maderaspatna* Tanaka	15.2	15.5	2.63	3.51	Bright orange	orange	13.2	0.21	9.0

Biodiversity of tree spices in Western ghats and their conservation

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Spices have played a very important role in shaping the history of human culture and civilization. Spices condiments and aromatic plants were the first articles traded by the ancient people. These prompted the foreigners, to the land of spices – India and finally Vasco-da-Gama landed on the Malabar Coast on May 20th 1948 - an event that changed Indian history in the centuries that followed.

India is the land of spices. It grows over 50 different varieties 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, clove and *Garcinia*).

Tree spices are spices originating from tree crops. Altogether 17 species are put under the group 'tree spices' (Table-1) of which most of them are grown in India, Sri Lanka, Indonesia, Malaysia, China, Myanmar, Vietnam, Tanzania and Jamaica or occurring in the humid tropical forests of South East Asia, Australia, Pacific Islands and Tropical America (Krishnamoorthy *et. al*., 1997). Nutmeg, cinnamon, kokum and tamarind are the important tree spices grown in India. Tamarind and curry leaf are grown widely. *Garcinia* is mainly grown in the South West region of India.Monocrop of tree spices are not common and they are integral part of homesteads in Kerala. In India nutmeg is cultivated in an area of 16,130 ha with the production of 11420 t (source DASD, Kozhikode). Kerala is the leading state in nutmeg cultivation with 97% of the area and 95% in production. Cinnamon is not usually cultivated on commercial scale in India. The total area is estimated only 350 ha. Tamarind is another major tree spice with 61336 ha and production of 1.21 tons. Tamil Nadu leads in area but Karnataka leads in production

Table 1. Important tree spices of commercial importance

Botanical name	Common name	Family	Parts used
Averrhoa carambola L.	Carambola	Averrhoaceae	Fruit
A. bilimbi L.	Bilimbi, Cucumber tree	Averrhoaceae	Fruit
Cinnamomum cassia Bercht&Presl.	Cassia, Chinese	Lauracea	Leaf, bark
C. tamala Nees.	Tejpat	Lauracea	Leaf, bark
C. verum Brecht.&Presl.	Cinnamon	Lauracea	Leaf, bark
Garcinia gummi-gutta (L.) N. Robson.	Gamboge	Clusiaceae	Fruit rind
G.indica Choisy.	Kokum	Clusiaceae	Fruit rind
Juniperuscommunis L.	Common Juniper berry	Cupressaceae	Fruit
Murraya koenigii (L.) Sprengal.	Curry leaf	Rutaceae	Leaf
Myristica fragrans. Houtt.	Nutmeg, mace	Myristicaceae	Seed & aril

Pimento dioica (L.) Merr.	All spice	Myrtaceae	Fruit
Syzigium aromaticum (L.) Merr.& Parry.	Cloves	Myrtaceae	Unopened flower bud
Tamarindus indica L.	Tamarind	Fabaceae	Fruit pulp
Z. limonella (Dennst.) Alston.	Indian pepper tree	Rutaceae	Fruit

Source: Peter 2000

Genetic resources

Cinnamon

The true cinnamon (*Cinnamomum verum* Bercht. &Presl,) commonly known as Sri Lankan cinnamon is an evergreen tree. Cinnamon of commerce is the dried bark of *C. verum*. It is indigenous to Sri Lanka, however the Western Ghats of India is considered to be the secondary center for this species. Cinnamon was first introduced to India from Sri Lanka by the British during the 18^{th} century and it is cultivated in Kerala, Tamil Nadu and Karnataka and is more prevalent in the hilly regions of Western Ghats. The oldest cinnamon plantation is the Anjarakandyestate (more than 250 acres) in the Kannur district of Kerala, which was planted by the British.

The genus *Cinnamomum* consists of about 250species comprising evergreen trees and shrubs; distributed in the Asiatic main land to Formosa, the Pacific islands and Australia. Hooker (1886) reported 25 species from the Indian sub-continent mainly from Western Ghats. Gamble (1925) reported 12 species of *Cinnamomum* from the Western Ghats and adjoining areas. The species occurring in Western Ghats, their distribution and description are presented in Table 2. The diversity in these materials is mainly species diversity only. As most of these species occur only in the wild, semi-domesticated gene pools of cinnamon do not occur. Owing to severe deforestation, there is every possibility of some species becoming extinct in the near future.

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

The *ex situ* conservatory at the Indian Institute of Spices Research conserves *C. cassia*, *C. camphora* (an economically important tree yielding camphor oil), *C. citriodorum*, lemon grass oil smelling *Cinnamomum* spp. collected from Munnar (Idukki District) *C. malabatrum, C. perrottetti, C. wightii, C. macrocarpum, C. sulphuratum, C. riparium*and *C. tamala*. The germplasm of cinnamon are also conserved at Konkan Krishi Vidyapeeth, Dapoli, Maharastra; Tamil Nadu Agricultural University (Horticultural Station. Yercadu); Regional Research Laboratory, Bhubaneswar and Kerala Agricultural University (Aromatic and Medicinal Plants Reserach Station, Odakkali)

Table 2. Species of *Cinnamomum* occurring in India

Name	Common Name	Place of distribution	Features
C.filipedicellatum Kostem.	Wild cinnamon	South India, Western Ghats, Anamalais, Nilgiris	Small tree, leaves opposite, with young leaves glabrous or span, tomentose underneath, flowers, glabrous or nearly, pedicels filiform, 5-15 mm long.
C. goaense Kostem.	Wild cinnamon	Northwestern Ghats	Leaves opposite with the basal lateral nerves reaching the leaf tip; lower leaf surface glabrous or with microscopical sparse, fruits ellipsoid with the persistent utmost basal parts of the tepals on the rim of the deep fruit cup.
C. macrocarpum	Wild cinnamon	South India (Nilgiris, Anamalais)	Tree bark and leaves giving faint smell of clove and aniseed; berries large, up to 1" in length, globose oblong, supported by a large thickened cup and pedicel.
C. malabatrum (Brum.f.) BI.	Wild cinnamon	South India, Western Ghats	Leaves with minute hairs mainly on their lower surface, bark pale brown whitish inside; fruit cup shallow, crowned by the complete indurate persistent tepals.
C. nicolsonianum Manilal & Shylaja	Wild cinnamon	South India	Medium tree, large leaves, very small panicles with very few flowers.
C. perrottelii Meissn.	Wild cinnamon	South India, Western Ghats	A mountain species with ovate leaves, very densely hairy on both the surfaces, the young emerging ones highly tomentose, more than older ones, bark tasteless.
C. riparium Gamble	Wild cinnamon	South India, Western Ghats	A graceful little tree, with long lanceolate narrow leaves and bright blue, shining, ovoid berry 0.5" long.
C. keralanese Kostem.	Wild cinnamon	South India, Western Ghats	Tree with light brown to reddish, odourless and tasteless bark, fruiting panicles pesudoterminal and axillary long, lax, fruit ellipsoid, cupula sub-obconical, slightly fleshy and not ribbed.

C. travancoricum Gamble	Wild cinnamon	Western Ghats	A small tree, the leaves with basal lateral nerves not reaching the leaf tip; leaves elliptic or subovate elliptic, obscurely acuminate with the undersurface of the young leaves sericeous
Cinnamomum verum Presl. (syn. *C. zeylanicum*Blume)	Cinnamon or Ceylon cinnamon	Sri Lanka, India	Small tree, bark aromatic, panicles medium-large and many flowers, fruits small, berry ovoid, dark purple
C. wightii Meissn	Wild cinnamon	Western Ghats	Bark slimy and without taste and odour; leaves opposite or spirally arranged, rigidly coriaceous, broadly elliptic; panicles very short, fruit cup obconical, more or less fleshy, not ribbed
C. sulphuratum Nees	Wild cinnamon	South India, Western Ghats, Nilgiris	A mountain species with lanceolate elliptic to elliptic leaves, above glossy, beneath initially densely, later sparsely or sublanuginose, tomentellous
C.heynianum Nees	-	Western Ghats	-
C. gracile Hook.f.	-	Western Ghats	-
C. chemungianum Mohan and Herry	-	Western Ghats	-
C. walaiwarense Kosterm	-	Western Ghats	

Garcinia

Garcinia is the source for a revolutionary natural diet ingredient which is currently a rage in America, Japan, Europe and other western countries. The principal acid in the fruit rinds of *Garcinia* isidentified as (-) hydroxy citric acid, HCA (1, 2-dihydroxypropane-1, 2, 3-tricarboxylic acid). *Garcinia* or Gamboge is obtained from the dried rind of *Garcinia combogia*. The other important species is *Garcinia indica* commonly known as kokum. *Garcinia* grows extensively in the Konkan region of Maharashtra, Goa, coastal areas of Karnataka and Kerala, evergreen forests of Assam, Khasi, Jantia hills, West Bengal and Gujarat.

The genus *Garcinia* of the family Clusiaceae, is a large genus of evergreen polygamous trees, shrubs, lianas and herbs. It consists of over 200 species distributed in the tropics of the world chiefly in Asia, Africa, Australia and Polynesia. The typical features of *Garcinia* species include monopodial growth, yellow exudates from stem coriaceous or leathery textured leaves etc. Most of the plants are known for their oil glands or secretary canals or cavities, which contain yellow or brightly coloured resins. About 35 species are reported to exist in India including some exotic ones many of which are economically important with immense medicinal properties. Out of 35 species reported to exist in India, 7 are endemic to Western Ghats, 6 in Andaman and Nicobar Island and 4 in North East India (Rodrigues, 2001).

Among the Garcinia species reported so far, Garcinia*cambogia, G. indica* and *G. cowa* are used as spices and condiments with medicinal properties while *G. mangostana* is an important fruit crop. *G. morella* are also cultivated to a certain extent. Some of the important species of *Garcinia* occurring in Western Ghats, India are given in Table 3.

Table 3. List of *Garcinia* species occurring in India

Species	**Distribution**
Garcinia. cowaRoxb. (G. kydiaRoxb)	Eastern parts of India, Assam, Bihar, Bengal, Orissa, Andaman and Meghalaya
G. echinocarpa	Thirunelveli forests
G. cambogia (Gaetn) Desr. (G. gummi-gutta (L). Robsmall)	Western Ghats, Maharashtra, Goa, Karnataka, Kerala, Shola forests of Nilgiris.
G. hanburyii Hook.	South India
G. imbertti Bourd	S. India
G. malabarica Talbot	S. India
G. morella Desr.	Assam, Khasi Hills, Western Ghats
G. spitcata Hook. [*G. ovalifolia* Hook. f.]	Western Ghats form Konkan Southwards
G. succifolia Kurz	S. India
G. travancorica Beddome	Western Ghats
G. wightii T. Anders.	S. Indian Forests
G. xanthochymus Hook. [*G. tinctoria* Wight *G. pictorius* Roxb.]	Eastern Himalayas, Western Ghats, Andaman islands, Assam and Meghalaya

Many species are threatened due to habitat destruction as is the case with *G. cadelliana* from South Andaman which is almost extinct. Little attention has been given to document and conserve the other economically important species of this genus

Nutmeg

Nutmeg is indigenous to the Moluccas islands in Indonesia ,introduced to India during the 18 thcentury by the British East India Company. Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice, yielding two spices, namely, the nutmeg (dried seed) and the mace (dried aril surrounding the seed). It is an evergreen, conical tree reaching a height of 10 metres, belonging to the family Myristicaceae.

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

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

The Western Ghats have three genera and five species of Myristicaceae; all of them are trees associated with evergreen to semi-evergreen forests. Of these *Gymnacrantheracanarica*and *Myristicafatua*var. *magnifica*are exclusive to the swamps. *M. malabarica*is occasional in the swamps and more frequent in the evergreen forests. *M. malabarica*, often produce stilt roots and flying buttresses, even though it is seldom associated with swamps, indicating its possible origin in the swamps. Myristicaceae was the most dominant family of the swamps forming 32% of the total number of trees.

M. fragrans is typically dioecious, with male and female flowers on different trees. Occasionally, male trees carrying a few female flowers are observed. However monoecioes plants have been recently reported from the Uttarakannada and Shimoga districts of Karnataka (Rema*et al* 2014). Unique mutants with yellow mace and kernelless nutmeg are also observed in the primary genepool of the tree.

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

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

Curry leaf

Curry leaf (*Murraya koenigii* Spreng.) is a perrnenial leafy tree spice. Curry leaf belongs to the family Rutaceace and is named after 'Murraya' after John Adam Murray, Professor of botany at Göttingen and editor of many Linnaeus's works. Curry leaf is found distributed throughout India upto an elevation of 1500 m. Curry leaf is an aromatic deciduous tree which grows about 5 m tall and 15-45 cm in diameter. Although the curry leaf plant is found in the wild, it is also widely cultivated for its aromatic leaves. It is mainly grown in homesteads, but widely cultivated commercially in Tamil Nadu and other states.

Tamarind

Tamarind (*Tamarindus indica* L.Fabaceae) is one of the important tree spices in India. It is a monotypic genus indigenous to Tropical Africa and growing widely in sub-tropical regions of India. Tamarind fruit is a rich source of tartaric acid and ascorbic acid. It is one of the common and important spices used in many of the Indian culinary preparations. Tamarind is generally propagated through seeds but air layering is reported to be successful up to 90%. TNAU has released a high yielding early bearing line PKM-1. It has got 39% pulp recovery and yields 260 kg ripe fruits/ tree.

Conservation and dissemination

Most of the above tree spices are conserved in the farmers' homesteads /estates besides their wild relatives under *in-situ* conditions in the Western Ghats forests.Though vegetative propagules form the major dissemination methods,the seeds are also occasionally used for propagating the spices.Most of the species produce fleshy fruits which attracts vertebrates like birds and small mammals. Malabar hornbills and bats,though pests, are helping in disseminations of the seeds albeit by default.Squirrels,monkeys and Malabar Civet also devour the fruits and disperse the seed.

Conclusion

Tree spices, as individual crop,are blessed with many potential pharmaceutical and ethno botanical attributes.While myristicinand elimicin in nutmeg are credited with anticancerous,anti-inflammatory properties,*Garcinia* has immense anti-obesity value.Cinnamon is at present amuch sought after commodity for avariety of ailments such as arthritis,diabetes,impotency,besides its cosmetic use. Though as a horticultural cropthe planters get reasonably good price for these crops,a pricing system based on the value added components of these commodity may augment their income further besides expanding the production.

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SESSION II

GENETIC RESOURCES, DIVERSITY, CONSERVATION AND UTILIZATION

LEAD PAPERS AND ABSTRACTS

Utilization of horticultural diversity for improvement

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India is endowed with varied agro climatic conditions, which are congenial for growing a wide range of horticultural crops. Almost all types of horticulture crops can be grown in one or the other region of the country. One hundred and ninety species of economically important crops have been listed out comprising 109 fruits, 54 vegetables and 27 species of spices and condiments, among others. India is the largest producer of fruits and vegetables in the world. Horticultural crops have attained 50% growth in production during the past 10-15 years. These crops form as a subset of agro-biodiversity, which include horticultural plant species or their wild gene pool, having genetic material of actual or potential value. The Horticultural Genetic Resources also include improved and obsolete varieties, populations, landraces, genetic stocks and breeding materials of crop plants and their wild relatives. Among horticultural genetic resources, landraces and populations are heterogenous group of plants, which are able to survive and sustain under varying agro climatic conditions. However, introduction of improved varieties over a period of time has replaced innumerable local varieties and landraces, which result in genetic erosion and genetic vulnerability to biotic and abiotic stresses, leading to crop losses. For example, high-yielding and yellow-vein mosaic resistant okra 'Pusa Sawani' has replaced most of the local landraces in India. Hence, cultivar replacement is considered to be one of the main causes of genetic erosion.

Origin of horticultural crops in India

India is the centre of diversity for many horticultural crops (Table 1), which were shown to have all kinds of endemic varieties, alleles and even, Linnean species. Moreover, these centres are characterized by repository of dominant genes and recessive genes in the periphery. Among horticultural crops, most of the main fruits and vegetables originated from the Near-Eastern Asia, Central Asia and Mediterranean centres, while root and tuber crops and tropical fruit trees are from the Central American and Andean centres. India is known as the land of spices, being the origin of black pepper and cardamom and also for ginger, turmeric, *Garcinia* and *Myristica* with maximum diversity. GIS is a wonderful tool available now for locating species diversity. Rich diversity also occurs in India for medicinal and aromatic plants and traditional knowledge associated with their uses, particularly in the Western Ghats and North-Eastern region. Besides, Indian subcontinent is rich repository for ornamental trees, shrubs, climbers, herbs and succulents. Wild relatives are also available in plenty in the rain forest habitats. These wild relatives and cultivated genetic resources are being maintained in the national repositories identified by ICAR in various national institutes (Table 2).

Genetic enhancement

The use of plant genetic resources in crop improvement, followed by adoption, cultivation and consumption or marketing of the improved cultivars by farmers, is one of the most sustainable methods to conserve valuable genetic resources (Haussmann et al. 2004). 1,530 improved high-yielding, high quality coupled with disease and peat resistance varieties and hybrids have been released by various institutes/ universities for cultivation in diverse agro climatic conditions of the country (Singh et al. 2009). As a result, productivity of banana and potato has gone up three times each and cassava two times. In the last 4 years itself, the country has recorded 8% increase in potato production. Regular-bearing mango hybrid, export quality grapes, multi-disease resistant vegetable hybrids, high-value spices and tuber crops of industrial uses have been developed. Tomato varieties resistant to tomato leaf curl virus, bacterial wilt and *Fusarium* wilt have been developed. Improved varieties have revolutionized the Horticulture sector. For instance, high-yielding Gauri, Sankar and Sree Bhadra sweet potatoes have brought a revolution by minimizing malnutrition, improving nutritional security in the Kandhamala district in Orissa (Singh et al. 2009). In an interesting article , Hajjar and Hodgkin (2007) detail the achievements on the use of wild relatives in crop improvement.

One of the areas where the use wild relatives have been successfully used is in the breeding for resistance to pests and abiotic factors. A large number of vegetable crops have been developed in India using wild relatives. In perennial crops the resistant wild relatives are used as root stocks such as *C.volkameriana* in Citrus and *Piper colubrinum* in Black pepper against Phytophthora.

Table 1. Primary centre of Origin of horticultural crops in India

Fruits	Mango, Citrus, Jack fruit, Bael, Aonla, Ber, Khejri, Jamun, Tamarind, Phalsa, Lasora, Karonda, Wood Apple, Pilu, Bilimbi, Garcinia
Vegetables	Brinjal, Smooth guard, Ridge guard, Cucumber, Parwal, Amaranthus, Basella, Sword bean, Winged bean, Kundru, Dolichos bean, Indian lettuce, Drumstick
Ornamentals	Orchids, Rhododendrons, Mask Rose, Begonia, Balsam, Globe Amaranth, Glory lily, Foxtail lily, Primula, Blue poppy, Lotus, Water lily, Clematis, Tulip
Spices and Plantation Crops	Black Pepper, Greater Galanga, Bengal cardamom, Anethum Sowa, Ajowain, Cinnamon, Cumin, *Curcuma* spp., Curry leaf, Long pepper, Betel vine, Long pepper, Ginger, Indian Cinnamon, Indian Tamarind, Kokum &Tamarind
Tuber Crops	Greater Yam, Lesser Yam, Potato Yam, Elephant foot Yam, Yam Bean, Winged Bean, Alocasia, Giant Taro, Colocasia

Medicinal and Aromatic Plants	Muskdana, Belladonna, Jamalgota, Malabar Grass, Rosha Grass, Citronella Grass, Lemon Grass, Datura, Puskarmul, Jasmine, Saya, Isabgol, Patchouli, Sarpagandha, Sandal wood, Costus, Nuxvomica, Indian Almond, Vetiver, Kutaki, Ban-kakri, Asparagus, Atees, Vatsnabh, Indian Ginseng, Ashoka, Arjuna, Bijayasal, Kurchi, Neem, Guruchi, Lodhara

Source: Country report on the State of Plant Genetic Resources for Food and Agriculture (1996-2006), NBPGR, New Delhi, India

Table 2. Genetic Resources of Horticultural Crops in Horticultural Institutes

Crop	**No. of Accessions**
Fruits	5,980
Vegetables	18,480
Flowers	2,743
Spices and Plantation Crops	8,196
Medicinal and Aromatic Plants	709
Total	36,108

Source: Singh et al. 2009

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Plant genetic resources of underutilized arid fruits

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India is home of variety of underutilized fruits commonly found in semi arid and arid regions which includes *ber, bael, aonla,* fig,*lasoda ,Karonda phalsa, ker and khejri* (Dhillon and Saxena,2005). A wide range of genetic variability is available in underutilized arid fruit crops which are mainly grown in arid and semi arid parts of the country. This genetic variability can be effectively utilized for the development of desired varieties in fruit crops as limited work has been done on arid fruit crops, which are perennial in nature (More and Singh, 2008). The common objectives in crop improvement of arid zone fruits till now have been to improve the quality attributes and appearance of fruits in addition to fruit yield. The other important objectives in breeding of arid fruit crops includes the development of varieties / rootstocks, which perform well even under extremes of temperature regimes and can withstand water stress or have low water requirement, besides tolerance for other abiotic and biotic stresses.

Even though, planned hybridization and clonal selection have been attempted in a number of fruit crops and these efforts have resulted in the development of promising varieties, clonal selection using variability from spontaneous mutations or selecting plants derived from natural hybridization still remains a major tool of improvement. Recently molecular and biotechnological approaches such as somaclonal variation, gene transformation or protoplast technology provide the scope for making significant changes to varieties, but less progress has been made in the arid zone fruit crops (Singh *et al*, 2012). However, systematic and dedicated efforts are still required for the development of ideal varieties through modern tools in arid fruit crops (Shukla *et al*, 2011).

To harness genetic variability for varietal improvement of arid fruit crops such as *ber*, pomegranate, *bael*, *aonla*, custard apple, date palm, *phalsa*, *lasoda*, wood apple, tamarind and fig, it is imperative to build a rich germplasm bank. The Central Institute for Arid Horticulture, Bikaner, Rajasthan ever since its inception is striding forward in this direction and has one of the richest germplasm pool of underutilized arid fruits. Besides, it has also been recognized as National Active Germplasm Site (NAGS) for arid fruits. Status of germplasm of arid fruits at CIAH has been presented in Table 1.

Table 1. Status of Germplasm of Arid fruits at National Active Germplasm Site (NAGS).

CIAH, Bikaner			**CHES, Godhra**		
Name	**Scientific name**	**No.**	**Name**	**Scientific name**	**No.**
Ber	*Ziziphus mauritiana*	318	Ber	*Ziziphus mauritiana*	55
Bordi	*Z. rotundifolia*	22	Custard apple	*Annona squamosa*	09
Pomegranate	*Punica granatum*	150	Pomegranate	Punica granatum	45

Aonla	*Emblica officinalis*	10	Aonla	*Emblica officinalis*	14
Date palm	*Phoenix dactylifera*	60	Sapota	*Achras zapota*	07
Bael	*Aegle marmelos*	17	Bael	*Aegle marmelos*	40
Jamun	*Syzigium cuminii*	02	Jamun	*Syzigium cuminii*	50
Cactus pear	*Opuntia ficus indica*	20	Tamarind	*Tamarindicus indica*	25
Phalsa	*Grewia subinaequalis*	06	Phalsa	*Grewia subinaequalis*	02
Fig	*Ficus carica*	03	Fig	*Ficus indica*	05
Mulberry	*Morus spp.*	15	Mango	*Mangifera indica*	52
Marula nut	*Sclerocarya birrea*	01	Wood apple	*Feronia limonia*	10
Sweet orange	*Citrus sinensis*	03	Karonda	*Carissa carandus*	40
Karonda	*Carissa carandus*	08	Mahua	*Madhuca latifolia*	50
Lasora	*Cordia myxa*	65	Chironji	*Buchanania lanzen*	30
Pilu	*Salvadora spp.*	02	Khirni	*Manilkara hexandra*	30
Ker	*Capparis decidua*	06			
Manila tamarind	*Pithocelobium dulce)*	03			

Conservation and Management of Genetic Resources of arid fruits

There are two principal methods of germplasm conservation, which are referred as '*insitu*' and'*exsitu*' conservation approach. *In situ* refers to maintaining plants in their original habitat for instance at farmers' fields (also known as on-farm conservation), while ex situ conservation imply maintaining plants outside their original habitats under facilities like genebanks, field gene banks/ NAGS or botanical gardens. Experience shows that diversity is only secure when diverse conservation strategies are employed. *Ex situ* and *in situ* approaches are not mutually exclusive; no single method of conservation is optimal for all situations, and no single method can succeed alone. Different conservation systems can complement each other and provide insurance against the shortcomings of any one method. Germplasm of arid fruits have been collected and conserved in field gene banks at AICRP on AZF centres located in different parts of country (Dhandar and Singh, 2004). However in this paper, emphasis has been made primarily on *ex situ* approaches as documentation is available on the status of *in situ* germplasm conservation in arid fruit crops.

List of some important underutilized arid fruit crops along with their salient feature(s) has been provided in Table 2.

Table 2. Some important varieties of arid fruit crops.

Name of Variety	Parentage in case of hybrids	Released from	Specific Characters
Ber/JujubeZizipus Mauritiana Lamk.Family : Rhamnaceae			
Goma Kirti (1997)	Clonal selection of Umran	CHES, Godhra	Highly yielder and early maturing variety. Resistant to various diseases and pests by virtue of its earliness.
Thar Sevika (2006)	Hybrid between Seb x Katha	CIAH, Bikaner	An early maturing variety. The fruits are juicy, sweet with a TSS content of 22-24%. Fruits after consumption do not cause throat soaring, which is common in other cultivars. Average fruit yield is 30-32 Kg/tree. Also suitable for staggered picking which can be done up to third week of January.
Thar Bhubhraj (2007)	A selection from local material of Bhusavar area of Bharatpur district of Rajasthan	CIAH, Bikaner	An early maturing cultivar having an average yield potential of 30-36 kg/tree. The fruits are ready for harvesting during last week of December-First week of January. The fruits are very juicy, sweet with a TSS content of 22-23%.
Narendra Ber -1*	Selection	NDUAT, Faizabad	Trees are spreading type, heavy yielder, fruits are round to oblong, yellowish green in colour.
Narendra Ber - 2*	Selection	NDUAT, Faizabad	Trees are medium in height, semi spreading, fruits are obviate with yellowish green skin.
Aonla*Emblica officinalis* Gaertn.Family: Euphorbiaceae			
Goma Aishwariya (2006) (CHES Sel.1)	A clonal selection of NA-7	CHES, Godhra	An early and drought tolerant variety. The average yield potential is 102.9 kg/tree. It has low fiber content and is suitable for processing and export.

BaelAegle marmelos **(L.) Corr. Serr.Family : Rutaceae**			
Narendra Bael (NB)-4	Selection	NDUAT, Faizabad	Trees are spreading and fruits are oblong in shape, fruit quality excellent and heavy bearer.
Narendra Bael (NB)-5	Selection	NDUAT, Faizabad	Prolific bearer and fruits are medium in size, round with thin skull, low fibre and seed content.
Narendra Bael (NB)-7	Selection	NDUAT, Faizabad	Fruits are very large in size, flattened round, yellowish green in colour.
Narendra Bael (NB)-9	Selection	NDUAT, Faizabad	Prolific bearing, fuits are medium to large size with oblong in shape, low fibre and seed content.
Narendra Bael (NB)-16	Selection	NDUAT, Faizabad	Fruits are elliptical round, pulp yellow, average weight 1.3 kg, T.S.S. 31%, and low fibre content.
Narendra Bael (NB)-17*	Selection	NDUAT, Faizabad	Fruits are attractive, average weight 1.75 kg, fibre content low.
CISH B-1	Selection	CISH, Lucknow	It is a mid season variety which matures during April-May. Trees are tall, vigorous with dense canopy, erect growth habit, precocious and heavy bearer. Fruit shape is oval to oblong. Average fruit weight 1.0 kg. Suitable for canning and slices preparation.
CISH B-2	Selection	CISH, Lucknow	Trees are dwarf with medium spreading habit. Foliage is sparse and almost thornless, precocious with moderate bearing habit. Fruits are oblong to round in shape. Suitable for processing with pleasantly aromatic pulp.
Goma Yashi	Selection	CHES, Godhra	Good quality fruits with large in size. Ovate in shape, greenish yellow in colour. Flesh colour is straw.
Pant Aparna	Selection	GBPUAT, Pantnagar	Its trees are dwarf with drooping foliage, almost thornless, precocious and heavy bearer. The leaves are large, dark green and pear shaped. Fruits are globose in shape with average weight 1.0 kg.

Pant Shivani	Selection	GBPUAT, Pantnagar	It is an early mid season variety. Trees are tall, vigorous, dense, upright growth, precocious and heavy bearer. Fruit weight range from 2 to 2.5 kg.
Pant Sujata	Selection	GBPUAT, Pantnagar	Trees are medium dwarf with drooping and spreading foliage, dense, precocious and heavy bearer. Fruit weight varied from 1 to 1.5 kg.
Pant Urvashi	Selection	GBPUAT, Pantnagar	It is mid season variety. Trees are tall, vigorous, dense, upright growth, precocious and heavy bearer. Fruits are ovoid, oblong. The fruit weight range from 1.5 to 2.5 kg.
Custard Apple*Annona squamosa* L.Family: Annonaceae			
Arka Sahan	Island gem (*Annona atemoya* Hort.) X Mammoth (*A. squomosa* L.)	IIHR, Bangalore	Fruits are light green in colour, moderately thick (0.5 cm) with large, flat eyes. The edible pulp is remarkable for its sweetness with 22.8% total sugars.
Balanagar	Selection	Selected near Hyderabad	Fruits are very large and heart shaped, very good pulp and heavy bearer.
APK (Ca) 1 (2003)	Selection	TNAU, (ARS), Aruppukottai	It bears higher yield in rainfed vertisol (black soil). It is a drought tolerant variety which bears sweet fruits (TSS of 24.5 Brix with an acidity of 0.2 per cent). The Fruit weigh ranges about 207.5 g with a mean of 72 fruits per tree per year. The first bearing commences in a graft/budded plant at 3-3 ½ years. The Optimum productive life is 25 yrs. The best season for planting is May – June / August – September. It yields about 7300 kg fruits / ha (14.90 kg / tree which is 30.7 per cent higher than Balanagar). It is suitable for cultivation in plains of Tamil Nadu especially in semi arid regions and marginal soils of both vertisol and alfisol in dry tracts. It is suitable for both rainfed and irrigated conditions.

Fig *Ficus carica* L.Family: Moraceae			
YCD.1 Timla Fig	Introduction	HRS, TNAU, Yercaud	The trees are well adapted to the rainfed situations of Shevroys hills and to the poor shallow and rocky soils. The trees showed high drought tolerance; besides, it is exceptionally hardy nature and free from any pest or disease including the common fig rust.
***KarondaCarissa carandas* L.Family : Apocynaceae**			
Pant Suvarna (1986)	Selection	GBPUAT, Pantnagar	Plant upright growing & sparse, fruit size 2.16 × 1.66 cm, colour dark brown at ripening.
Pant Manohar (1991)	Selection	GBPUAT, Pantnagar	Medium sized, dense bushes, fruit size 2.13 × 1.69 cm, flesh 88.27 %, TSS 3.92%, acidity 1.82%, dark brown colour
Pant Sudarshan (1991)	Selection	GBPUAT, Pantnagar	Fruit size 2.16 × 1.69 cm, colour dark brown, flesh 88.47%, TSS 3.45%, acidity 1.89 %.
Tamarind *Tamarindus indica* L.Family: Leguminosae			
PKM 1 (1997)	Clonal selection from local type Endapuli	TNAU, Periyakulam	High yielder, bears fruits in clusters (37), fruits are characteristically semi circle in shape, high pulp recovery (39%) with high tartaric acid and ascorbic acid content.
DTS-1 (2005)	Clonal selection	UAS, Dharwad	High yield potential and starts bearing within 5 to 6 years of planting.
Akola Smruti (AKT-10) (2010)	Selection	PDKV, Akola	Regular bearing, slightly curving fruits, very negligible incidence of fruit borer.
Urigam	Selection	Local genotype selected from Dharmpuri district in Tamilnadu	Short in size. Pods are lengthy, fleshy and tasty. Pods are flat and exhibit a typical inward curvature. Average fruit weight is between 150-200g. Seed content varies from 10-12/pod.
Prathisthan	Selection	FRS, Aurangabad	High Yielder.
Yogeshwari	Selection	Forest Department, Karnataka	Red pulp.

Pomegranate*Punica granatum* L.F: Punicaceae			
Goma Khatta	Selection	CHES, Godhra, Gujarat	Suitable for *anardana* purpose. The yield potential is 6.59 kg/plant and *anardana* yield is 1.18 kg/plant. Seeds hardiness is medium. Fruit having 46.7% of Juice and TSS is 14.5^{0}Brix. Acidity is 7.3% (More *et al*, 2008).

* Varieties identified in National Workshops/Group Meetings of AICRP's.

Ber (*Ziziphus mauritiana* Lamk.)

The genetic diversity exits in *ber* growing areas of the country and it should be exploited for different traits. Maximum variability in *ber* is available in dry parts of country as well as desert. Several *ber* germplasm including species, cultivars and other types have also been collected at different Research stations in the country and are being maintained in the field gene banks. Among various field gene bank centres, CIAH, Bikaner; NBPGR, Jodhpur; MPKV, Rahuri; CCS HAU, Hisar; CAZRI, Jodhpur, Regional Station, PAU, Bahadurgarh, SDAU, S.K. Nagar are important centres . At CIAH, Bikaner highest collections (318) have been made in the National Field Repository. A large number of cultivars (> 150) are in cultivation in India. In India, a number of varieties have been developed and released through selection methods**.** Most of the common cultivars are the result of selection made by local people in different regions of the country. The promising cultivar under commercial cultivations are Gola, Seb, Banarsi Karaka, Banarsi Pebandi, Kaithali, ZG-1, Sanaur-1, 2, 3, 4, Katha, Umran, Mundia, Chonchal, Illaichi, Rashmi, etc. (Shukla *etal,* 2011). B.S.75-1 variety of *ber* has been developed from CCS HAU, RRS, Bawal which is resistant against fruit fly and powdery mildew. Hybridization work is going on in *ber* at HAU, RRS, Bawal and highest fruit yield was obtained in Hybrid-1 (64.7 kg/tree) and incidence of powdery mildew was negligible followed by Hybrid-10 (63.7 kg per tree) (Anon., 2011).

Narendra *Ber* Selection-1 has been released from NDUA&T, Faizabad and it is performing well under climatic conditions in Eastern UP (Anon, 2011). The new promising *ber* varieties such as Thar Sevika and Thar Bhubharaj developed by CIAH, Bikaner for cultivation in arid conditions has been released (Shukla *et al.,* 2004).

Pomegranate (*Punica granatum*)

Though it is a commercial crop, its strain which produces sour fruits and used widely as an acidulant, has not received much attention. The sour type pomegranate is utilized for *anardana* purpose. It has potential to exploit for further improvement. A rich genetic diversity has been observed in foot hills in Himachal Pradesh (Singh and Singh, 2006). In Himachal Pradesh, a sour pomegranate-'*Daru*', comes abundantly in wild. This is used mostly in the preparation of *anardana*, an acidulant product used in the culinary preparation. 'Amlidana' is a F_1 hybrid variety suitable for *anardana* production was developed at IIHR, Bangalore. Amlidana is an F_1 hybrid (Ganesh x Nana). It grows well under tropical climate with quality fruit attributes Amlidana is superior to sour variety *Daru*, whose trees come up naturally in temperate region of north India. Its fruits provide more acidic (16.18%) *anardana* and higher fruit yield/ tree. In addition, short-statured trees are suitable for high-density planting, giving increase fruit yield/ unit area (Jalikop *et. al*., 2002). Under evaluation of germplasm, Amlidana was found suitable for hot arid region for *anardana* purpose (Singh *et al*, 2011a).

When the breeding objective is for disease resistance, like bacterial blight, the progeny should be screened both in the nursery and in field and the resistant types are selected which often require further improvement for fruit traits. Currently two sources of resistance for blight viz., '*Daru*'- a wild sour pomegranate, and '*Nana*' - an ornamental *bonsai* like type have been recognized. If such non-cultivated types are involved in the breeding work, in order to eliminate several undesirable traits, one has to go for repeated backcrosses by making selection in each generation. Once the superior selections are made, they have to be multiplied by air layering and tested against appropriate ruling varieties in a replicated trail before identifying for release. Multi-location evaluation is preferred. Screening of 52 hybrids is in progress. All genotypes were produced sweet arils and low acidic fruits.

Bael (*Aegle marmelos* Correa.)

Bael plant is found growing naturally in Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Orissa, West Bengal and Chhattisgarh with large genetic variability, which should be exploited. In Uttar Pradesh, Deoria, Basti, Gorakhpur, Gonda, Faizabad, Sultanpur, Jaunpur, Pratapgarh, Mirzapur, Allahabad, Lucknow, Etawah, Agra, etc. are the districts where large number of promising genotypes are either growing naturally or planted near the houses. There is a fast genetic erosion in wild *bael* genotypes, therefore, its conservation has become necessary (Srivastava *et al*., 1998). Rai *et al.* (1991) reported vivid account of *bael* genetic diversity available in India. The variability in *bael* germplasm was observed in identified types at different locations (Rai *et al*., 1991). Apart from the tree morphological characters, wide variability exists in fruit size and shape, bearing habit, flesh colour, texture, fibre content, sugar content, mucilage content, etc in different parts of country(Singh *et al*,2009; Vishalnath *et al*,2003). In Jaunpur area of UP, very old naturally growing bael plants are available. Some types have more number of seeds, gum locules and thick pericarp (Misra *et al*., 2000). However, some selections have been made at NDUA&T, Faizabad and GBPUA&T , Pantnagar and CISH, Lucknow, which are gaining popularity for commercial cultivation. At Central Institute for Arid Horticulture, Bikaner also collection of *bael* germplasm has been done, which are under evaluation. Besides this, some germplasm were also collected from nursery/farmers' field and maintained in the field repository at CAZRI, Jodhpur; CISH, Lucknow, CCS HAU, RRS , Bawal; NDUAT, Faizabad, GBPUAT, Pant nagar and TNAU, Aruppokottai for conservation and evaluation. Lal (2002) evaluated 12 genotypes collected from Jaipur (Rajasthan) and found that 8 genotypes produce fruits of excellent quality under semi-arid conditions. In Chomu area of Jaipur, fruit sample from seedling plants were collected during 2009. Variation was observed in fruiting, size, quality of fruits and two genotypes were identified. Fruit cracking was also observed in *bael* trees grown in Sikar district.

Recently *bael* NB-16 and NB-17 from NDUA&T, Faizabad and CISH B-1 and CISH B-2 from CISH, Lucknow has been released for commercial production. Pant Aparna, Pant Sujata, Pant Urvashi and Pant Shivani have been developed from G.B. Pant University of Ag. & Tech. Pantnagar (Singh *et. al.,* 2011) and are suitable for commercial cultivation in different parts of country.

Aonla (*Emblica officinalis* Gartn.)

Aonla is medicinal fruit tree and generally growing in the forests and also cultivated in systemic manner. A number of *aonla* variety series like NA-6, NA-7,NA-9, NA-10 have been developed from NDUA&T, Faizabad; Annad *Aonla*-1,*Aonla*-2, from AAU, Anand, and CISH, Lucknow. Laxmi-52 *aonla* is a selection and recently released from CISH, Lucknow. The genetic diversity of wild grown *aonla* is found in forests throughout the country which are still unexploited for their commercial utilization and conservation. It is a salinity and drought tolerant plant but susceptible to low temperature in arid region. Fruit is used for making several ayurvedic medicines and for making value added products such as squash, juice, candy, preserve, sweets, mouth freshener,etc.. Very little efforts have been made to collect vast variability for valuable traits like bearing potential, nutritional and medicinal value, insects & disease resistance, frost tolerance, etc. Almost all varieties are developed through selection methods in *Aonla* (Mehta and Singh, 2003). Recently, a selection from plus tree, Goma Aishwariya an early, drought tolerant variety has been released from CHES, Godhra. (More *et al,* 2008). *Aonla* BSR-1 small sized fruit, good bearer, reddish colour fruit, has been released from TNAU, Coimbatore. In *aonla*, the major problem is of frost/ low temperature and there are no varieties available to tackle this problem especially in hot arid region. Development of suitable genotypes of frost resistant is required.

Annona fruits

Annona is one of the 40 genera of Annonacae family. It has 120 species, 5 of them have pomological significance. Among the edible *Annonas*, cherimoya (*Annona cherimola*.), sugar apple (*A. squamosa*) and the hybrid between the two, atemoya, are most popular. The other less important edible *Annona* species are *A. reticulata* L. (Bullock's Heart),*A. diversifolia* (Ilama) and *A. muricata* (sour *spp*). The edible *Annonas* species differ for fruit traits and are amenable for genetic manipulation, as they cross with each other easily. Each species can benefit from the other edible *Annonas* for one or the other specific fruit and/or plant traits and hybridizing them should generate useful recombinants as illustrated by the popular *atemoya*.

Among the annonaceous fruits, sugar apple, locally called *sitaphal* or *sharifa* is by far the most relished and widely consumed fruit of India. Most of the *Annona* varieties in cultivation were often developed by clonal or seedling selection by mainly exploiting the intra species variability. Sugar apple plants come in wild abundantly in the vast arid tracts of the country. There are few varieties like Balanagar, Red Sitaphal, Local Sitaphal, British Guinea, Mammoth and Washington. Presence of several big seeds and poor shelf life are the major constraints limiting cultivation of *sitaphal* fruit on a commercial scale.

Inter-specific hybridization

Evolving *Annona* hybrids is primarily same as described for pomegranate, only care necessary is that the hybrid seeds have to be stratified by keeping under running water for about 48 hours for better seed germination. *Annona* breeding was initiated at Indian Institute of Horticultural Research, Bangalore, several intra- and inter-specific hybrids were produced and evaluated, which resulted in isolation of variety 'Arka Sahan' from the cross atemoya (cv. Island Gem) x Sugar Apple (cv. Mammoth). This exemplifies the use of allied species in breeding of arid fruits, if the traits of interest are not detected in the same species. Hybridization work is also being done in Custard apple at MPKV, Rahuri and Hybrid No. -6, Hybrid No.-13 and Hybrid No.-22 have been found promising. Hybrid No.- 13 has bigger fruit size and less seed percentage (7.02%) and TSS 26% with higher yield (12.3kg/plant) than other hybrids.

Date palm (*Phoenix dactylifera* L.)

A rich genetic diversity is available in costal belt of Kachchh region, Gujarat in India which should be exploited (Singh *et al*., 2009). In other parts of country, seedlings are growing in meagre population. At CIAH, Bikaner, 60 genotypes/ cultivars have been conserved in National field gene bank collected from different available sources as well as introduced from abroad. Further, SDAU, DRS, Mundra, (Gujarat); CAZRI, Jodhpur, SKRAU, Bikaner, PAU, RFRS, Abohar, (Punjab); Central State Farm, Jetsar, Sri Ganganagar, has also maintained and evaluated the date palm germplasm. There is no hybrid reported in date palm so far. Further, no breeding work has so far been taken up on date palm in India except evaluation of cultivars/genotypes against rain damage and selection of some promising female seedlings from the Kachchh region of Gujarat. Most of the cultivars of date palm have introduced from different countries from time to time e.g. Halawy, Barhee, Medjool, Khalas, Sayar, Zahidi (USA), Khadrawy (Iraq), Barshi , Khuneizi, Nagal, Khashab (Oman), Hatemi, Tayar, Ruziz (Saudi Arabia), Amri, Sakloti, Agloni, , Chipchap and Braim (Iraq) during 1998. Sewi and Amhat (Egypt) during the year 2009. Both cultivars have established well under field conditions.

All the commercial date cultivars have developed through selection of chance seedlings based on local needs. From the rich genetic diversity of nearly 1.66 million palms developed from seeds in the coastal belt of Kachchh region of Gujarat, 20 promising palms have been selected, most of which yield non-astringent fruits at doka stage (Muralidharan *et al,* 2008). One of them bears coconut shape fruit. These selections flower twice in a year. An early ripening date seedling has been identified at Abohar.

At Abohar, Zahidi cultivar has been found to be resistant to rain damage; Barhee is more tolerant than Shamran. It was also found that Medjool is resistant to rain damage, as it missed rains during fruit ripening,which is alate maturing cultivar. A large number of varieties and some promising selections (Sel. - 9, Sel.-13, Yaqubi, Kotho, Trofo, Gulchati, Bhugoso, Madhepura, Khedoi-7, Sopari, Saidy,) have been made in our country from natural populations existing in Kachchh region. Some selections have also been made by the farmers of the region (Muralidharan *et al.,*2008). Further, these yellow and red berry colour types are suitable for making different processed products (Singh *et al,* 2011).An elite type of green colour, sweet berry at doka stage has been identified from seedlings population in Kachchh region of Gujarat.

Fig (*Ficus carica* L.)

Poona Fig is the most popular cultivar in our country. The varieties Bangalore, Bellary, Coimbatore, Daulatabad, Dindigul, Ganjam, Hindupur, Lucknow and Saharanapur have clearly acquired the names from the locations in which they are grown. Since, these varieties resemble cv. Poona Fig in plant and fruit morphology, they are possibly clones or ecotypes of cv. Poona Fig and hardly warrant varietal status. Dinkar, an improvement over cv. Daulatabad for yield and quality is a recently identified variety, both of which resemble Poona Fig variety in fruit characteristics. The other varieties Black Ischia, Shahi, and Maisram are yet to achieve prominence. As many as 700 varieties of fig are known in the world and there is good scope to introduce, evaluate and popularise the exotic fig varieties in our country. Recently some promising types have identified.

Three exotic varieties viz., Deanna, Conadria and Excel were found promising. All the exotic types are early, and like Indian edible figs, fruit develop syconia parthenocarpically *i.e.,* without the interference of fig wasp, which assists pollination in several edible and non-edible types. The eye or ostiole of fruits of cv. Poona Fig is loose which facilitates easy access to pulp for insects and fungi. Thus the ripe fruits spoil quickly and the fruits split open at the ostiole. However, the tight eye of Conadria and Excel protect the fruit from spoilage and splitting (Anon, 2011).

Lasoda (*Cordia myxa* Roxb.)

It is known as Indian cherry, *lehsua* or *goonda*. The other important species are *C. gharaf*, (goondi), *C. rothii, C. macleodii, C. vestita* and *C. wallichii* (Yadav and Goel 2006). Out of these, goondi (*Cordia gharaf*) is a popularly grown species (Pundhir, 1987; Singh *et al,* 1996). Great variation exist in natural population with respect to morphological characters particularly plant height, spread, leaf size, fruit size; fruiting behaviour; quality parameters like fruit colour, pulp content, pickling quality, seed and pulp ratio etc. (Singh and Vishwanath, 1991).

The proper efforts have not been done to exploit genetic diversity of *lasoda* trees. However, in the recent past some efforts have been made by NBPGR Regional Station, Jodhpur and Central Institute for Arid Horticulture, Bikaner to identify some big fruited types with high productivity. At CCS HAU., Hisar, different genotype was evaluated by Saini *et al.* (2002) and they have reported variability in plant height and spread. Kaushik and Dwivedi (2004) reported wide range of biodiversity in morphological and quality characters from 45 collection of *lasoda* from Haryana.

There is no named or improved cultivar in *lasoda*. In general, two types of plants viz., large fruited and small-fruited are found growing and are sold by nurserymen. Large fruited cultivars have an average fruit weight of 8.55 g, whereas small-fruited cultivars have fruit weight of 3.0 g. In case of large fruited cultivars, fruit have comparatively more pulp thickness and therefore are suitable for consumption. A large fruited types in Gujarat also recognized as 'Paras Gonda', is a general term for any fruit variety with big size fruits. Similarly in Rajasthan 'Puskar Local' is of big size with good fruit shape. At CIAH, Bikaner under *ex-situ* conservation, 65 types of *lasoda* have been collected and planted under field conditions to identify promising types. One promising type of *lasoda* has been identified. CIAH Selection 1 is performing well under irrigated hot arid ecosystem with respect to fruit size, pulp content and productivity. The average annual production of tender fruit is more than 100 kg tree (Vishalnath *et al.,* 2008). However, plants are susceptible to frost/very low temperature during winter season.

Phalsa (Grewia subinaequalis)

No remarkable variability has been found in *phalsa*except erect and bushy type plant habit. It is mainly grown on boundary of farm and orchards. The genotypes large fruit size with less seeds and high pulp content should be identified and utilized. The fruit is highly perishable and used as fresh as well for processing purposes. There are no known varieties except local types. Its improvement requires varieties with long storability and keeping quality. It is mainly planted in orchards as filler crop and as hedge plants on the boundary. It can be planted at 2-3m distance. Fast growth of plants and regular pruning has good potential for its cultivation. It is pruned from 10cm above ground level every year. Fruit yield is low (2- 4 kg/bush) in comparison to other fruit crops depend on management practices.

Karonda (*Carissa carandus*)

It is one of the few fruits indigenous to India while 30 species of genus *Carissa* have been reported; many species are found growing wildly in India while other species came from Malaysia and South Africa. On the basis of fruit colour, the cultivars of *Karonda* can be classified as: (i) Green fruited, (ii) Pink fruited, and (iii) White fruited. There is a quite resemblance in the shape and size of their fruits. However, there is a tremendous scope for improvement using selection force and vegetative method of propagation. Some promising clones have selected in Maharashtra. These are K_1, K_2, K_3 (Joshi *et al.,* 1986). At MPKV, Rahuri, promising clones as No. 3, 12, 13 and 16, have been identified (Karale *et al.,* 1989). At GBPUAT, Pantnagar, three clones have been selected and named as Pant Manohar, Pant Sudarshan and Pant Suvarna. These varieties are of big fruit size and high yield. It is generally planted on farm/ orchards boundary and it is very important plant for live fencing. It is evergreen shrub or small tree and attain height of 3 to 6 m when allow to grow. The species is thorny bush commonly found in degraded areas and ideal for use in hedges. A promising genotype of *Karonda* (CHES K-1) has identified at CHES, Godhra which is red colour fruit type and high yield potential.

Tamarind (*Tamarindus indica*)

Tamarind (*Tamarindus indica* L.) is an excellent tree for social forestry, agro-forestry, wasteland development and dry land horticulture. There are several types of tamarind. They can be broadly grouped under three types based on fruit size and shape, colour of pulp, taste etc., as follows.Tamarinds in the America are of the shorter type. Paulos (1975) recognized a tamarind type known as "Valakatchi" which bears long and rectangular pods as against some other types, which produce short and cylindrical pods. Karale (1998) reported that tamarind pods vary considerably in size and shape and variability in yield of pods and quality is found. Many are sickle shaped while some have straight long pods (16 to 22 cm) while others were with short pods. Seeds also exhibit a wide range of variation in shape size, colour and the ornamentation of the seed coat.

On the basis of pulp colour

There are two distinct phenotypes of tamarind based on mainly their pulp colour.

1. The yellow or brown pulp type turning dark brown on storage. It is harvested after full maturity.
2. The reddish pulp type is locally known as "Raktichinch". The term red type covers the various shades of pink pulped fruits. The red type is sweeter than brown (common) type because it has lower content of free acids and is generally harvested when fruits are immature and green. It is mostly prefered for making preserves. A high yielding Red type (*Yogeshwari variety*) has been released by Marathwada Agricultural University, Parbhani, Maharashtra.

On the basis of organoleptic taste

The cultivated types could be broadly classified into two groups namely sweet and sour types.

Sweet type: The ripe fruits of this type have sweeter pulp coupled with less acidity and fruits are mainly used for dessert purpose (Karale, 1998). Makham Waan, Secthong breed, Manila sweet are few cultivars found mostly in South East Asia (Thailand). A sweet type viz., No. 263 has been located by MAU, Parbhani.

Sour type: It is highly acidic in taste and pulp is commercially marketed. The tamarind variety `Pratisthan' released by Fruit Research Station, Aurangabad is a sour type and is reported to constitute of 61 per cent pulp, 12 per cent seed and 27 per cent shell. The sour type selections `Urigam' and `Cumbum' (good yielder) are popular in Tamil Nadu. A high yielding sour type PKM-1 (Periyakulam-1) has been released during 1992 from Horticulture Research Station, Periyakulam, Tamil Nadu . This cultivar is preferred for its early bearing habit and claimed to be suitable for high density orcharding (160 plants/acre against 40 plants/acre under conventional planting). Patil *et al,* (1997) reported high yielding elite types DT-1 (500 kg) and DT-28 (450 kg) from University of Agricultural Sciences, Dharwad.

Trees of outstanding merit are to be selected after a thorough survey in the tamarind growing regions. The selected trees should have higher yield potential, excellent fruit quality and better performance for precocious and regular bearing. The fruits should contain thicker pulp with less seeds, yellow or dark red pulp colour with extra white endocarp (locally known as *phool patti*) coupled with high acidity are desirable attributes of tamarind pulp (Karale *et al.*, 1997). The average composition of the pod is 55 per cent pulp, 34 per cent seed and 11 per cent shell and fibre. The selected types should be propagated vegetativly to maintain homogenity in the population and to reduce long juvenile phase and a mother orchard has to be established for preparing planting material.

Estimation of genetic divergence among 282 genotypes at 8 different agro-climatic locations revealed high variability for 18 characters. In all 8 principal components accounted for 80 per cent of the divergence. Pulp yield/tree was the most important character contributing to divergence followed by tartaric acid content. Pulp yield/tree ranged between 14.6 and 99.6 kg/tree while seed yield was 3 to 87.5 kg. The range of tartaric acid was 1 to 17.8 kg/ha.

A promising line have been identified and released at Institute level as Goma Prateek from CHES, Godhara, Gujarat. Fruit yield /plant is 58.5kg during 9th year of fruiting under rainfed conditions.Karale (1998) carried out detailed study on 37 seedling originated genotypes and observed high heterozygosity and large variation with respect to pod shape, size, fruit quality and productivity. Many were sickle shaped while some had straight long pods (16 to 22 cm). The extra white endocarp membrane "*phool patti*" fetches more price and is an important quality character in tamarind trade. Further, he reported that there was not much difference in respect of TSS content of the pulp among the sweet, sour and red types. But the colour of pulp and seed varied among the types and within the types also. The pulp colour varied from reddish brown to different shades of black and sweet types recorded medium values for various physical characters. Based on positive attributes T-1, T-16, T-22, T-26, T-28, T-29 in sour (brown pulp) type, TR-1 in red pulp type and TS-1 and TS-2 in sweet pulp type were selected as elite types.

Wood apple *(Feronia limonia)*

Wood apple (*Feronia limonia* Linn. Swingle), syn. *Limonia acidissima L. Feronia elephantum* Correa, *Schinus limonia* L. belongs to family Rutaceae. Wood apple is also called kainth, monkey fruit, curd fruit and kathabel in India. The wood apple is native to India and common in the wild form in dry plains of India and Ceylon. There are two types of wood apple, one with fruit larger and sweeter than the other and states that the ripe fruit pulp contains 2.3 per cent acid and 7.25 per cent sugars.

The plants growing so far or of seed origin and found to have lot of variability which can be used for making selection of superior types. There are two forms one with large, sweetish fruits and the other with small, acidic fruit. Seven germplasm collected from different places were evaluated at Central Horticultural Experiment Station, Vejalpur (Gujarat). However, at CIAH, Bikaner three genotypes collected from Udaipur, Arrupukottai and Dharwar are being evaluated for growth and flowering in plants (Annon., 2011-12).Young plants were found susceptible to frost in hot arid region.

Biotechnological approaches for improvement of arid fruit crops

Biotechnology is emerging as a powerful tool for crop improvement. Biotechnological approaches like gene transformation and somaclonal variation are attractive as they make possible a great range of improvements to varieties in a short period of time with little or no change in the genetic makeup of otherwise acceptable variety. Application of biotechnological tools in crop improvement programmes can be effective in three different complementary ways: speeding up the process of conventional breeding, creating genetic variability through tissue culture, and evolving novel genotypes through recombinant-DNA (r-DNA) technology (Chopra and Sharma, 1991). Somatic hybridization approach helps in generating cybrids by fusion of two sexually incompatible species. In developing new fruit varieties, biotechnology has two main applications: (1) transfer of desirable genes from quite distant living being, and (2) assist the conventional breeding programmes by reducing the time required for developing a variety and the number of progenies to be raised in the field. Genetic engineering enables to add any gene from any living organism including bacteria. Moreover, biotechnology makes it possible to transfer specific genes to a crop variety in one step, avoiding several back-crossing that is often followed, which is very difficult and time consuming and sometimes impractical because of perennial and heterozygous nature of many of the arid zone fruit crops. Anticipated changes in climate and its variability, particularly extreme temperature and changes in rainfall patters are expected to make crop improvement even more crucial for food production the biotechnological approaches such as molecular breeding and genetic engineering and their integration with conventional breeding to develop crops that are more tolerant of abiotic stresses (Varshney *et al.*, 2011).

Conventional breeding has several limitations among others; it is time consuming, difficulty of raising large population and poor understanding genetics of several traits. Micro propagation technology ensure true to type, rapid and mass multiplication of plants that possesses special significance in vegetatively propagated plant species. Research in genomics allows high- resolution genetics analysis for physical mapping and positional gene cloning of useful genes for crop improvement. Molecular (DNA) markers help in precise characterization of germplasm, construction of saturated linked maps and DNA fingerprinting of crop varieties. Molecular markers are now increasingly being used for marker- assisted gene pyramiding and alien gene introgression. Current research, involving large scale DNA sequencing, microarrays and robotics, is heading towards gene revolution and nanobiotechnology (Mendeley, 2010). Hence, genome mapping, aimed at molecular markers tightly linked to the traits under selection, is particularly important in fruit tree species in permitting early selection of the most interesting genotypes. Molecular markers based on PCR technology, such as RAPDs, AFLPs and SSRs have been found more efficient than markers such as RFLPs and isozymes in characterizing genotypes. Sivalingam *et al.,* (2012) characterized twenty two germplasm accessions of *Cordia myxa* collected from Rajasthan through morphological and RAPD markers. In their study, out of 50 random decamer primers used for random amplification (RAPD), 25 were polymorphic. Average polymorphism resolved by these markers among these accessions was 69.8% with an average polymorphic information content of 0.43. Genetic diversity revealed by Jaccard's co-efficient was between 0.44 and 0.94, and three major clusters were identified among these accessions by phylogenetic analysis using NTSYSpc-2.02e software. RAPD markers associated with leaf size and pulp:stone ratio were also identified. This study shows the existence of high genetic diversity among these accessions.

Moisture stress and high temperature tolerance are the traits that are to be addressed often in arid fruit crop breeding. In response to moisture stress heat shock proteins have been identified in some plants. Modification of heat shock proteins in the cell via genetic engineering has been done in herbaceous plants indicating a possible use of this strategy for increasing thermal tolerance in arid fruits (by use of appropriate promoters). Many of the horticulturally valuable varieties or rootstocks often show very poor rooting ability. Rooting can be improved by inoculating *Agrobacteriumrhizogenes* by wounding the basal part of in *vitro* micro cuttings. The concentrated efforts and standardization of several techniques like induction of somoclonal variation and *in vitro* selection, somatic embryogenesis, *in-vitro* regeneration, protoplast culture, genetic transformation in arid fruit crops is necessary if we have to see biotechnological tools benefiting this group of fruits production.

In conclusion, it could be mentioned that despite several limitations and problems associated with breeding of arid fruit crops by conventional methods, novel biotechnological approaches will not replace the former approach, but it will effectively compliment the traditional breeding methods. Conservation of genetic resources of underutilized arid fruits is very essential for future crop improvement programme to cater the increasing demand of millions. This attains further significance in view of the fact that cultivated area expansion under fruit crops in tropical and subtropical parts of the country has limited scope due to burgeoning population, industrialization and urbanization. Under such scenario, the focus of fruit cultivation is now shifting towards hitherto neglected and marginal lands, which are aplenty in arid regions '*the land of underutilized fruit crops*'.

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Genetic resources of underutilized fruits of tropical region

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The term 'underutilized' or 'minor fruits'often refer to those fruits which have less acreage in a state or country as well as based on the class of consumers in majority. These plants are less prone to pests and diseases, resistance to drought and hardiness**.** They have the ability to withstand and grow in adverse land and climatic conditions. In spite of their role in nutritional, economical and ecological security, less attention has been paid either for their crop improvement and production or commercialization. It is reported that only 25 fruits are commercially exploited and many underutilized fruits also deserve attention as they may help in the utilization of the marginal land and improving the degraded habitats, besides adding to the income of resource poor farmers (Jalikop, 2006). Tropical regions of India and other Asian countries are claimed to be native for many underutilized fruits. In this paper, how far their genetic resources are exploited will be discussed.

Wood Apple (elephant-apple, monkey fruit, and curd fruit)

Wood apple, botanically known as *Limonia acidissima* (syn. *Feronia elephantum*, *Feronia limonia*) is the only species within the monotypicgenus*Limonia*. It is native in the Indomalaya ecozone to Bangladesh, India, Pakistan, Sri Lanka, and in Indochinese ecoregion east to Java and the Malesia ecoregion. It is a large tree growing to 9 metres (30 ft) tall, with rough, spiny bark. The fruit has a very hard rind which can be difficult to crack open, and contains sticky brown pulp and small white seeds. The fruit looks similar in appearance to fruit of Bael (*Aegle marmelos*). Studies conducted at TNAU revealed that there exists variability for the duration of flowering and the extent of availability of fruits (from September to February) and a high yielding superior genotype has been identified and soft wood grafts are being supplied to the growers.

Jamun

The jamun (*Syzgium cuminii*) tree, native to India, thrives easily in hardy tropical regions and is found in all parts of our subcontinent as well as countries of Southeast Asia and Eastern Africa. In India, it is grown widely in the Gangetic plains, and the Cauvery delta in Tamil Nadu. The tree bears fruits for 60 to 70 years and the fruits ripen in June or July. This purple tropical berry has a unique taste, colour and flavour. The most commonly found variety of jamun is often oblong and has a deep purple to bluish colour. The pulp of the fruit is grey or pink and has a seed in the centre. The fruit is acidic and astringent in nature, with a sweet taste.Lot of variation exists in respect of growth and fruit characters. As majority of jamuntrees are of seedling origin, they show tremendous variation in their morphology and physico-chemical attributes .The extent of variability increases when this highly cross-pollinated plant multiplied sexually. Sanjay Singh and Singh (2012) assessed the variability in terms of flowering, fruiting and fruit traits under Gujarat conditions. Regional Fruit Research Station , Ventura , Maharashtra maintains a rich germplam and one promising germplasm has been released in the name as " Konkani Bahadoli" which is having bold fruits, small seeds , heavy and cluster bearing habit (Salvi, 2006) . Still many types differing in economic traits need to be surveyed, collected and maintained. Genotypes with extended fruiting period have to be identified as a priority one as this fruit is now available only for very limited weeks in nature. Seedless Jamun is also available at TNAU but its limiations are small in size and instability in seedlessness due to its chimer nature.

Jackfruit

The jackfruit (*Artocarpus heterophyllus*), also known as jack tree, belongs to the family (*Moraceae*). It is native to parts of South and Southeast Asia, and is believed to have originated in the southwestern rain forests of India, in present-day Kerala, in Tamil Nadu (in Panruti), coastal Karnataka and Maharashtra. Varieties are distinguished according to characteristics of the fruit's flesh. In Brazil, three varieties are recognized: *jaca-dura*, or the "hard" variety, which has a firm flesh and the largest fruits that can weigh between 15 and 40 kilograms each, *jaca-mole*, or the "soft" variety, which bears smaller fruits with a softer and sweeter flesh, and *jaca-manteiga*, or the "butter" variety, which bears sweet fruits whose flesh has a consistency intermediate between the "hard" and "soft" varieties. In Indochina, there are 2 varieties, being the "hard" version (more crunchy, drier and less sweet but fleshier), and the "soft" version (more soft, moister, much sweeter with a darker gold-color flesh than the hard variety). Extensive studies conducted at KAU and TNAU revealed that jack fruits exhibit considerable variability for almost vegetative and fruit characters as it is a highly cross pollinated crop. Exploiting the genetic variability, through clonal selection, TNAU has developed many superior varieties such as Palur – 1, Palur-2 and PPI-1 Jack. Further, high yielding genotypes viz A.H.15 and 1000 fruited jack are under evaluation in TNAU. Still, systematic survey needs to be undertaken thoroughly to explore the wide genetic variability available in the seedling population of jack trees grown in the Western Ghats and North eastern hills. At Kallar and Burliar Fruit Stations in Tamil Nadu, a total of 30 seedlings and 20 clonal progenies were assembled from Myanmar, Indonesia, Sri Lanka, Philippines and Malaysia. Among the collections, Burliar Jack seedlings followed by Singapore and Velipala seedlings yielded better and are now being grown by jack lovers. The studies on a total of 204 trees belonging to 67 accessions including wild and cultivated types from Kerala, Karnataka and Tamil Nadu are maintained at the National Bureau of Plant Genetic Resources (NBPGR) Regional Station, Thrissur, Kerala. Reddy *et al.* (2004) studied physio-chemical characteristics of jackfruit clones from South Karnataka and found diversity in several characters. Jagadish *et. al.* (2007) analyzed 24 different firm type jackfruit clones from Western Ghats and found variation in total soluble sugars (TSS), acidity, TSS : acid ratio, sugars, starch and carotenoid contents in the bulbs.

Aini pala

Aini pala (*Artocarpus hirsutus)* also known as Wild Jack or Jungle Jack is a tropical evergreen tree species that is native to India (Karnataka, Kerala, Maharashtra and Tamil Nadu), where it prefers moist, deciduous to partially evergreen woodlands.It grows in altitudes ranging from sea level to an elevation of 1000 m in places with an annual rainfall of 1500 mm or more. They are endemic to the Western Ghats and are found in its evergreen forests. The canopy tree can reach a height of up to 35 m and about 4.5 m in girth. The tree is prized for its durable timber which is comparable in quality with teak. The timber was used extensively in the construction of ceilings, door frames and furniture in older buildings, especially in Kerala. The ripe fruit of A. hirsutus is eaten after removing the spiny outer skin. The structure of the fruit is similar to that of the much larger jackfruit. The seeds are also edible, usually fried as a snack. There is practically no genetic variability in this species.

Breadfruit

Breadfruit (*Artocarpus altilis*) belonging to the family, Moraceae, is found growing throughout Southeast Asia, South India and most Pacific Ocean islands. Breadfruit trees grow to a height of 25 m (82 ft). The trees are monoecious, with male and female flowers growing on the same tree. Seeded types (diploids) and seedless types (probably triploids) are found in this fruit. It is an introduced fruit by Portuguese in Southern India and studies carried out at KAU by assessing the variability in 60 different geographical locations proved the absence of genetic variability. Genetic diversity probably exists in its places of origin.

Mangosteen

The Mangosteen plant is a tropical evergreen tree, and the fruit is often referred as the "Queen of Fruits". Garcinia is a large genus that consists of about 400 species, and originated from East India, Malay Peninsula and South East Asia, as well as Indonesia. Based on morphological and cytological studies, it is suggested that mangosteen originated from South East Asia; subsequently it is proposed that mangosteen is an inhabitant Indonesian fruit. Some species of Garcinia, including *G. mangostana* produce fruit without pollination, the phenomenon is referred to as gamospermy, which is the production of seed without fusion of gametes. Cytological and molecular studied confirm that *G. hombroniana* (2n=48) and *G. malaccensis* (2n = 42) were the progenitors of G. mangostana which is considered as an alloteteraplod (2n= 90) .Being an apomictic species, the progenators resemble the parent plants , hence genetic variability is totally nil. Even in Indonesia, limited variability mostly due to environmental influence was alone documented. Population from different geographical origin might exhibit some variability. Promising varieties identified in Indonesia viz Wanayasa, Puspahiang, Malinau and other varieties from different South East Asian countries need to be introduced to widen the genetic base in this crop.

Durian

The durian is the fruit of several tree species belonging to the genus*Durio*. There are 30 recognised *Durio* species, at least nine of which produce edible fruit. *Durio zibethinus* is the only species available in the international market: other species are sold in their local regions. Regarded by many people in southeast Asia as the "king of fruits",[3] the durian is distinctive for its large size, strong odour, and formidable thorn-covered husk. The fruit can grow as large as 30 centimetres (12 in) long and 15 centimetres (6 in) in diameter, and it typically weighs one to three kilograms (2 to 7 lb). Its shape ranges from oblong to round, the colour of its husk green to brown, and its flesh pale yellow to red, depending on the species. No named cultivars are available in India but distinct varities clonally multiplied are maintained in many south East Asian countries which need to be introduced.

Malayan apple

Malayan apple, *Syzygium malaccense* is a species of floweringtree native to Malaysia, Indonesia (Sumatra and Java)Vietnam and Thailand, has been introduced throughout the tropics, Malay apples first came to the shores of Goa by way of the Portuguese. Today, the fruits grow in Bengal, Goa and throughout South India. As a tropical tree, it requires ample humidity, high rainfall, and no frost. Once these basic conditions have been met, the trees need little else to thrive. Malay apples have two seasons: one from May to July**,** and the other from November to December.Malay apples have a short shelf life. The fruits have little commercial viability, despite the tree's prolific production: Each fruit must be carefully plucked from the tree and maintained in cool storage shortly thereafter. There is practically no variability seen in this fruits available in India. Most of the trees found in the backyard in Kerala, Tamil Nadu and Karnataka could be easily traceable to single source viz SHF, Kallar (Tamil Nadu or Wynad and their self pollinating nature also limits their variability. However, the incredible diversity of Malay apples exists in its place of origin, especially in terms of size, colour and taste which need to introduced for commercial exploitation.

The wax jambu (*Syzygium samarangense*) is a non-climacteric tropical fruit with its origin in the Malay Archipelago1. This fruit is common and very much enjoyed throughout the pacific islands and tropical Asia. It is also found in the Caribbean. The varieties found in Asia in the present day have been cultivated for untold centuries and tend to be larger and sweeter than those growing elsewhere in the tropics. Rose apple.

Rose apple (Syzygium jambos) is native of Malay Archipelago, distributed now in both south Indian hill stations and North eastern states. It practically exhibits no variability for growth or fruit traits The Surinam cherry, *Eugenia. uniflora (* also called Brazil or Brazilian cherry, Florida cherry) is native from Surinam, Guyana and French Guiana to southern Brazil . There are 2 distinct types: the common bright-red and the rarer dark-crimson to nearly black, which tends to be sweeter and less resinous. The types introduced earlier in India are mostly are of sour type *vis a vis* the superior sweet types available in South east Asian countries. They deserve introduction to India.

Bilimbi

Averrhoa bilimbi (commonly known as bilimbi, cucumber tree, or tree sorrel) is a fruit-bearing tree of the genus*Averrhoa*, familyOxalidaceae. It is a close relative of carambola tree. Possibly originated in Moluccas, Indonesia, the species are now cultivated and found throughout the Philippines, Indonesia, Sri Lanka, Bangladesh, Maldives, Myanmar (Burma) and Malaysia. It is also common in other Southeast Asian countries. In India, where it is usually found in gardens, the bilimbi has gone wild in the warmest regions of the country. The genetic resources available in this fruit is very narrow in terms of taste (mostly sour type) and size (mostly small) and superior types from its origin country need to be introduced to widen its genetic base.

Carambola

Carambola, also known as starfruit, is the fruit of *Averrhoa carambola*, a species of tree native to the Philippines, Indonesia, Malaysia, India, Bangladesh and Sri Lanka. The fruit is popular throughout Southeast Asia, the South Pacific and parts of East Asia. The tree is also cultivated throughout non-indigenous tropical areas, such as in Latin America, the Caribbean, and the southern United States. The fruit has distinctive ridges running down its sides (usually five but can sometimes vary); in cross-section, it resembles a star, hence its name.

The existing varieties in India are of inferior in quality, mostly sour in taste but improved verities are available in Malaysia and Thailand etc. One such introduction from Malaysia at Nagercoil (Kanyakumari district) by a private grower is big in size with good fruit qualities. Efforts are being made by TNAU to propagate this superior type clonally. In Florida, an improved variety, 'Arkin'– a sweet carambola with good handling characteristics was identified in late 1970s. Soon afterward, the limited commercial area of carambola under cultivation in south Florida (4 to 12 ha) was top-worked to 'Arkin' and this new cultivar led to a rapid increase in consumer demand for the fruit which further stimulated interest in establishing new commercial plantings. Today, the 'Arkin' variety represents 98% of the current acreage in South Florida. Other important improved cultivars are Dah Pon (Taiwan), Demak (Indonesia) , Golden Star (Florida) etc.

Cherimoya

The cherimoya is the fruit of the species *Annona cherimola*, which generally is thought to be native to the Andes, although an alternative hypothesis proposes Central America as the origin of cherimoya because many of its wild relatives occur in this area. Today cherimoya is grown throughout South Asia, Central America, South America (mainly in Chile) Southern California, Portugal etc. The cherimola available in India exhibits very limited variability. There is a need to introduce good genotypes from its of origin.

Atemoya

The atemoya, a man made hybrid developed by crossing cherimoya (*A. cherimola*) with sugar-apple (*A. squamosa*) originally developed at Miami in 1908. An atemoya is normally heart-shaped or rounded, with pale-green, easily bruised, bumpy skin. Near the stem, the skin is bumpy as it is in the sugar-apple, but become smoother like the cherimoya on the bottom. The flesh is not segmented like that of the sugar-apple, bearing more similarity to that of the cherimoya. It is very juicy and smooth, tasting slightly sweet and a little tart, reminiscent of a *piña colada*. The taste also resembles vanilla from its sugar-apple parent. Subsequent hybridization work has resulted in the development of new Atemoya cultivars viz Geffner, Africon Pride, Bradley and Malamud (pink fleshed) which need to be introduced to India to widen our genetic base as the existing atemoya type is of a single genotype in India.

Soursop

The soursop plant *(Annona muricata*) produces natural substances known as *Annonaceous acetogenins* in its leaves, bark and seeds. Numerous in-vitro studies, including eight clinical studies by three separate research groups, have shown that these compounds are able to target various types of cancer cells without damaging healthy cells. Although it is native to Latin America, and the West Indies, it is now found growing in southeast China, Australia, and in many other countries throughout Africa, Southeast Asia and the Pacific as well.In India, it exhibits lot of variability for the fruit size. TNAU has so far assembled a total of ---- genotypes mainly differing in fruit shape and size. Their genetic diversity for acetogenin activity is being assessed now.

Sweet tamarind

Tamarind (***Tamarindus indica***) is a leguminoustree in the familyFabaceae indigenous to tropical Africa. The genus ***Tamarindus*** is a monotypic taxon, having only a single species. Though the fruits of Tamarind are of two types, sour and sweet , the latter one is regarded as a fruit tree in South east asian countries. Few seeds introduced and raised at Coimbatore conditions did not produce quality sweet tamarinds as compared to South Asian countries.More over these types were extremely susceptible to leaf webber

Other minor fruits

A. Karonda or Carissa- *Carissa carandas* is the common species found in India, Bangladesh; naturalized in S China, Mauritius, Nepal, Pakistan, Indochina, Java, Philippines, West Indies. .Fruits are said to be rich in Vitamin C, calcium, magnesium and phosphorus. The fruit of *C. macrocarpa* are especially relished and eaten raw or used to make jelly. There is large natural diversity in karonda with respect to size, shape, colour, taste, and quality of fruits which need to be assessed and documented.

B. Malabar Tamarind

It is botanically known as ***Pithecellobium dulce*** , a species of flowering plant in the pea family, Fabaceae, that is native to the Pacific Coast and adjacent highlands of Mexico, Central America, and northern

South America.[2] It is an Introduced species and extensively naturalised in the Caribbean, Florida, Guam as well as in India, Bengal and the Philippines. It is considered an invasive species in Hawaii. The flowers produce a pod, which turns pink when ripe and opens to expose an edible pulp. The pulp contains black shiny seeds that are circular and flat. The tree is drought resistant and can survive in dry lands from sea level to an elevation of 1,500 m (4,900 ft), making it suitable for cultivation as a street tree. Survey conducted in the dry southern district of Tamil Nadu has led to the identification of a superior type which is clonally propagated and released as PMM-1 by TNAU.

Kokam

Garcinia indica, a plant in the mangosteen family (Clusiaceae), commonly known as *kokum*, is a fruit-bearing tree that has culinary, pharmaceutical, and industrial uses. It is found in forest lands, riversides and wastelands. These plants prefer evergreen forests, but sometimes they also thrive in areas with relatively low rainfall. It is also cultivated on a small scale. It does not require irrigation, spraying of pesticides or fertilizers.

The outer cover of fruit is dried in the sun to get *aamsul* or *kokam*. It is used as a slightly sour spice in recipes from Maharashtra. Kokum yields a peculiar flavor and blackish red colour. It is extensively used in Assamese cuisine in many dishes like " masor tenga " or sour fish curry and " tenga dali " or sour dal.It is used as a cure for upset stomach and cold. A few dry pieces are soaked in water for some time and then the pieces are mashed in the water itself and can be taken in whole. It gives relief within few minutes. It is a preferred substitute for tamarind in curries and other dishes from the Konkan region. It is also used in cuisine from Gujarat, where it is frequently used to add flavor and tartness to dal (lentil soup) for flavor balance, and parts of South India.

Moottu Pazham

Baccaurea courtalensis, a tall tree produces iInflorescencecauliflory; flowersunisexual, dioecious; maleinflorescence in clustered racemes on short tubercles all over the trunk, red; femaleinflorescence in clustered racemes, mostly confined to base of the trunk, hence its name.

Minor citrus fruits

Many minor citrus fruits such as grapefruit (Citrus *paradisii*), pommelo (C. grandis) and their hybrids including mini orange (Kumquat) need attention as they are economically important and hold promise under tropical ecosystem. Improved varieties in this group are to be introduced as the existing genotypes donot have economic value.

Conclusion

Thus it is obvious from the foregoing discussion that the genetic resources in these crops are very limited. In those minor crops which are native to India like Jamun and Jack, focus should be made to document the extent of naturally occuring variabilty while in the case of exotic crops, efforts should be made to introduce promising commercial varieties to widen the genetic base as there is no scope to create variability with the existing materials.

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Status and prospects of underutilized fruits of Goa

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Goa is part of Konkan region on west coast of India, endowed with rich biodiversity. It is needless to emphasize about the occurrence of enormous biodiversity existing in well known genetic hot spots like Trans-Himalayan region, North Eastern areas and Western Ghats of Indian subcontinent. The latter houses the unique Konkan tract all along the Arabian sea of Peninsular India. The rich wealth of *flora and fauna* of this region has made it a paradise of nature as it houses rich genetic diversity. One of the most fundamental values of plant diversity is in supplying the food, protective foods and medicinal herbs, besides many industrial raw materials, for the benefit of mankind. Here comes an array of horticulture crops into picture. The agro climatic conditions and edaphic factors of the region including Goa are uniquely favourable for a number of horticulture crops.

State of Goa encompasses an area of 3,702 km^2 (3,61,113 hectares) and lies between the latitudes 14°53'54" N and 15°40'00" N, and longitudes 73°40'33" E and 74°20'13" E, bound by the Arabian Sea on the West, State of Maharashtra on the North and Karnataka on East and South with a coastal line of 105 km long. Falling in hot humid per humid eco-region of Agro climatic zone of the country, the state experiences the temperature in the range of 18 to 36 ^{0} C. During summer the temperature ranges from 24^{0}C to 36^{0}C, whereas during mild winter months, it varies from 18^{0}C to 30^{0}C. The average relative humidity is 75.90%. There is abundant solar radiation during winter and summer months (7-9 hours of bright sunshine), while it is relatively less during monsoon months. The annual rainfall ranging from 2500 to 4000 mm is received in about 100 -120 days between June and September, in an unimodal pattern.In Goa, the land elevation ranges from sea level to 1,022 meters in Western ghat region of Satari taluka. Though tourism and mining are at forefront in terms of employment generation, agriculture has been providing livelihood support to almost 12% of the population and is essential for the state to support the latter two. (http://www.agri.goa.gov.in/agriculture-in-goa).

The soils are predominantly lateritic and laterites (73.4 %) followed by alluvial and marshy soils (11.7 %), sandy coastal soils (10.11%) and saline soils (4.79 %). The entire territory of Goa is underlined by crystalline and metamorphic rocks comprising of granite, phyllites and meta-bassalts. These rocks are overlined by lataerite and alluvial soils. Soils are deep to very deep. Major soil series are coarse to medium textured, while some are medium to fine textured. These soils are well drained but have poor water holding capacity, although dense vegetation and grass cover have contributed to high contents of organic matter (0.5 to 1.5 % organic carbon) in several soils. The pH of the soils is 4.5 to 6.5. Soils, in general, are productive with irrigation and fertiliser management (Anonymous, 1999).

Horticultural crops in Goa

The above edaphic and agro-climatic factors contributing to form the Goan eco-region with hot humid per humid conditions, are practically supporting an array of plant genetic resources of horticulture crops and their biodiversity. Thus, Goa state is an abode of horticultural crops comprising of innumerable fruit crops, vegetables, plantation crops and spices, medicinal & aromatic crops and flower crops covering about 63% (1,02,715ha.) of the cultivable area (1,62,505ha.) of the state. Each group of these crops is bestowed with rich genetic diversity with unique features in its own kind. Major fruit crops like mango, banana, pineapple, etc, cover about 11,163 ha., while other fruit crops a number of under utilized/ lesser known fruit crops including Jack fruit, citrus, sapota, bilimbi, hog plum, kokum, etc., cover about 3815ha with an estimated production of about 40, 000 tons and productivity level of 10,000kg/ha. (Fig.1 & 2) This group having lot variability in it forms a unique horticultural genetic resources of the region which needs special attention considering their commercial and nutraceutical significance.

Figure 1.Total Production of fruits including under utilized fruits (t) in Goa.

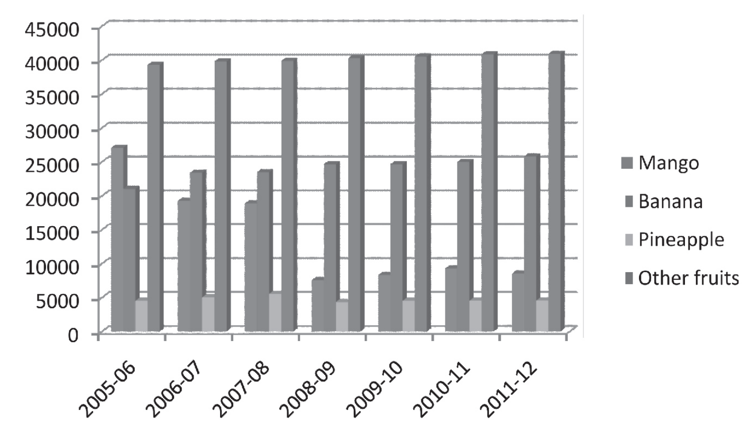
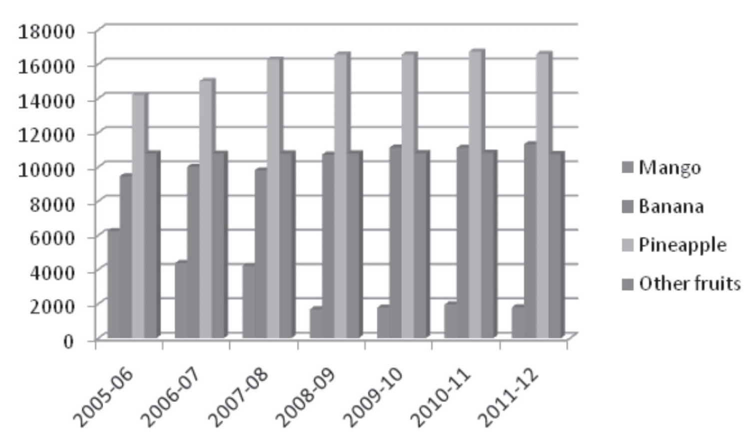


Figure 2. Productivity /Average yield (Kg/ha) of fruit crops in Goa



Under-utilised fruit crops of Goa

Unlike major fruit crops, under utilized fruit crops, despite their significance, are not given production attention. Many times, the fruits of these crops are simply collected from the naturally grown trees in the farm or in forest areas or from one or two trees grown in homestead gardens, especially for domestic purpose. A vast list of this group of fruit crops of the state are listed in table 1, with their common and scientific names, season of fruiting .

The basic information on fruits available or grown, the families they belong to, the ways they are used, the seasons of flowering and fruiting, market demand etc. are furnished in Table 01.

Table 1. Commonly seen underutilized Indigenous fruits of Goa

English name	Local name	Botanical name	Family	Season of Fruiting
Adam's fruit	Vovla	*Mimusops elengi*	Sapotaceae	Feb-April
Hog plum	Ambada	*Spondias pinnata*	Anacardiaceae	Aug-Nov
Bilimbi	Bimbla	*Averrhoa bilimbi*	Oxalidaceae	Sep-Nov
Bread fruit	Nirpanas	*Artocarpus ultilis*	Moraceae	Mar-Apr, Jul-Sep
Churna	Chunna	*Zizyphus rugosa*	Rhamnaceae	Apr-May
Carambola	Karmal	*Averrhoa carambola*	Oxalidaceae	Jan-Feb, May-Jul
Chivra	Chivra	*Grewia microcos*	Tiliaceae	Apr-May
Jack	Panas	*Artocarpus heterophyllus*	Moraceae	May- Jul
Jagomas	Jagma	*Flacourtia jangomas*	Flacourtiaceae	Oct-Dec
Jamun	Jambhla	*Syzigium cumini*	Myrtaceae	Apr-May
Karonda	Kanna	*Carrisa carandas*	Apocynaceae	Apr-May
Kokum	Brindan	*Garcinia indica*	Guttiferae	Apr-Jun
Rose apple Wax jambu Malayan rose apple	Jam Jam	*Syzygium jambos* *S samarangense* *S malaccanse*	Myrtaceae	Jan-Feb, Mar-Apr
Mobola plum	Mattoma	*Parinari spp*	Chrysobalanaceae	Dec-Jan
Soursop/ graviola		*Annona muricata*	Annonaceae	
Bullocks heart	Ram phal	*Annona reticulata*	Annonaceae	
Pomelo	Toring	*Citrus grandis*	Rutaceae	Sept- Jan.
Monkey Jack	Watambo	*Artocarpus Lackoocha*	Moraceae	Used Savouring agent

Kokum (*Garcinia indica* Choisy)

This tree species belongs to family Guttiferae and naturally exists in farms, forest regions, stream banks etc. It has got multifaceted usages such as fruit, spice, medicinal crop etc. The fresh fruits are used as such for preparation of squash, juice, RTS etc, whereas the dried rind is used as a spice ie. souring agent in Goan cuisine especially in Goan fish curry. Besides these domestic uses Kokum is presently in limelight in global pharmaceuticals trade because of its virtue of containing alpha Hydroxy citric acid in its rind which has the chemical property to inhibit accumulation of fatty acids. Therefore HCA extracted from kokum rind would form the vital component of products like anti-obesity drugs, slimming agents etc. While the fruit rind contains, anti-obesity factor, ironically, the seeds of kokum are rich sources of fat content. Traditionally a product named kokum butter is extracted from the seeds and is used domestically. Further this butter forms an important base in cosmetic product like lipstick, face pack etc. Kokum trees that naturally exist due to their seedling origin, diocious nature and cross pollination, exhibit wide variation in morphological and physico-chemical characters.

Table 2. Variability found in Kokum in Goa

Variables	Range of variables	Remarks
Canopy shape	Conical, Pyramidal, Dome shaped, Spreading type	Affects the ease of harvesting
Leaf	Narrowly to broadly lanceolate, rarely ovate	----
Fruiting season	Early (Feb-mid April), Mid season (Mar end – mid May), Late (mid Apr- June)	Early &mid season bearers are choice of growers
Fruit colour	Yellow to dark maroon	Rich source of anthocyanins
Fruit weight	10-50 g	Good rind and juice recovery in bigger fruits
Fruit shape	Spherical, Oblong, Oval, fruits with pointed tips	---
Rind thickness	0.14 – 0.48 cm	Higher rind recovery is profitable
No. of segments	4 – 8 segments /fruit	Depends on sex of tree
Dry seed weight	0.09 to 0.52 g	Source of natural fat
Juice percentage	19.18 - 90.76.	Juicy types preferred for syrup, *agal etc.,*
TSS of juice	1.95-22.40 ^{o} Brix	Advantage of selection for different value added products
Acidity	1.1 – 6.8 %	Advantage of selection for different value added products
HCA	19.32 to 37.39 %	Anti-obesity compound
Kokum fat in dry seeds	11.54 – 43.18 %	Industrial and Pharma applications

(Priya Devi, 2009)

Jack fruit (*Artocarpus heterophyllus*)

Belongs to family Moraceae and is occurring in abundance in nature. Basically there are two ecotypes *viz*., firm fleshed and soft fleshed ones. The former is used for dessert purpose and the latter both for dessert as well as different forms of processed foods like leather, papad etc. Immature fruits of both types are used for culinary purposes. This tree species is also heterozygous in nature and shows variation in traits.

Table 3. Fruit characteristics of jack fruit accessions

Characteristics	Range
Fruit Shape	Ellipsoid/Oblong/Clavate/Irregular
Stalk length (cm)	2.3-9.8
Stalk girth (cm)	6.9-10.3
Stalk attachment to fruit	Depressed /Flattened
Fruit length(cm)	33.9 – 68.2
Fruit girth (cm)	59.80 - 90.80
Fruit weight(kg)	5.57-16.10
Shape of spine	Sharp /Intermediate
Spine density	Sparse /Dense
Fruit shelf life (days)	2-5
Fruit quality	Poor/Moderate/Good
Fruit attractiveness	Poor/Moderate/Good
Fruit surface	Spiny/Smooth
Rind thickness	Thin/Medium
Fruit rind colour	Green/Greenish Yellow
Rachis length(cm)	15.8 - 38.2
Rachis Diameter	5.8-11.1
Number of flakes(bulbs)/ fruit	83-271
Weight of flakes per fruit (g)	1.680 - 6.042
Weight of fresh flake with seed(g)	15- 44
Weight of fresh flake without seed(g)	10 - 34
Flake length (cm)	3.63-7.55
Flake width(cm)	2.20- 4.05
Flake thickness	Thin/Medium.Thick
Flake fibre content	Low/Medium/
Flake shape	Spheroid/ Oblong with curved tip/Twisted/Rectangular/ Irregular
Flake texture	Soft/Firm

Flake/ Fruit ratio	0.71-0.82
Pulp taste	Insipid /Sweet
Pulp consistency	Firm/Medium/Soft
Pulp flavour	Intermediate/Strong
Pulp juiciness	Juicy/Not juicy
Pulp colour	Deep yellow/ Yellow/Light yellow
Seed length(cm)	2.79-3.74
Seed width(cm)	1.47-2.74
Number of seeds per fruit	83-271
Seed weight/fruit (g)	735-1588
Seed shape	Oblong/Reniform.Irregular
Seed surface sliminess(ripe fruits)	Slightly slimy /Intermediate
Seed coat thickness	Thin /Intermediate
Seed surface pattern	Regular striations
Seed coat colour	Off white/Creamish
Adherence of seed coat to kernel	Easily separable/ Difficult to separate
Flake without seed /seed ratio	3.0- 4.4

Bread fruit (*Artocarpus altilis*)

This is a perennial tree species (family- Moraceae); produces fruit that is used as a vegetable. The tree bears fruits almost throughout the year, but the two peak seasons of availability are March-April and July-Sept. Bread fruit trees are found in almost every back yard. As the propagation is by root suckers / root cuttings, there is less variation noticed. But still slight variation in terms of size and shape of fruits is observed. This being a starchy fruit finds its own place in the Goan cuisine. The mature fruits are sliced, deep fried and relished tantamount to fish fry especially by vegetarians and also by non-vegetarian populace during off season for availability of fish. The starch powder extracted from bread fruit forms a component of baby food etc.

Carambola *(Averrhoa carambola)*

This species belongs to family Oxalidaceae. This is an ever green medium sized perennial tree that bears star-shaped fruits. As the species can be propagated both by seeds as well as grafts, there is variability in fruit of carambola from sour to sweet. A distinct difference is observed in fruit quality between sour and sweet type of fruits. The sour fruits are greener and smaller in size, rich in acids whereas the sweet ones are bigger, yellowish green, fleshier and with appealing sugar: acid ratio. Dried flakes of sour carambola are used as souring agents and fresh fruits are used in curries / pickles whereas fresh fruits of sweet type are used for dessert purpose and preparation of juice/squash etc.

Bilimbi (*Averrhoa bilimbi)*

This is a close relative of carambola, an evergreen medium stature perennial tree, bearing green, cylindrical, fleshy fruits directly on trunk / older branches (cauliflorous flowering). They are very common in Goan backyards. The fruits are used as souring agents and more often in pickles. There is less variation observed in this species.

Ambada/Hogplum (*Spondias pinnata*)

This species belongs to family Anacardiaceae, a tall stately, semi-deciduous type of tree, bearing greenish oval fruits. The trees exist in road sides, backyards, farm bunds etc. There are two distinct types of fruits available *viz.,* sour and sweet, the former with a relatively large sized seed and the latter with thin seed. Ambada fruits are used for preparation of curry, chutney etc. The fruits are relished for the sour taste.

Jagoma(***Flacourtia jangomas*****)**

This belongs to family Flacourtiaceae. This is an evergreen perennial tree species found mostly in coastal regions and dioecious in nature. There are spines present over trunk and older branches. The fruits are available during Oct-Dec; dark red / maroon in colour, smaller, containing numerous small edible seeds. The ripe and fresh fruit is consumed as such after softening the pulp by gently pressing it between the fingers. The pulp tastes sweet to acidic. There is variation observed in terms of fruit size and quality.

Bakul furit (*Mimosops elengi*)

This belongs to family Sapotaceae. This is a medium- huge perennial tree bearing brown fruits containing 1-3 light brownish seeds that look like those of Sapota. The pulp is not very fleshy but sweet; the fruits consumed as dessert and except for fruit size, not much variation exists in this fruit species.

Roseapples (*Syzygium species*)

Syzygiums belong to family Myrtaceae. These are medium – large sized perennials bearing fruits twice a year ie. During Jan-Feb and Apr- May. There are three species found in Goa *viz**S. jambos*** (globose, creamish yellow fruits, seedless),*S. malaccense* (ovaid-pear shaped red fruits, seedless) and *S. samarangense* (pear shaped, greenish yellow, seeded). All types are crispy and watery, acid – sweet in taste and consumed fresh. Not much variation is observed within a species.

Karonda (*Carissa carandas*)

This species belongs to family Apocynaceae. This is an evergreen perennial thorny shrub bearing purplish black fruits during Apr-May. As it is native to India, variation is observed in fruit size and earliness. The mature unripe fruits are used for pickling and chutney making and the ripe fruits for dessert purpose. Products like squash, juice, wine are also made out of ripe- fruits.

Figure : Local Karonda fruits on tree and fruits collected by venders for sales

Still, this is not cultivated as a potential crop of commercial interest. Produce (ripe fruits) collected from naturally occurring wild trees are sold by street vendors in small quantities.

Jamun (*Syzygium cumini)*

This is a perennial tree species (family-Myrtaceae) bearing dark purple fruits during Apr-May. As it is believed to be native to India, vide variation is exhibited in terms of fruit size, shape, colour, bearing habit, biochemical traits etc. The trees are found widely distributed in Goa. But bearing is observed to be not regular but alternate / irregular in Goa. The fruits are consumed fresh and also in form of squash/ juice/wine. Due to its anti-diabetic property, it is valued in ayurvedic pharmaceutical industries.

Mattoma *(Parinari curatellifolia)*

This is an evergreen tropical tree (Family- Chrysobalanaceae), most frequently found growing in poorly drained areas and inland, at moderate altitudes. The little-known fruit has potential to improve nutrition, boost food security, foster rural development and support sustainable landcare. The crushed pulp of the fruit is an ingredient in drinks and since it ferments well, is often used to make alcoholic drinks as well

Table 4. Physico-chemical traits of few under-exploited fruits of Goa

Name of Fruit	Type/Source	Fruit wt.(g)	Length (cm)	Girth (cm)	Pulp (%)	Seed (%)	TSS (Brix)	Acidity (%)
Rose Apple	Light Pink	55.94	5.66	4.82	81.59	18.41	5.6	0.47
i).Malayan Apple	Big Size							
ii) Wax Jambu	Light green	60.4	8.46	5.08	83.44	16.56	3.8	0.36
	Seedless							
		40.8	4.56	3.98	100	--	4.8	0.12
Carambola	Sweet	96.6	11.94	2.78	99.1	0.9	6.6	0.29
Carambola	Sour	75.6	9.28	2.38	99.0	1.0	3.8	2.40

Bimbla	Soft Ridged	12.12	5.3	1.80	100	--	3.8	2.80
Jagoma	Small,round	5.94	22	1.80	92.58	7.42	18.2	0.56
Chara	Small,round purple	1.22	1.88	1.56	66.21	33.79	21.4	0.48
Adam's fruit	Brown,Oval	12.6	4.72	8.18	60.55	39.45	23.0	0.13
Karonda	Round,purple	2.75	1.3	1.2	95.21	4.79	14.4	1.15

Constraints

a. Lack of general awareness about nutraceutical significance of these fruit crops has resulted in tagging these crops as under utilized fruits. As a result of this, commercial prospects are not fully explored.

b. Most of these crops occur naturally as self sown plants or seed propagated ones in backyards. In many crops, there are no identified varieties for commercial cultivation and propagation of quality planting material is not adequately attempted. Because, the produce of these crops fetches less income due to low prices, in the present context. Therefore, much of the produce from this group of fruits, in general, go as wastage without using them.

c. Some under utilized fruits are small sized wild berries born in thorny shrubs rendering them poor marketability and difficult for collection or harvesting for deriving commercial value.

d. Many potential underutilized fruit crops are growing on marginal / waste land situations with out any genuine attention from the horticulturists.

Prospects and research needs

Accommodation of these crops in farming system – mode - agro forestry- Kulagars

It is observed that many of these crops are usually seen growing in wild areas without any much care and special attention. Hence the good way to promote these fruits by introducing these plants in Farming system- such as Kulaagars. The thorny plants of Karonda, Churna, can be introduced in Kulaagars all along the borders, so that it can also act as hedge protecting the Kulaagars besides being a source of additional income.

Processing and value addition

Another good way of utilising these fruits is by processing and preparing value added products. Some of the fruits mentioned above are sour in taste and can be the source of raw material for pickle making. Fruits such as Bimbla, Kanna, and Jack are already used in their tender stage for pickle making. While fruits of Aambada and Bimbla can be used for making sweet pickle. Though preparation of sweet pickle out of these fruits is house hold at present, the same can be tried at commercial scale. Bread fruit and jackfruit are used for preparation of Papads by the farmers engaged in maintaining Kulaagars. Jack fruit is also used for preparation of chips in Goa. Carambola, Jamun and Kokum fruits are used in preparation of Juice and Squashes. Also fruits such as Adam's fruit, Carambola and Jamun can be tried for preparation of Jam. The possibility also can be explored to utilise these fruits for making mixed fruit jams and jellies in combination with other fruits .

Awareness/ not to neglect

Though these crops are grown in wild and have less attention, they have their own unique characters and qualities. Hence there is immense need to promote these fruits by creating awareness among the locals and popularisation of these fruits in the form of value added products.

Nutritional point of view

The fruits of Kokum, Jamun are well known from ancient times for their medicinal as well as nutritional properties. Besides above mentioned fruits, the fruits of Annona muricata commonly knows as Saursop are also known for its medicinal properties especially in the treatment of cancer. Laboratory and field research suggests that soursop-derived substances may have potential for various future applications, since they have shown antileishmanial and cytotoxic, antinociceptive, anti-inflammatory, anti-diabetic and anticancer effects in laboratory experiments. Similarly the other fruits can also be explored for the medicinal and nutritional properties.

Introduction and evaluation of new fruits

Introduction and evaluation of non-traditional but commercially important fruits like rambutan, Avaocado, etc. for commercial exploration will greatly facilitate the tourism industry.

Future thrust

1. Although some of these fruits are abundantly available in their habitat, it is required for collecting the core Germplasm collection for their conservation, characterization and characterization to mitigate the climate change driven problems in future. Therefore, collection and conservation of Germplasm resources needs special thrust for future benefits. In vivo and in situ conservation approaches may be explored for conservation.
2. Potential Germplasm accessions need to be evaluated for short listing new varieties possessing commercial attributes and processing qualities.
3. Production technology and propagation techniques need to be standardization for commercial production and production and supply of quality planting material of newly developed varieties.
4. Storage and handling studies are imperative for effective secondary agriculture activities.
5. Keeping the unique Nutraceutical qualities of the fruits, value added products like RTS of health drinks and herbal drinks specialty fruits need to be explored and products popularized through appropriate production and marketing linkage chains.

6. Since this group of fruits is an important source for health protective properties, like antioxidants, vitamins and secondary metabolites, etc., there is need to give special attention to probably explore them for addressing new out break of diseases and strange health problems.
7. Indigenous studies on clinical trials for precise utilization in the line of Indian system of medicine will for new horizon for utlizing this group of fruits.
8. Though currently, there is appreciable research impetus on kokum, further surveys have to be conducted and elite trees should be identified. Then, the short-listed mother trees need to be clonally propagated on large scale, field tested on farm and off-farm and released. Furthermore, the value added products of kokum need to be popularised at national and international level.

On farm conservation and utilization of underutilized fruits and tree spices

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As defined in the Convention on Biological Diversity (CBD), "*in situ* conservation" means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties. The CBD requires, under the Article 8, that the countries develop guidelines for selecting areas for *in situ* conservation, establish protected areas, regulate the use of resources so as to make a sustainable use and protect ecosystems and natural habitats. *In situ* conservation is dynamic in contrast to the semi-static nature of *ex situ* conservation. *In situ* and *ex situ* approaches complement each other to help us maintain much more genetic diversity than it would be possible when only one method is used. Although this was realized quite early on our efforts in conserving plant genetic resources, most national programmes focused mostly on *ex situ* conservation (Altieri and Merrick, 1987; Brush 1992, 1993). In addition, it was mostly considered as more appropriate to wild plant genetic resources. Nevertheless, due to recent awareness on biodiversity conservation *in situ* conservation has been generally receiving increased attention even in the case of crop genetic resources. This is mainly because of its ability to maintain the evolutionary potential of species and populations especially in the hands of farmers and communities, and because it helps increase the access to and control of local communities over their genetic resources (Jarvis, 1999; Ramanatha Rao *et al*, 2000). However, given the fact that human activities can cause habitat destruction and loss of biodiversity in some cases, and the maintenance of biodiversity in other cases, it will be necessary to complement it with *ex situ* conservation. Any *in situ* conservation (wild or on-farm) activities must focus on assessing, locating and monitoring diversity. It is the information on genetic diversity - how much and where it is located and how it is changing over space and time – that is the most important for conservation and more so for utilization of that diversity (Ramanatha Rao and Sthapit, 2012). Although in this paper the terms 'on-farm conservation' and '*in situ* conservation' are used as interchangeable, it is important to note that *in situ* conservation crop biodiversity could be considered as having 2 components- **on-farm conservation** of traditional crop cultivars (landraces) or farming systems by farmers within traditional agricultural systems and ***in situ* conservation** ofcrop wild relatives and naturally occurring useful plants in natural habitat. The later, at times, can be linked with the larger biodiversity conservation efforts (protected areas, forest conservation etc.) (Ramanatha Rao and Sthapit 2012). This approach to conservation has been gaining importance in recent years, though farmers have been using it for centuries.

Underutilized fruit and tree spices (UFTS)

Although the term 'underutilized' crop has been defined in various ways in world literature, most of these have been given importance to features, among others, like linkages with the cultural heritage of the locality, multiple uses, traditional crops in localized areas, and neglected by agricultural research and development agencies. We believe this applies equally to fruit crops and tree spices. For the purpose of this paper, we have adopted the definition given by IPGRI- Underutilized crops are those marginalized by farmers and consumers due to agronomic, genetic, economic, environmental and cultural reason, which were once important and major crop in the community (IPGRI 2000). It may be useful to develop a check list of criteria for selecting UUFTS in India, so that work on them could be more focused. The following are some such criteria (modified from von Maydell, 1989).

» They should be in demand or have potential for generating demand
» They should be accepted by people, often something to do with cultural identity/ importance
» They should have low risk or have risks that can be managed easily
» They should be free from negative properties of effects
» They should be adapted to local conditions, often vital in specific ecosystems
» They should be easy and safe to establish, with low inputs
» They should be fast growing and shorter gestation period
» They should produce high yields and/or produce high quality produce
» They should be compatible with other land uses
» They should be important for food security, if not for subsistence itself in a locality/region

Based on such criteria, few of the important UTFS are listed in Table 1, which is by no means to be considered as exhaustive and is limited to some examples. This table includes only species that are native to South Asia or those that were introduced long ago and have naturalised in India. Most of the more recent introductions, such as mangosteen (*Garcinia mangostana* L.), velvet apple (*Diospyros blancoi* A.DC.), durian (*Durio zebethinus* Murr.), not included, the reasons for which will be discussed later on.

Common Name(s)/ Botanical Name	**Distribution/cultivation in India**	**Main uses in India**
Karonda *Carissa carandas* L.	Native to India, mostly distributed in all the montane areas, extending into Nepal and Afghanistan	Rich source of iron- treatment of anaemia. Fair amount of Vitamin C, Used mainly for pickling and as ingredient in jelly, jam, syrup and chutney. Valuable for stabilizing eroding slopes.
Custard apple *Annona squamosa* L.	Native to the tropical Americas and West Indies, but the exact origin is unknown. A post-Columbian introduction, it grows in all tropical and sub-tropical areas in India.	Fresh consumption. Oil extracted from seeds used as pesticide.

Panampulli or Vilaiti Imli *Garcinia gummi-gutta* (L.) Roxb. (syn*Garcinia cambogia* (Gaertn.) Desr.	Mainly in the Western Ghats	Rind extract used as a food ingredient. Used in traditional medicine. Hydroxycitric acid form fruit is purported to help in weight loss
Rose apple *Syzygium jambos* (L.) Alston	Date of introduction from SE Asia, is unknown, but appears to have naturalized in south Indian conditions, especially in southern Western Ghats	Good source of vitamin C; fruit can be eaten raw or used in recipes.
Jackfruit *Artocarpus heterophyllus* Lam.	Native to South and Southeast Asia, and is believed to have originated in the south-western rain forests of India, Widely cultivated and popular food item in tropical regions of India, Bangladesh, Nepal, Sri Lanka, and several SE Asian countries.	Fresh consumption, cooking etc. Timber.
Bael, Quince *Aegle marmelos (L)* Correa.	Native to India. It is present throughout Southeast Asia as a naturalized species.	Eastern fresh or dried. Young leaves and shoots as salad. Medicinal uses
Jamun *Syzygium cumini* (L.) Skeels.	Origin in South Asia and distributed in Bangladesh, India, Nepal, Pakistan, Sri Lanka, Malaysia, the Philippines, and Indonesia	Fresh consumption, juices, natural dyes, medicinal.
Aonla *Phyllanthus emblica* L. (*Emblica officinalis* Gaertn.)	Native to tropical south and southeastern Asia, mainly in central and southern India, Pakistan, Bangladesh, and Sri Lanka.	Pickles, juices and medicinal purposes.
Phalsa *Grewia asiatica* L.	Native to south Asia, is distributed from Pakistan, India east to Cambodia. Cultivated in many tropical countries	Fresh fruit consumed, made into juice, tree bark for medicinal purpose
Carambola/Starfruit *Averrhoa carambola* L.	Native to Southeast Asia and the Indian Subcontinent	Fruits eaten fresh, mixed with other fruits, in salads, made into rinks, can be stewed, pickled, made into chutney and jam.
Tamarind *Tamarindus indica* L.	Probably indigenous to tropical Africa, but has been cultivated in Indian for over 2000 years and highly naturalized	A tree spice. Culinary uses, jam, blended into juices or sweetened drinks, sorbets, ice creams and all manner of snacks. Timber. etc.

Walnut *Juglans regia* L.	Native to Central Asia, extending from Xinjiang province of western China, lower ranges of mountains in Nepal, Bhutan, Tibet, northern India, Pakistan and Sri Lanka.	Nuts, timber.
Elephant apple*Dillenia indica* L.	Native to South and south-eastern Asia	Not cultivated. The fruit pulp is bitter-sour and used in Indian cuisine in curries, jam and jellies; mixed with coconut and spices to make chutneys
Cinnamon *Cinnamomum verum* J.Presl	Occurs naturally in the forests of Western Ghats and commercially cultivated in Kerala, Karnataka and Tamil Nadu.	Bark is used as spice
Nutmeg *Myristica fragrans* Houtt.	Native to the Banda Islands in the Moluccas, Indonesia. n Malaysia, in the Caribbean, and in Kerala	Tree spice

Some important features of UUFTS are briefly mentioned below and effect of these features (Box 1) on their *in situ* conservation will be discussed in a later section. It is important to note here that different crops or crop categories are underutilized to very different degrees and in different aspects and suggest practical means to quantify these differences (Galluzzi and Noriega, 2014) and in different regions of a country.

Box 1. Features commonly attributed to UU crops (Galluzzi and Noriega, 2014)

» Limited research efforts devoted to the species

» Limited representation of the species in globally available *ex situ* collections

» Limited representation of the species in national *ex situ* collections

» Limited efforts in germplasm characterization

» Limited knowledge of the species' distribution and production levels

» Lack of plant breeding efforts and commercial varieties of the crop species

On-farm and *in situ* conservation

The effects of growers-practices and preferences are of paramount importance for conservation and utilization of crop genetic resources, while in the case of plant species that are gathered from the wild (example, elephant apple), the level of extraction becomes very important.

Role of *in situ*/on-farm conservation

It is now well recognized that the *in situcamp*/on-farm conservation of agrobiodiversity helps not only to conserve the genetic diversity in target crop species, but also the evolutionary processes and the ecosystems that host the genetic diversity. On-farm conservation can play a role in other several aspects of an ecosystem (such as ecosystem health, services and functions) and in socioeconomics of communities that are involved in such conservation efforts. Following are some areas in which on-farm conservation may play some role (Ramanatha Rao 2000):

Essential information for starting an on-farm/*in situ* conservation programme(Ramanatha Rao and Sthapit 2001; Maxted et al. 1997)

- » The extent and distribution of diversity maintained on farm or in the forests
- » The processes used to maintain this diversity
- » Who is maintaining this diversity?
- » The factors that influence these people to maintain diversity on farm or in the wild
- » Direct and indirect values of genetic diversity in terms of economic and socio-cultural benefits, ecological benefits and genetic benefits.

1. Conservation of the processes of evolution and adaptation
2. Conservation of diversity at all levels (ecosystems, species, intra-specific)
3. Integrating farmers/communities into national conservation systems
4. Conservation of ecosystem services and ecosystem health
5. Maintaining the process of local crop development
6. Improving the livelihoods and quality of life of farmers
7. Empowering farmers and communities over their crop genetic resources and improving access to them
8. Providing information for national seed policy decisions regarding importance traditional seed supply system
9. A component of complementary conservation strategy-linking farmers to genebank

A well-organized *in situ* conservation programme may accomplish several things, including (Ramanatha Rao and Sthapit 2012):

- » nurturing responsibility and improving one's ability to respond to adverse conditions.
- » promoting leadership qualities among the active participants
- » empowering those that are usually at the bottom of the pyramid
- » promoting the ability to work as a team and capacity to manage teams
- » encouraging participants to be aware of their social responsibilities and trusteeship

» consolidating custodians and community role in community based management of agricultural biodiversity as a proxy method to realize on-farm conservation

Establishing an *in situ* conservation programme

To establish an *in situ* conservation programme for agricultural crops and their wild relatives (note that much of the following discussion focuses on crop species, most of the principles apply to their wild relatives as well, with certain modifications per the context) we will need to consider the following broad requirements (for details on each of these, see Ramanatha Rao and Sthapit 2012):

» Institutional framework
» Sensitizing and strengthening local community
» Collaboration
» Framework for collaboration
» Representative partnerships and equitable sharing of benefits

Process of On-farm Conservation

Once understanding between institutions, collaborators and farming communities has been reached, and most of the researchers and other partners understand the nuances of participatory approaches to conservation, the actual on-farm conservation work could start. This would include preparation, site selection, sampling and developing and putting in place the mechanisms for on-farm management of agrobiodiversity. Ahead of site selection, the existing data such as descriptor lists, databases of e*x situ* germplasm collections, herbarium collections, published literature in the natural and social sciences and other unpublished information shall be collected and used for eliminating inappropriate sites. Personal knowledge of experts, including personnel from NGOs, CBOs, and others existing local institutions would be most valuable. Simultaneously, the criteria for site and farmer selection have to be well defined. Broadly speaking, the criteria would be based on the genetic diversity, accessibility and interest of the farmers to continue to grow the varieties that are being targeted and these will have to be evaluated through a survey. Some generalized criteria that could be used for developing an on-farm conservation programme could include (Ramanatha Rao and Sthapit 2012):

1. Ecosystems: Select sites in diverse agroecosystems preferably with different ecotypes to ensure conservation of larger range of crop genetic diversity.
2. Intra-specific diversity within target species: It is important that the areas selected are grown to different landraces.
3. Specific adaptations: Efforts should be made while selecting different agroecosystems (see 1 above) to select sites with extreme environmental conditions (high soil salinity, cold temperatures, etc) and variation in pests. This will help to include types with specific adaptations.
4. Genetic erosion: For obvious reasons, it is better to select sites with less threat of genetic erosion to increase the life of conservation efforts.

5. Diverse use values: It is possible to ensure conservation of hidden genetic diversity by selecting sites with diverse use values of crops for food and other uses.
6. Farmers and communities: Farmer's interest and willingness to participate are keys in site selection and clear acceptance of the importance of target crops for various ways of life; farmers' knowledge and skills in seed selection and exchange; and market opportunities
7. Partners: Partners with interest in community and cooperation, experience in conservation interventions and community participation expertise.
8. Logistics: These would include mainly the accessibility of the site throughout the year (in *in situ* conservation monitoring is essential) and availability of resources.

The existing data should be combined with an exploratory survey, using a Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), or a similar approach. The Community needs to be sensitised to issues on hand and for this use of participatory approach is recommended (Ramanatha Rao and Sthapit 2012; Sthapit et al., 2012; Subedi et al; 2013; Biggs 1988). Community biodiversity management (CBM) is an approach that empowers custodian HHs and farming communities to manage local genetic resources for sustainable livelihoods through collective decision-making. Empowerment of farming communities, conservation of agricultural biodiversity and supporting biodiversity-based livelihoods are the three building blocks of CBM approach. CBM integrates knowledge and practices embedded within local, social and cultural systems (Subedi and Sthapit et al. 2006). CBM can only be achieved by recognizing and strengthening communities and their institutions from the onset of any intervention by a conservation or development organization. CBM is a process-led methodology that builds on the capacities and interest of farming communities and, frequently, on their existing community structures (see figures) and therefore, takes time to produce results. The CBM approach is driven by four key principles to ensure empowerment (knowledge), livelihoods (benefits) and conservation (sustainability) (Sthapit et al., 2012):

1. Let the locals lead
2. Build on local innovations, practices and resources
3. Diversify biodiversity-based livelihood options
4. Provide a platform for social learning and collective action.

This approach will afford greater opportunities in life to the disadvantaged community

The primary considerations before launching and *in situ* conservation of crop genetic diversity are 1. Benefits to farmers and 2.Identifying crop genetic diversity to conserve *in situ*. As *in situ* conservation of crop biodiversity is a long-term programme, it requires control of land rights in local communities, education, extension and development of environmental awareness. Once again it is reiterated that any *in situ* conservation programme should benefit the local communities. Management by local communities can often be developed to effectively link conservation and use. Thus, peoples' participation and cooperation between local people, researchers and conservationists and NGOs, is paramount for the success of on-farm conservation efforts. One should also consider the establishment of areas of intensive management or high yielding plantations within the areas and reserve forests where *in situ* sites are located. This would help in long term sustainability of *in situ* conservation programmes. It should also be underlined that, during the course of *in situ* conservation, there can always be unforeseen developments (social, developmental, environmental) that can interfere with the continued conservation of crop genetic diversity; however, such situations need be dealt with when they occur and should not be factor to dissuade our on-farm conservation efforts.

Initial steps in launching an *in situ* conservation programme for any crop genetic resource, including wild relatives could be (Ramanatha Rao and Sthapit 2012):

» Identify sites with typical ecotypes/landraces of the target crops in country concerned

» Identify crop wild relatives and target UUFTS species in natural habitats, forested areas, protected areas etc.

» Identify organizations and communities that are stakeholders

» Identify threats to continued maintenance of farms and forested areas with unique and diverse crop cultivars and wild relatives

» Identify means to remove the threats in short term (to gain time to put in place the longer term efforts)

» Ensure continued management of such farms and forested areas by enhancing benefits to farmers, the custodians of genetic diversity and the people living in and near forests

» Identify means to remove the threats in the long term (these could full understanding of the context for *in situ* conservation of crops and wild relatives, and other issues such as adding value, market incentives, improving the current cultivar for specific traits so that the maximum diversity is maintained, ecotourism, sustainable harvesting etc.)

» Identify sustainable ways to monitor genetic erosion of crop genetic diversity using help of local institutions or organizing participatory approaches such as diversity fairs and CBR by the local community itself.

Next Steps

The following general process of *in situ* conservation may be useful in moving forward in this are:

» Creating (or using existing) institutional framework and management

» Site selection (Training could be provided to national programme personnel how to do it in participatory manner)

» Sensitizing and strengthening local community and institutions

» Locating diversity (e.g. crop diversity fairs, forest surveys)

» Measuring and assessing diversity

» Understanding value of genetic diversity

» Understanding and validating the processes that maintain diversity

» Monitoring diversity (e.g. Community biodiversity register)

» Developing strategy for on-farm/*in situ* conservation

» Linking problems with new opportunities (capacity of local farming community enhanced using CBR and diversity fair, adding value through market and non-market incentives etc.)
» Identification of custodians of diversity and providing incentives
» Delineating good practices that lead to either maintaining and/or enhancing diversity and adopting and implementing
» Institutionalizing on-farm/*in situ* conservation strategy integrating farmers into national PGR system

There will be a need for national partners to spend some time to work out above processes in the context of underutilized crops and specific target crop farming system. Community participation is central to *in situ* conservation, which needs substantial input from national partners to sensitize the national programmes and communities before a pilot scale *in situ* conservation strategy for any crop could be developed.

In situ/on-farm conservation of underutilized fruit and tree spices

In forgone sections we have discussed briefly on UUFTS and various consideration that need to be looked into starting an *in situ* conservation programme. We shall now attempt to see how these two can be bought together. The merger of this would depend mostly on the context (i.e. location where the programme will be undertaken and local support for the programme) and the specific features of the UUFTS. The former cannot be considered now, for obvious reasons. So we will look at the specific needs of UUFTS.

Introduced UUFTs

Initially, we had mentioned that we will not be considering the introduced spices for this work. Reason for this is quite simple. Conservation of introduces species is not a priority for India. Technically speaking, such species usually possess little genetic diversity as the sample size at the introduction may be (usually it is) very small. In addition, as most of the introductions (at least those that are legally introduced into the country) would have been taken from an institutional collection which might have already gone through a genetic bottleneck, thus reducing further genetic diversity in them.

Limited research efforts devoted to the species

In the section on 'On-farm and *in situ* conservation' we have noted that for implementing a workable on-farm/*in situ* conservation programme we need information on: the extent and distribution of diversity maintained on farm or in the forests; the processes used to maintain this diversity, breeding systems and population genetics, etc. Since globally the research efforts are mostly focused on major food and fruit crops, there is very little information on these issues for most of UUFTS. There is a need to overcome this lack of information through increased research on issues like, genetic diversity, farming communities and local knowledge, product development, nutritional values and marketing.

Limited representation of the species in globally and nationally available ex situ collections

This may not be directly related to establish on-farm conservation programme on UUFTS. However, having large collections in genebanks help researchers to focus on them in their efforts to understand the species and crops.Taking examples from other crops, including fruit and spice crops. Having selected materials in genebanks help in newer approaches such as linking genebanks with farmers and communities and use the available genetic diversity in *ex situ* for improving its access to farmers and use them to provide short term benefits to communities, while long term *in situ* conservation efforts.

Limited efforts in germplasm characterization:

This problem limits studies on UUFTS, which, as noted above are fundamental to put in place conservation programmes. For proper characterization, internationally accepted descriptors seem to be available only for jackfruit (IPGRI 2000) and for others there appear to be minimal descriptors by the National Bureau of Plant genetic resources (NBPGR) (Mahajan et al. 2002). These need to be refined with the addition of descriptors on ethnobotany and local knowledge so that the can be really useful in for implementing on-farm conservation programmes.

As noted earlier, the list presented in Table 1 is \is not an exhaustive. There are many more, localized fruit species that are mainly gathered from the wild which may be highly nutritious and paly role in the food and nutrition of rural populations Such fruit species need to be properly characterized and evaluated and measures for their conservation and use need to be undertake. For such species, *in situ* conservation in conjunction with forest conservation would probably quite appropriate.

Limited knowledge of the species' distribution and production levels:

Literature search reveals that, except of a few of the UUFTS (e.g. jackfruit) there is very little information on their distribution, production areas and quantity produced. Farmers practising low-input agriculture and in marginal areas have been conserving significant amounts of plant genetic diversity, on both the species and interspecies levels. They depend on varietal mixtures, multiple crops, intercropping, home gardens and polycultures, as well as on genetically diverse varieties of individual crops. Monitoring genetic diversity at community level helps to develop options for adding value of local crops and integrated local institutions into PGR conservation through use and market promotion (Sthapit et al. 2001; 2012). Documenting the amount and distribution of genetic diversity on-farm requires information on the genetic identity of farmer named varieties, the genetic structure of populations, the pattern of farmer named variety occurrence, and the seed supply systems (Jarvis et al., 2000; 2007; 2010).

Lack of plant breeding efforts and commercial varieties of the crop species:

Unlike the other features above, this is some sort of blessing in disguise. Except in few UUFTS, very little genetic improvement efforts have been made. This has resulted that the farmers have been grown diverse and divergent cultivars of UUFTS. Such a situation is a good starting point for following *in situ* conservation approach. In addition, a number of UUFTS may still be being exploited by gathering/

collecting from wild/forested areas. Hence, it should be possible integrate conservation of such species with forest conservation/protection.

Concluding remarks

In situ conservation or on-farm conservation of crop genetic diversity is feasible and should be component of any national effort to conserve crop genetic resources. However, currently *ex situ* approach appears to be the main focus of many national programmes. There is a need for shift of focus on increased used of *in situ* approach. Together these two approaches will help us effectively conserve and provide access to maximum crop genetic diversity that will be required to meet future demand for food, feed and other human needs. For doing so, we need to understand how farmers value crop diversity, how they select and exchange the materials within and between communities so that sustainable crop genetic resources conservation *in situ* can be achieved. In addition, on-farm conservation will assist the researchers to work towards the development goals of the conservation efforts, i.e. the well being of our main partners, the farmers.

The UUFTS as fruit and spice crops are those marginalized by farmers and consumers due to agronomic, genetic, economic, environmental and cultural reason, which were once important and major crop in the community. Such crops have the potential to play a number of roles in the improvement of food security that including- subsistence, income generation, risk-avoidance, avoiding over-reliance on major crops and in preserving/maintaining cultural and dietary diversity. Application of *in situ*/on-farm conservation approach to UUFTS, requires to fit this approach to the peculiar features of most of the underutilized crop genetic resources.

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Genetic resource management of underutilized fruits of Western ghats

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Western Ghats region is one of the 33 recognized ecologically sensitive zones in the World. India has four such sensitive zones. The Western Ghats is a long stretch ranging from Gujarat in the North to Kerala in the South, the pristine bio-geographical region covers an area of 160,000 km^2 between the latitudes 8020' and 2004' N and the longitudes 730 and 770 E, stretches parallel to the west coast of the Peninsular India for about 1600 km in length. It starts in the Tapti Valley which is situated between Gujarat and Maharashtra. It has over 7,400 species of flowering plants, 139 mammal species, 508 bird species, 179 amphibian species and 288 fresh water fish species; it is likely that many undiscovered species live in the Western Ghats. At least 325 globally threatened species occur in the Western Ghats. This is one of the centers with remarkable plant diversity in wild relatives of crop plants. The tropical rain forest of theWestern Ghats region is remarkably rich in terms of lesser known wild fruit plant diversity.

The tropical rain forests occurring on the slopes of these mountain ranges are of Gondwana landmass origin and known to host about 4000 Angiosperm species. According to current information, there are 1500 endemic species, which include 1215 tree species with 352 endemics.Thespecies richness and degree of endemism are remarkably affluent in some pockets likeatAgasthyamalai and Nilgiri hills of the Southern Western Ghats and those regionsarerecognized as centers of plant diversity by WWF & IUCN. This biogeographic zonehasmulti dimensional affinities with distant landmasses like Malaysia, Africa and Polynesia.According to phyto-geographical analysis, the West coastand the Western Ghats of the Peninsular India (Malabar Province) is included under theIndo-Malaysian Subkingdom of the Palaeotropical Kingdom comprising African, Indo-Malaysian and Polynesian regions. Wild edible plants have sustained human populations in each of the inhabited continents. Human consumption of wild plants has been documented from antiquity to the Common Era. Dietary use of wild fruits, nuts, seeds, and leaves appear in numerous historical records. Today, most human plant foods are based on a rather limited number of crops. However, it is clear that in many parts of the world, the use of wild plants is not negligible.

In India, the indigenous fruits collected from the wild play a significant role in the food and utrient security of rural poor and tribals. Some wild fruits have been identified to havebetter nutritional value than cultivated fruits. Fruits serve as alternatives to staple food during periods of food deficit and are the valuable supplements for a nutritionally balanced diet and are one of the primary alternative source of income for many resource poor communities, besides a source of species for domestication. Apart from their traditional use as food, these wild plants have potentially many advantages. They are used as medicine, fodder, and for sacred rituals and are used in traditional functions. The edibles having nutritional food value provide minerals like sodium, potassium, magnesium, iron, calcium, and osphorus and are not in daily use. They are resistant to many pests and diseases and are often used in different formulations of Indian folk medicine. These fruits, which have rich nutritional/medicinal value and are not in regular cultivation as crops like major fruit crops, are termed underutilized fruits.

Four groups of underutilized diversity of fruits and nuts are:

1. Lesser utilized species confined to only local tribal cultivation.
2. Commonly cultivated species by the tribal population with several unidentified utilities
3. Species those which have not under cultivation practice but harvested from the wild.
4. Species those which regionally under cultivation, but their value has been confirmed elsewhere under similar climatic conditions.

Almost all fruit species having medicinal properties are used in various traditional systems of medicines. These are not under cultivation but mostly harvesting is done from the wild. Some wild edible fruits like *Artocarpus hirsutus* Lamk., *Syzygium laetum, Syzygium zeylanicum*, *Syzygium gardeneri* Thw. *Elaeocarpus serr*atus L., *Elaeocarpus munronii* (Wt.) Mast., *Baccaurea courtallensis* Muell-Arg., *Buchanania barberi* Gamb., *Buchanania lanceolate.,Salacia beddomei* Gamb., *Salacia fruticosa*, *Salacia macrosperma* Wt. *Alangium salvifolium*, *Elaeagnus conferta*, and wild relatives of cultivars like *Flacourtia montana* Grah., *Syzygium cumini* L., wild varieties of mango species (*Mangifera indica* L.) and Malabar Tamarind (*Garcinia gummigutta*), are rarely under cultivation in homesteads and gardens.

The underutilized fruit species indigenous to the Western Ghats region could be broadly classified into wild edible fruits, wild relatives of cultivars, medicinal fruits, wild relatives of spices and condiments, toxic fruits, ornamental fruits, narcotic & stimulant fruits and wild fruits used for rituals and ceremonies. There are several wild edible underutilized species which are not known to modern civilization, mostly known to local folks and tribes, owing to their natural distribution and confined to narrow isolated pockets or landscape Shola forest regions.

The wild relatives of popular cultivars of fruits and nuts are another category having significant role in modern horticulture. Wild progenitors of mango (*Mangiferaindica*L.), plantains (*Musa acuminata* ssp burmanica), Malabar tamarind (*Garcinia gummi-gutta*), lovi-lovi (*Flacourtiamontana*), date palm (*Phoenix laureirii*) are a few examples of wild relatives of popular fruit plant cultivars. *Buchanania barberi B. lanceolate, B.lanzan*, *B. axillaries* etc are wild edible nuts occurring on the slopes of the Western Ghat region in Kerala. Several wild fruits are used in Ayurvedic preparations used for the health care of Keralites. *Emblica officinalis*, *Terminalia arjun, T. chebula, Aegle marmelos, Solanumtorvum, S. xanthocarpum, Hydnocarpus hexapetalum,Strychnos nux-vomica, Mucumapruriens, Garcinia gummi-gutta, Piper longum*are a few examples of wild fruit collections used in ayurvedic systems of treatment and health care practice.

Wild relatives of spices and condiments are another significant category in the history of fruit plants. The Pepper and cardamom of the Malabar Coast had played the significant role in the invasion of Europeans Indian Subcontinent. The Wild prototypes of *Piper nigrum* and *Elettaria cardamomum* are still occurring and distributed in several regions of the Western Ghats. *Myristica malabarica, M.dactyloides, Knema attenuata, Garcinia gummi-gutta, G.indica* etc are examples for wild relatives of spices and condiments.

There are several wild plants having promising ornamental fruits which can be domesticated for beautification of gardens and avenues. *Syzygium zeylanicum, Eugenia bracteata, Salacia chinensis, Dillenia* *indica, Dillenia pentagyna, Flacourtia montana, Baccaurea courtallensis, Enseta superba, Ficus benjamina, Mesua ferrea, Garciniamorella, G. indica, Heritiera littoralis, Sterculia guttata,Ochna obtusat, Dysoxylum malabaricum, Aphanamixis polystachya, Ximenia americana* are promising species.

Toxic fruit plants are also found growing in certain parts of Western Ghats. *Crotontiglium, Datura metal, Cerbera odolum, Adenia hondalum, Strychnos nux-vomica* are a few examples of species which produce severe toxic fruits. *Croton tiglium* fruits are used as fish poisoning for fishing from large watersheds and lagoons at several regions.

There are wild fruits which used as natural stimulant to enhance energy. *Trichopus zeylanicus* sp. *travancorensis* is an endemic herb reported from Kerala having this property. This information was a traditional know-how of the 'Kani' tribe in Kerala. Fruits have amazing attributes in the bio- cultural diversity. Well known are the use of coconut, areca nut, mango, banana, guava are common fruits used in rituals and religious ceremonies as offerings to the Gods or Goddesses in the Hindu temples in Kerala. They have the traditional belief that the first fruit of their harvest has to be offered to the God or Goddess. Some wild fruits are also used for this purpose especially by the tribal communities. *Artocarpushirsutus* fruits are one of them used as an offering to God at some places in the southernpart of Western Ghats.

The tribe populations of Western Ghat region play an important role in identification of nutritional and medicinal values of these underutilized fruits as they are the major consumers of these fruits. Several tribal communities throughout the stretch of Western Ghats have reported wild edible fruits with multipurpose utilization. For example, thirty eight species of wild edible fruits belonging to 25 genera and 17 families used by Muthuvans were recorded. Due to climate change, the level of poverty and environmental degradation, there is a high risk of biodiversity loss at a large scale. Under such circumstances, the knowledge and uses of nutritious, climatically adapted wild edible fruits will be irreversibly lost. Hence, research is needed to increase awareness on the use and genetic resource management of wild edible fruits.

The entire area of the Nilgiris constitutes the present district of Nilgiri in Tamil Nadu. It was originally a tribal land and was occupied by the Todas, Kotas, Kurumbas, Kattunayakkas and Panyas. Among them, the Badagas are one of the major communities in the district who reside in the mountain as long as other tribal populations lived. The weather in this district favors the growth of wild edible fruits. There are many edible fruits existing naturally in forest as well as in the fringe near in situ forest cultivable areas. These fruit plants are playing a vital role in providing nutritional and economic values in the rural areas. Badaga tribes of Nilgiri District use more than 30 wild fruits for their cultivation and self consumption purpose. But the commercial importance and the market value of these wild fruits is relatively unknown to them. Hence a research study is required to explore these fruits and effectively manage the resources of wild edible fruits and enhance their cultivation prospects inlarge scale which would go a long way in uplifting their economic status in near future. India is one of the twelve mega diversity in the world.

The Nilgiris falls within the Western Ghats and is considered to be a home of more than 3500 species of wild plants. The forest of the Nilgiris provide a large number of plants whose fruits, seeds, tubers, shoots etc. make an important contribution to the diet of the people, particularly those living near forest and other rural areas. These plants not only provide in expensive food but several other useful products like medicine, fiber, fodder, dyes, etc. Historically, fruits have been used as medicinal agents. These fruits contain a significant level of biologically active components with rich source of vitamins,minerals and other nutrients, but in contrast, wild fruits are often viewed with distrust. With the use of underutilized fruits less known, these local inhabitants tend to destroy the wild areas with such fruits for cultivation purpose. Recent phytochemical investigations in fruits have attracted a great deal of attention on their role in preventing malnutrition. Though there are many wild fruits in the western ghat region, there is no organized prospecting, exploration collection, evaluation, characterization, conservation, documentation and improvement for identification of superior genotypes for development of agro–techniques. Hence much emphasis should be given to these aspects, besides studying nutritional and anti-oxidant properties,product development and marketing. The fruits are nature's gift to mankind. These wild fruits are chiefsource of vitamins, minerals and proteins. These constituents are essential for normalwell being and help in maintaining a healthy state. There are less known edible fruit-yielding plants from Nilgiris. These underutilized fruits have played a vital role in supplementing the diet of the people.

Due to the introduction of exotic varieties, the dependence on wild fruits in urban areas has gradually declined. But many tribal pockets still use them as a supplement to their food. Some of them are preserved for the use in the dry period or sold in the rural market. But the popularity of these wild forms has recently decreased. These are generally used as raw or processed, which help to compensate the day-to-day requirement of calories. These fruits play a significant role in human nutrition, especially as sources of carbohydrates, proteins, vitamins C (ascorbic acid), A, thiamine (B1), niacin (B3), pyridoxine (B6), folacin (also known as folic acid or folate) (B9), E], minerals, dietary fiber and enormous medicinal potential [2-5] Their contribution as a group is estimated at 91% of vitamin C, 48% of vitamin A, 30% of folacin, 27% of vitamin B6, 17% of thiamine, and 15% of niacin in the diet. Fruits and vegetables also supply 16% of magnesium, 19% of iron, and 9% of calories. They provide fiber which prevents constipation. The enhanced production and consumption of these fruits in arid zones provide dietary supplementation as well as commercialopportunities. Plant species documented as wild used for foodpurposes. This includes 11 fruit species which were investigated for their nutritional foodvalue and medicine. It has been observed that the traditionalknowledge is worthy and valuable. There are a few positive points in favour of fruits cultivation and the value of quite a few under-utilized fruits remains unexplored and under-exploited. Quite a few of them besides being nutritionally rich are also of great medicinal value. Secondary market interests of diversified diets, greater health and foods required to improve nutrition haveconsiderably strengthened the use of fruits by the modern consumer. Many of thembesides being reservoir of vital minerals and vitamins are also of therapeutic value.

Cellular antioxidant activity (CAA), total phenolic content, and oxygen radical absorbance capacity (ORAC) values of 25 less known fruits have been analyzed. The antioxidant compound resveratrol found in grapes skin (and thus red wine) is good for cardiovascular health. Grapes may help lower blood pressure and signs of heart muscle damage, and improve heart function. Wild blueberries are the top notchers in antioxidant activity based on these parameters (cultivated blueberries showed less antioxidant activity).Pomegranates,blackberries, raspberries and cranberries also have good scores while apples andstrawberries aren't that high in antioxidants, comparatively. Bananas and melons turnedout low scores. Cherries may help lower the risk of metabolic syndrome (also calledinsulin resistance syndrome) andcardiovascular disease. Some food-based alternativetherapies used for relieving symptoms of allergic rhinitis include bromelain, found inpineapples. Pomegranates have very high antioxidant activity, offering brain and memoryprotection. Research shows that drinking pomegranate juice may help with loweringthe risk for hardening of the arteries or atherosclerosis. Cancer-preventive properties ofpomegranate juice, specifically against lung and prostate cancer have been documented.Anthocyanidins are a group of naturally occurring antioxidants found in many fruits as wellas red wine which have previously been proven to have chemo therapeutic properties.

These compounds can also selectively kill leukemia cells in culture without discernible toxicity against healthy cells.Wild fruit plants can be inter-cropped with commercial crop plants. This willreduce food scarcity, improve economy in tribal areas and help in rejuvenation of barren lands.From the past, fruits have played a very vital role as a dietary supplement. The dependence on these fruits has gradually declined as more exotic fruits havebeen introduced into the market. But many people in tribal areas still use locally available fruitsand supplement their basic food. Some of them are preserved for use in dry period or sold in rural market. Special attention must be given to this group of fruits in order tomaintain and improve this source of food supplement. Overall, a wider and sustained acceptance of wild fruits as important dietary components must bestimulated. A scientific study of underutilized fruits is important for the potential sources whichcould be utilized at the time of scarcity or during normal days or cultivated as a source offood material for an ever increasing population. Fruits have high quality edible proteinsto warrant their use in food industries and as nutraceuticals. Of the total floristic wealth of about15,000 species of angiosperms available in India, about 1,000 species fall into the wildedible fruit plant category. Many of the wild edible plants and fruit species are rich in nutrients. This plant wealth is being used in various forms only by tribal and natives of the area. But it is a pity that the rich plant wealth is vanishing rapidly due to various factors, such as climate change and associated human activities. As a result, there is ecological imbalance resulting in depletion of wild plant resources which include underutilizedfruit plants.

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Status of underutilized fruit crops in Northeast India

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The North Eastern region of India, comprises of eight states, *viz*., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim lies between 21°57' and 29°28' north latitude and 89°40' to 97°50' east longitude. The total geographical area of the region is 2.55 lakh km^2, which is about 8% of the country's total area. The horticultural crops are contributing 3.52% of the total geographical area of the region. The physiography of the region is divided into three divisions, *viz*., Meghalaya plateau, the North Eastern hills and the Brahmaputra valley. The NE hills alone accounts for 65% of the total land area while the Brahmaputra valley and the Meghalaya Plateau cover 22% and 13% of the area respectively. The unique agro-ecological and phyto-geographical conditions of the region offer scope for cultivation of a wide variety of horticultural crops. Moreover, the region has a great variability and diverse types of underutilized fruit trees that exist in the forest, while some are semi-cultivated.

The fruit crops, which are neither grown commercially on large scale nor traded widely, may be termed as underutilized fruit crops. These crops are cultivated, traded and consumed locally. The popularity of these fruit crops varies from crop to crop and locality to locality, which however, can be enhanced to a greater extent through publicity. The underutilized fruit crops have many merits such as hardy in nature, hence, easier to grow and produce good crop even under adverse agro-climatic conditions. They have the potential to play a number of roles in the improvement of nutritional and medicinal security. Moreover, these are cheap and readily available. The farmers of India have the awareness about these crops and their medicinal values.

Diversity of underutilized fruit crops in Northeast India

There is no proper estimation on the area and production of underutilized fruit crops in the region. Underutilized fruit crops are mostly collected from natural habitat to meet subsistence needs. Little is known about the ecology; improve varieties, yield and quality of these crops. Similarly, nothing concreate has been done to promote their use and maximize their economic value. Till date, no scientific orchard has been developed for underutilized fruit crops in the region. However, lately a few crops for instance, *Sohiong* (*Prunus nepalensis*), *Sohshang* (*Eleaegnus latifolia*), *Sohphie* (*Myrica fraquhariana*), carambola, aonla etc. are in the stage of domestication and post-harvest packages have also been developed due to their high demand in market.

The region is one of the richest reservoirs of genetic variability with more than 136 horticultural species growing in region, in addition to about 693 species of orchids which are flourishing in the region. This region is endowed with enormous genetic diversity in a number of crops like citrus, banana, mango, rice and maize. It contains as many as 17 citrus species with 53 varieties and 7 probable hybrids and is the natural home of many citrus species like *Citrus indica, C. assamensis, C. latipes, C. ichagensis, C.*

macroptera, C. aurantium and *Citrus reticulata*. Of the 300 edible plant species found in the NE region, some of them are really worth consuming. The various types of underutilized fruit crops found in different state of the regions based on areas and their distribution are presented below.

Table 1. Diversity of underutilized fruit crops in Northeast India

Scientific name	Family	Distribution	Flowering	Fruiting	Economic utility
Actinidia strigosa	Actinidaceae	Sikkim	Feb. –Mar.	Sept .-Nov.	-
A. callosa	Actinidaceae	Arunachal Pradesh (AP)	Mar. - April	Sept. – Nov.	-
Baccaurea sapida (Roxb.) Muell.-Arg.	Euphorbiaceae	Sikkim, Meghalaya, Assam, AP, Tripura.	April - May	May-July	Eaten fresh, Squash
Averrhoea carambola L	Oxalidaceae	Meghalaya, Assam	-	March-April	Eaten fresh, squash
Docynia indica D. hookeriana	Rosaceae	Meghalaya Sikkim	Feb-March	Aug-Sept	Eaten fresh, pickle, Jelly
Emblica officinalis	Euphorbiaceae	All NE States	Oct.-Nov.	Dec.-Jan.	Pickle
Phyllanthus acidus	Euphorbiaceae	Mizoram	-	Dec.-Jan.	Eaten fresh
Elaeagnus latifolia Linn. *E. pyrifolia*	Elaeagnaceae	North east frontier tracts lower Assam Meghalaya	Aug.-Nov. Nov-Feb	March-April Jan-April	Fruit eaten Fresh, Chutney, Jam
Garcinia lanceaefolia	Clusiaceae	Meghalaya, Mizoram, Nagaland, Assam	Feb-March	June-July	Eaten fresh
Garcinia cowa	Clusiaceae	Mizoram	February-March	April-June	Fruit eaten fresh and for juice
Myrica esculenta	Myricaceae	All NEH region	Oct-Nov.	March-April	Pickle, eaten fresh, refresh drink
Myrica fraquhariana	Myricaceae	Assam, Nagaland, Meghalaya.	Oct-Dec.	April-June	Pickle, eaten fresh, refresh drink
Passiflora edulis P. edulis var. flavicarpa	Passifloraceae	Meghalaya, Mizoram, Manipur, Nagaland, Sikkim.	April - June	June - Sept.	Eaten fresh, juice preparation

Pyrus pashia	Rosaceae	Meghalaya	Mar - April	Dec – Jan	Eaten fresh in Khasi & Jaintia Hills, Rootstock for pear
Prunus nepalensis	Rosaceae	Meghalaya, Manipur, Nagaland	Oct-Dec	June - Aug	Eaten fresh, jam, jelly, RTS drink, wine
Dillenia indica	Dilleniaceae	Meghalaya, Assam	March - May	Oct - Nov	Chutney, pickle
Machilus edulis King.	Lauraceae	Sikkim, AP. and other NE Region	-	Nov - March	Pulp of fruit skin eaten
Diploknema butyracea (Roxb.) *Syn. Bassia butyraceae Roxb.*	Sapotaceae	Sikkim, AP.		April - June	Seed produce edible butter, used in soaps, candle and to treat gout and rheumatic.
Phoebe cooperiana Kanjilal & Das	Lauraceae	AP		Aug - Oct	Fruit is eaten raw or cooked.

Nutritional status of underutilized fruit crops of the NEH region

Fruit plants form the major supplier of subsidiary nutrition to the ethnic and local communities among a wide spectrum of wild species in its natural habitats. The nutritive value of underutilized fruit crops is comparable with those of commercial fruit crops. In addition, this fruit plants also possess higher amount of antioxidants properties, which are essential for preventing several lifestyle diseases and disorder of the modern population.

Table 2. Nutritive value of underutilized fruit crops of the NEH Region

Species	**Moisture** (%)	**Ash** (%)	**Fibre** (%)	**Fat** (%)	**Protein** (%)	**Carbo -hydrate** (%)	**Total sugar** (%)	**Lignin** (%)	**Cellulose** (%)
Baccaurea sapida Roxb.	35.39	3.85	20.48	0.73	5.58	51.90	10.87	17.10	13.78
Eleaegnus latifolia L	87.31	3.16	9.30	0.52	7.80	74.06	2.10	2.65	12.87
Prunus cerasoides D. Don	83.00	3.11	7.32	0.59	3.50	84.07	6.96	18.11	11.56
Rubus ellipticus Smith.	80.60	4.10	7.90	7.10	4.00	72.70	8.50	15.10	17.30
Spondias axillaris Roxb.	65.68	2.70	39.90	0.05	4.11	52.28	2.31	19.44	25.81

Zanthozylum rhetuza Wall.	25.55	3.44	11.51	0.53	5.56	76.36	3.61	17.13	16.15
Machilus edulis King	-	2.65	-	25.50	4.51	51.50	2.40	-	-
Diploknema butyracea (Roxb.)	-	3.20	-	1.57	3.81	81.63	8.21	-	-
Docynia indica	-	3.03	-	0.350	1.75	71.73	12.89	-	-

Table 3. Mineral status of underutilized fruit crops of the NEH Region

Species	**N** (%)	**P** (%)	**K** (%)	**Ca** %)	**Fe** %)	**Zn** (%)	**Mg** (%)	**Cu** (%)	**Na** %)
Baccaurea sapida Roxb.	0.78	0.13	0.73	0.16	0.08	600.00	0.51	76.67	0.04
Eleaegnus latifolia L	1.25	0.10	0.91	1.47	0.18	1186.66	0.54	46.66	0.05
Prunus cerasoides D. Don	3.79	0.18	0.47	0.20	0.21	201.66	0.59	11.33	0.04
Spondias axillaris Roxb.	0.35	0.16	0.67	1.58	0.11	831.25	0.68	60.00	-
Zanthozylum rhetuza Wall.	0.87	0.14	0.72	0.88	0.05	1163.33	0.35	116.66	-
Machilus edulis King	-	0.12	0.61	0.15	0.25	-	-	-	0.02
Diploknema butyracea (Roxb.)	-	0.09	0.82	0.82	0.18	-	-	-	0.07
E. indica	-	0.14	0.43	0.12	0.11	-	-	-	0.03

Table 4. Chemical status of underutilized fruit crops of the NEH Region

Species	**T.S.S.** (%)	**Acidity** (%)	**pH**	**Vit. C** (mg/100ml)	**Reducing sugar (%)**	**Total sugar** (%)
Elaeagnus latifolia Linn.	9.1	2.16	-	21.15	1.4	6.09
Phyllanthus acidus	4.68	2.27	4.15	21.15	-	-
Baccaurea sapida (Roxb.)	8.2-14.1	1.93	-	-	5.1	13.69
Garcinia cowa						
1. Juice sac	6.8	2.34	3	42.30	1.01	3.4
2. Rind	5.6	2.37	2.8	21.15	-	-
Myrica sp.						
1. Big size fruit green colour	5.7	4.31	-	17.63	0.97	2.48
2. Small size green colour fruit	6.3	4.83	-	28.2	0.83	2.18
3. Small size pink colour fruit	6.2	2.44	-	4.03	3.57	7.68
Passiflora edulis	14.7	4.42	-	-	-	-
Prunus nepalensis	16-23.20	0.13-0.77		8.81-12.34	-	3.53- 10.37
Prunus cerasoides	6.8			44.27		6.28

Dillenia indica	4.8	1.2	-	-	-	
Rubus ellipticus Smith	6.7			18.38		8
Spondias axillaris Roxb.	10.24			35.29		2.58

Table 5. Antioxidants properties of underutilized fruit crops of the NEH Region

Species	Total phenolic content (GAE mg/g of DM) (Mean	Total flavonoid content (mg/g of DM) (Mean ±Sem)	Total flavonol content (mg/g of DM) (Mean ±Sem)	Ascorbic acid equivalent (mg/g of DM) (Mean ±Sem)	Free radical scavenging ability IC50 value (mg/g of DM) (Mean ±Sem)
Eleaegnus latifolia	10.86	9.67	16.58	15.05	0.25
E. pyrifolia	6.45	1.66	3.52	7.09	0.38
Myrica nagi	16.74	3.79	11.17	17.42	0.27
M. esculenta	28.56	2.25	8.87	19.33	0.16

Technological advancement in underutilized horticultural crops

A very little work has been done for commercial utilization of the underutilized fruit crops of the region. However, based on the demand for improved technology by the end users some work has been initiated by ICAR Research Complex for NEH Region in last few years.

Production Technology of Sohiong (*Prunus nepalensis*)

The best time for harvesting is 270 – 285 days after fruit set (DAFS) when the colour changes from light purple to dark purple. Physico-chemical characteristic were also found to be higher during 270 – 285 DAFS. Sohiong plants are propagated through seeds. Propagation from seeds resulted in variation in fruit quality, long gestation period (> 7 years) and huge canopy size. ICAR Complex for NEH Region standardized the grafting technique to produce true to type, good quality planting materials. The following steps are involved in production of quality grafts.

Seed extraction

Fully matured, ripen fruits should be collected during September for raising rootstocks. The fruits should be soaked in water for 3-4 days for fermentation to remove the pulp adhering on the seed. After removing the pulp, the seeds should be washed in water and shade dried for 24 h.

Raising of rootstock

Freshly extracted dried seeds are kept for 3-4 weeks in moist sand for stratification. Seed coat starts rupturing at 3 weeks of stratification. These ruptured seeds should be sown in poly bags containing equal amount of soil, sand and FYM at about 5 cm depth during October. Seed germination will start about 30 to 45 days after sowing. Soaking of seeds in 100-150 ppm GA3 or 0.5 % Thiourea for overnight will improve the germination.

Selection of scion

The mother tree should be precocious, high yielder, free from pest and diseases and the fruit should possess good quality. Five to six month old shoots with pencil thickness of 25 – 30 cm length having 3 to 4 internodes should be selected as scion material for grafting.

Grafting technique

One year old rootstock of pencil thickness (0.5-1.0 cm) should be used for grafting purpose. Best time for grafting is 2nd week of October, when stock and scion are in dormant condition. The rootstock and scion should be of same size.

Effect of grafting method and growing environment on plant growth

The experiment was conducted to standardize the grafting method(s) and growing environment. The maximum graft success (80%) was recorded in both open and polyhouse conditions in wedge grafting and under net house condition in tongue grafting. The graft union takes place within 30-45 days of grafting.

Production technology of Sohshang *(Eleaegnus latifolia)*

The right stage of harvesting Sohshang is 75-80 days after fruit set when the fruits develop deep orange to pink colour. Sohshang can be propagated by both seeds and cutting. Seed lose its viability to 50-60 % within a week after extraction. Seed should be shown in nursery within a week of extraction from fruits. Cuttings of pencil thickness with 10-12 cm length having 3 nodes should be taken from mature current year's shoot. It should be planted during rainy season in nursery or poly bag filled with soil mixture. Cutting takes 15-20 days to start sprout and ready for planting in field within 3-4 months after sprouting. The maximum rooting success is found under net house (80%) followed by open condition (50%), while least success is found in poly house condition (30%).

Value addition and post harvest management of horticultural crops

Indigenous and minor horticultural crops available in the region are not being exploited properly, but they have the potential to alleviate the poverty, food and nutritional security through processing, value addition and diverse use. These fruits and vegetables are rich in vitamins and minerals. Besides, they are rich in secondary metabolites and medicinal properties which could be exploited in industrial and medicinal sectors.

ICAR research Complex for NEH Region has standardized the protocols for preparation of value added products 1) Sohiong RTS and squash, 2) Sohiong candy, 3) Sohiong powder, 4) Sohiong wine, 5) Sohiong fruit powder, 6) Sohshang leather and 7) Soshang jam.

Strategies for the development of underutilized horticultural crops

» Afforestration and rejuvenation of degraded forests may be carried out with emphasis on supplementing and enriching biodiversity of edible food/horticultural crops. Joint forest management programmes should facilitate spread of ITK available with local communities on sustainable collection and use of various edible species.

» Domestication of potential wild species through homestead cultivation should be encouraged for avoiding over-exploitation from natural sources.

» More R & D efforts in these will add substantially in production & productivity, and limited number of species needs to be targeted for detailed research and development including post harvest management and value addition through national programmes focusing on their conservation and use.

» Strategies need to be worked out particularly at national and regional levels to develop and make available promising selections/varieties, overcoming constraints of production of good seed material, planting material, *in-vitro*/tissue cultured material etc.

» There is a necessity to make the farming community aware about the nutritional importance of unexploited fruits. For this, extension agents may organize special awareness camps/campaigns, exhibition, etc. at micro and macro level. Similarly, use of mass media like radio, TV, news paper and other printed literature can play an effective role in creating awareness among the farmers.

Status of underutilized fruits in Andaman and Nicobar Islands

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Andaman and Nicobar Islands represent one of the richest repositories of biodiversity in the South and North East Asia. Situated between two major biodiversity hotspot, namely the Indian subcontinent and the Malaysian-Indonesian region, it is hardly surprising that the Islands manifest biodiversity of extraordinary range within a limited geographical area. These Islands come under the humid tropical region with an average rainfall of about 3000 mm. About 6% of the total geographical area i.e. 46,000 ha is under agriculture. The undulating nature of land makes it unsuitable for paddy and associated crops. However, the climatic conditions are highly suited for cultivation of horticultural crops, which are presently being grown in an area of about 37,160 ha. The important horticultural crops grown widely in these Islands are coconut, arecanut, banana, mango, guava, black pepper, clove, cinnamon, ginger, nutmeg, brinjal, chillies, cowpea, okra and all cucurbitaceous vegetables. These Islands have a vast variety and biodiversity in underutilized wild tropical fruits, many of which are of evolutionary climate in specific niche. Most of these fruits trees have remained semi domesticated while many species have become rare and endangered due to large scale urbanization (Patel et al., 2006; Singh 2007; Nayak et al., 2012).

Biodiversity of Minor fruits in A&N Islands

The unique positioning of these Islands between the two major biodiversity areas namely the Indian subcontinent and the Malaysian- Indonesian region endows it with an unmatched distribution of plants with representatives of the Indian, Myanmarese, Thai, Malaysian and Indonesian floras. The flora of the Andaman group of Islands shows closer affinity to the Indi- Myanmarese- Thai flora, while the Nicobar groups of Islands are closer of the flora of Malaysian- Indonesia(Balakrishnan and Ellis 1996). Some of the identified indigenous fruits in Andaman and Nicobar Islands which are rich in nutrients and economic importance are listed in Table 1.

Table 1. Distribution and uses of underutilized fruits of Andaman and Nicobar Islands

Botanical Name	Family	Common Name	Distribution	Uses
Annona glabra	Annonaceae	Alligator apple/Jungli Sitaphal	South Andaman	Good source of vitamin A and C. Used as a salt tolerant root stock for custard apple and soursop.
Annona squamosa	Annonaceae	Sita phal/ Sugar apple/ custard apple	semi wild in forest of A&N Islands	Good source of proteins, carbohydrates, sugar and acidity.
Annona muricata	Annonaceae	Soursop	Found as semi wild in forest of A&N Islands	Used for preparation of products like jelly, beverages, ice creams and syrups. Medicinal properties are attributed to leaves and juice
Annona reticulata	Annonaceae	Ramphal/ bullock's heart	Found as semi wild in forest of A&N Islands	Used for preparation of products like jelly, beverages, ice creams and syrups. Medicinal properties are attributed to leaves and juice
Flacourtia ramontchi	Flacourtiac eae	Governor's plum	Found as semi wild in forest of A&N Islands	Rich source of protein and Vitamin C. Medicinal properties are attributed to leaves and bark.
Baccaurea ramiflora	Euphorbiaceae	Khatta phal	Throughout of A&N Islands	Plant parts used as
Agle marmelos	Rutaceae	Bael	Found semi wild along roads and near streams	Pulp is eaten and sherbet is made from it and having medicinal value
Ardisia solanacea	Myrtaceae	Khariphal	Middle Andaman, long Island, Havelock and Rutland	Rich source of Vit. A and C. Fruits are used for making processed products.
Salacia chinensis	Celastraceae	Madhuphal	Found in bordering on mangrove and tidal creeks	Rich source of Vitamin A, C and proteins
Passiflora foetida	Passifloraceae	Wild passion fruit	Found as a weedy species	Leaves and unripe fruits contain cyanogenic glucoside. Used as cover crop.
Passiflora edulis	Passifloraceae	Passion fruit	Introduced from Kerala and foot hills of Tamil Nadu	Good source of Vitamin C and A. juice is used for making drinks and jams.

Pandanus andamanansium	Pandanaceae	Pandanus/ elephant tree	Endemic to A&N Islands and distributed all localities of swampy areas of A&N Islands	Used in folk medicines.
Pandanus lerum	Pandanaceae	Pandanus/ elephant tree	Endemic to A&N Islands and distributed all localities of swampy areas of A&N Islands	Spathe of male inflorescence emits a fragrant smell, which is of great use in making kewra attar and kewra water.
Pandanus tectorious	Pandanaceae	Fragrant screw pine	Seashores and on farming belts which fringe the beaches just above high water mark.	Used in folk medicines and used for making of kewra attar and kewra water.
Syzigium claviflorum	Myrtaceae	Wild jamun	Baratang, South Andaman and Navy Bay.	Good source of Vit. C and A. Fruits and seeds are used as medicines.
Mangifera griffithi	Anacardiaceae	Wild mangoes	Mount Harriet (South Andaman)	Good source of Vit C and A.
M. andamanica	Anacardiaceae	Jungli am	South Andaman, chouldari and Chidiyatapu	Good source of Vit C and A
M. camptosperma	Anacardiaceae	Jungli aam	Middle Andaman, long Island, Baratang, South Andaman and Rutland	Fruits are locally consumed
Syzigium jambolana	Myrtaceae	Java plum	South and Middle Andaman, Barren Island	Fruits are edible and used as medicine for diabetes
Nephelium lappaceum	Sapindaceae	Rambutan	Introduced from mainland and found limited in backyard	Fruit is edible
Syzigium aqueum	Myrtaceae	Water apple	Found as semi wild in forest of South Andaman	Fruit is edible
Averrhoea biimbi	Oxalidaceae	Bilimbi	Introduce by the settlers from mainland	Used for making pickle, curries and preserves.
Garcinia mangostana	Guttiferae	Mangos teen	Found semi wild in Haddo	Most delicious fruits are best eaten fresh

Dillenia indica	Dilleniaceae	Chalta	South Andaman	Used for making processed foods and used as cooling beverages.
Baccaurea platyneura	Anacardiaceae	Chaur	Found in evergreen forests of middle and South Andaman	Kernel oil used for preparation of native medicines instead of almond oil.
Dracontomelum dao	Anacardiaceae	Wild amra	South Andaman	Used for making processed foods. Good source of Vit C.
Artocarpus altilis	Moraceae	Bread fruit	Nicobar Islands	Used as a vegetable.
Artocarpus heterophyllus	Moraceae	Kathal	Throughout A&N Islands	Ripe fruits used for different culinary preparations and unripe fruits used as a vegetable. It yields yellow for mending earthern wares.
Artocarpus lakoocha	Moraceae	Monkey jack	Nicobar Islands	Fruit is edible
Ficus carica	Moraceae	Gular/ Anjeer/fig	Introduced from mainland	Fruits are eaten fresh or stewed and may be dried.
Ficus racemosa	Moraceae	Wild fig	Middle Andaman, South Andaman and Havelock	Higher sugar content and fruits used as a laxative
Averrhoea carambola	Oxalidaceae	Carambola	Introduced by the settlers of mainland and adopted exceedingly well in the Islands.	It contains oxalic acid and Vitamin A. used for making processed foods.
Morinda citrifolia, Morinda citrifolia var Bracteata, and Morinda trimera	Rutaceae	Noni/ Burmaphal	Found as semi wild in A&N Islands	All the parts of the plant having medicinal properties.

Among the minor fruits distributed in these Islands, fruits like rambutan and mangosteen are of considerable economic importance as these are the major fruit crops throughout the SE Asia. Some tropical fruits having export potential like durian, avocado, litchi, and longan are to be introduced as the climatic conditions of Andaman and Nicobar Islands are suitable for these crops. These minor fruits hold much potential and could, in the future, serve as driver for improved livelihood opportunities and rural development in these Islands.

Potential uses of Minor fruits

Many underutilizedfruit species are nutritionally rich and are suitable for low input agriculture as they naturally occur either in wild or can sustain adverse climatic conditions of the growing regions. Tsunami affected lands in Andaman and Nicobar Islands are one such example where these crops can provide sustainable production with least risk. In this way, they can contribute significantly to maintain rich diversity and hence more stable agro-ecosystems.

Fruits have both restorative as well as curative properties *viz*. aromatic, cooling, digestive, stomachic, stimulant, astringent, emollient, useful in seasoning, maturation and fermentation of culinary, processed food and drinks. There are few other fruits which possess specific properties such as diuretic, diaphoretic, sedative or stimulant to nerves, improver of peristaltic movements of intestine and liver ailment, cardio tonic, relieving cough, cold, bronchitis, asthmatic spasm, blood pressure *etc*. Some minor fruits contain essential oils in their peel, foliage or roots and exhibit carminative and germicidal properties.

In addition to their therapeutical values, these fruits provide nutrition, strength and vigour to our body and restore loss of minerals and amino acids, thus protecting it against many deficiencies and diseases. Singh *et al.* (2002*)* reported the nutritional composition of some of the minor fruits found in Andaman and Nicobar Islands. The study revealed reported that the level of carotinoids varied from 7071 to 1485.00 μg/100g, which was recorded in *Artocarpus integrifolia*followed by *A.lakoocha, Carissa, Spondias cythera, Spondias pinnata, Syzigium claviflorum* and*Gnetum gnemon*. West Indian cherry (*Malphigiaglabra*) contains an exceptionally huge amount of ascorbic acid to the tune of 3000-4000 mg/100g. Some of the other minor fruits found in the Islands are fairly good source of ascorbic acid *viz*. *Artocarpus spp*.,*Muntigia calabura and Mangifera andamanica*.Tamarind, karonda, bael, wood apple and aonla were found to be rich source of calcium (Singh et al, 2003; Singh and Medhi, 2003b; Singh 2006; Singh et al., 2011; Singh and Singh, 2013).

Noni is one of the important minor fruits and has been reported to exhibit antibacterial, antiviral, antifungal, antitumor, antihelminthic, analgesic, hypotensive, anti-inflammatory and immune enhancing properties. The plant has also been popular as a source of red, yellow and purple dyes. Noni juice has become increasingly popular in recent years as a health drink in western and Asian countries. Over200 companies have come up in the market with their diverse product ranges consisting of beverages (fruit juice, juice drinks), fruit powders (for manufacture of reconstitution juice or juice drinks products made from dried ripe or unripe fruits), toiletries (lotion, soaps, etc.), oil (from seeds), leaf powders (for encapsulation or pills), bio pesticides *etc*(Singh et al., 2009, 2011b, 2012a).

Significance of Underutilized fruits for tribals of Andamans

Wild fruits were important sources of food for mankind before the dawn of civilization and domestication of present day fruits. Cavemen in forests also depended on these fruits and passed on valuable information on utility and choice of wild species to the future generations. Till date, tribals inhabit many islands of the A & N group. There are five kinds of tribes or aboriginals in this Union Territory, Nicobarese, Great Andamanese, Jarawa, Ongees and Shompens. Forests, the original habitat of many tribal groups, are the repository of nutritious fruits, which grow in the wild and are consumed locally without any marketing.

Movement of these semi nomadic tribes is largely influenced by the availability/ otherwise of fruits and game.

A survey conducted to find out edible fruits and their potential use in medicines revealed that fruits of *Pandanus sp.*,jackfruit, tamarind, bael, *khattaphal*, sapida, breadfruit, wild mangoes, wild amra, hogplum, *chaur*, soursop, bilimbi, lasoda, *madhuphal*, Indian almond, Bridilia, Wild Fig, Monkey Jack, Rose apple, Wild Passion fruit, Wild ber *etc*. are being used by the tribals for various nutritional and medicinal purposes. These fruits have been major sources of raw materials for drugs since antiquity and have provided bulk of products used in traditional system of medicines (Medhi and Singh, 2004; Singh et al., 2004a; Patel et al., 2006; Nayak et al., 2012; Singh et al., 2013). A brief account of the fruit crops used by the tribals in curing various diseases has been presented in Table 2.

Table 2. Diversity of underutilized fruit crops in therapeutic use by the tribals

Name of the species	Traditional uses by the aboriginals
Pandanus andamanesium	The lower portion of the fruits is fleshy and is consumed by all the tribals of the Bay Islands as staple food. The fruit is also largely used for making flour for bread by the local people; the leaves are used for thatching huts by the Shompens and the Nicobarese. The tender leaves pounded with coconut oil are rubbed on body by the Nicobarese young people before to play games.
Pandanus lerum	The fruit is boiled and paste baked into thin flat cakes. This is powdered for storage and eaten in times of scarcity. The terminal bud and tender floral bracts are also eaten and used for flavoring. Leaves are used for thatching and for making mats, sacks, baskets, umbrella and other articles. The plant is useful binding soils and sometimes used for fencing. The spathe of the male inflorescence emits a fragrant smell which is of great use for making kewra water. It is also used in folk medicine.
Morinda citrifolia	Nicobarese call it Lorang, they use each and every part of the plant. They eat the fruit with salt or cook it, and also the leaves of the plant are used as vegetable as it contains proteins. The bark of the plant is also used for making yellow dye.
Morinda bracteata	The leaves and fruits are eaten by the Nicobarese and Shompen tribals. The roots and leaves in combination with several other ingredients and coconut milk are made into paste by the Nicobarese to treat bone fractures.
Passiflora edulis	The fruit is edible when ripe, but unripe is poisonous. The leaf juice mixed in equal amount of water is used by the Nicobarese as eye drops to treat conjunctivitis. The leaves are used as a dressing for wounds and in conjunctivitis by the Nicobarese. The fruits are used by the Nicobarese for stomach troubles
Dracontomelon dao (Blanco) Merr.& Rolfe	Ripe fruit is stewed and used for jams, jellies and juices. Boiled and dried fruits can be kept for several months. Young steamed leaves are eaten as a vegetable. The wood is light brown and buoyant, and has no value for timber. There are diverse medicinal usage of fruits, leaves and bark in different parts of the world. The treatment of wounds, sores and burns is reported from several countries.

Averrhoea bilimbi	The fruit is occasionally eaten raw with salt or sliced thin and added to salad. It is used extensively as a souring agent for many native dishes. It may also be processed into candies or made into chutneys, relishes and pickles. Its raw juice is an effective remover of stains or spots on clothes, rust stains and brasswares and stubborn food particles on enamelware.
Annona squamosa	Eaten as a dessert fruit, although pulp of fruit may be mixed with milk to form a drink or made into ice-cream. The tree serves as host for lac-excreting insects. The crushed leaves are sniffed to overcome hysteria and fainting spells; they are also applied on ulcers and wounds and a leaf decoction is taken in case of dysentery. The crushed ripe fruit, mixed with salt, is applied on tumors. The bark and roots are both highly astringent. The bark decoction is given as a tonic and to halt diarrhoea. The root, because of its strong purgative action, is administered as a drastic treatment for dysentery and other ailments.
Averrhoea carambola	Dried fruits are used in fever. Ripe fruits used in dysentery, remedy for bleeding piles. relive thirst.
Baccaurea ramiflora	The fruit is highly nutritious and very rich source of Vit. C and protein. Seeds are used against vomiting and asthmatic trouble. Every part of the plant is equally useful in the antidotal treatment of snake bite or a scorpion sting.
Baccaurea sumatrana	The shrub or small trees bearing leaves which are warned in coconut oil and used as poultice by the Nicobarese.
Dillenia indica	The juice of the fruit is mixed with sugar and used as cooling beverage in fevers and as a coughing mixture.
Syzygium claviflorum	Seeds used as medicine and contain ellagic acid. Fruits used as astringent in bilious diarrhoea and in diabetes. Fermented fruits juice stomachic, carminative and diuretic. Nicobarese women consume the fruits during pregnancy, to improve hemoglobin percentage.
Ardisia solanacea	The fruits are consumed by the Shompen of great nicobar. The roots are boiled in water and taken by the Shompens for washing of uterus after child birth.
Mangifera andamanica	Consumed locally as a good source of vit C.
Sauropus androgynus	The pounded leaves or fruits are boiled in coconut oil by the Nicobarese and rubbed on the body as a renovating agent.
Annona muricata	The fibrous fruit has juicy aromatic flesh and eaten by Nicobarese. The Nicobarese apply pounded leaves on skin to cure itch and with coconut oil, these are ameared to cure abscesses.
Annona squamosa	The leaves are ingredients of a formula of the Nicobarese to heal cure fractures.
Syzigium aqueum	The leaves mixed with *Clerodendrum inerme* (Linn.) Gaertn. are pounded and on dislocated or fracture bones by the Nicobarese.
Psidium guajava	The leaves are ingredient of a formula of the Nicobarese for dysentery and stomach irritation.
Artocarpus lakoocha	Ripe fruits are eaten or used as preserve for chutney.

Salacia chinensis	The ripe fruits are edible. The leaves with other ingredients are made into a paste by the Nicobarese and applied on abdomen for relieving labour pain in ladies.
Passiflora foetida	The fruits are edible when ripe, but poisonous when unripe. The leaf juice mixed with equal amount of water is used by the Nicobarese as eye drops to treat conjunctivitis. The leaves are used as a dressing for wounds and in conjunctivitis by the Nicobarese for stomach trouble.
Anthocephalus chinensis	The fruit is edible and the Ongees eat it. The bark is employed to make a vessel by the Shompens to cook *Pandanus*. This is also applied in joint pains by the Nicobarese.

Plant diversity represents the primary source for food, shelter, medicines and many other products and means that make life on earth possible and enjoyable. Increased reliance on major food crops has been accompanied by a shrinking of the food basket which human kind has been rekeying upon for generations. This nutritional paradox has its roots in the agricultural 'simplication', a process that favoured some crops instead of other on the basis of their comparative advantages for growing in wider ranges of habitats.

The nutrients consist of carbohydrates, proteins, fats, vitamins and minerals. Present nutritional situation is alarming in the country because 36% of children affected with malnutrition in the world are Indians. Anemia is prevalent in 60% of our children and 1/3rd children are born underweight.To combat malnutrition, the right strategy is to increase the production of local or nontraditional fruits; of which majority grows in wild, semi-wild condition as stray plants and in tribal areas and also it can generate income from disposal of the surplus fruits. Some of these fruits have already become popular in last a few years like *Morinda citrifolia*, Passion fruit, Alligator apple, Soursop etc. Since the list of non- traditional fruits is very large and all fruits cannot attain the status of commercial fruits, some criteria may be adopted to determine the potential of a fruit for commercial exploitation. These criteria may be high productivity, market demand, freedom from the serious attack of pests and diseases, easier post harvest management, high nutritive value and availability of production technology. However, for some important species, information on their nutritional value are made available. Dry matter content was higher (88.10%) in Alligator apple followed by 75% in cultivated fig, and the least DM was found in Chalta (5.15%). Among the micronutrients, Calcium was high in Pandanus (6.65%) and 6.5% in Soursop and 5.34% in wild jack fruit, while in *Morinda citrifolia* calcium was 3.49% and the lowest calcium was recorded from Sapida and Khoonphal (0.01%). Phosphorus was maximum in Soursop (25%) and minimum in Alligator apple (0.039%)(Singh et al., 2003; 2004b; 2004c; Singh et al., 2005; Singh and Medhi, 2003).

Percentage of crude protein was higher in wild Jack fruit (10.85), Khattaphal (9.63) and Chalta, whereas, 8.75 in West Indian cherry, while in *Morinda citrifolia* the percentage of crude proteins was 6.25 and the lowest of 0.75 on Soursop. Higher content of Potassium (1200ppm) from Sapida and Khoophal followed by 825 ppm in *Morinda trimera* and 48.62 ppm in *Morinda citrifolia*. Among the micronutrients, iron content was higher in Khoonphal (2800ppm) and (24.74 ppm) in wild jack fruit. In *Morinda citrifolia*, it was 3.3 ppm (Singh et al., 2003).

Table 3. Macro and micro nutrients of important underutilized fruit of A &N Islands

Local fruits	Macronutrients						Micronutrients					
	DM %	Ash %	Ca %	P %	EE %	CP %	K (ppm)	Zn (ppm)	Co (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
Jamun	34.4	0.98	4.70	0.92	-	6.56	59.09	0.70	2.03	0.84	2.53	2.48
Morinda	38.52	3.34	3.49	1.56	3.41	6.25	48.62	0.06	-	-	0.48	3.30
Wild guava	40.13	3.37	1.9	0.34	3.94	6.12	21.12	0.1	0.3	0.02	-	3.31
Karonda	70.74	10.0	10.0	1.06	9.53	9.38	33.11	0.09	0.86	0.003	-	5.0
Wild passion	-	-	1.2	0.32	9.53	-	28.36	0.07	-	0.04	-	2.5
Kahttaphal	12.28	5.72	4.48	1.36	5.44	9.63	44.95	0.05	-	0.08	-	3.98
Velvet apple	13.17	3.36	1.28	0.43	5.94	5.63	17.56	-	-	0.14	-	0.37
Wild jack fruit	17.35	14.46	5.34	0.05	1.88	10.88	33.5	0.21	-	-	1.17	24.7
Attaphal	37.83	3.37	3.08	-	4.3	5.56	47.05	0.03	-	0.41	-	-
Poon	32.69	1.49	4.25	-	17.4	4.88	26.03	0.43	-	0.31	0.52	3.84
Khariphal	8.74	4.2	0.07	1.53	1.51	-	4.5	-	-	-	-	-
Bael	35.66	3.29	4.76	-	0.10	-	-	-	-	-	-	-
Bethphal	37.43	3.34	2.80	-	0.73	4.25	16.88	0.44	-	0.29	-	1.37
Cultivated fig	75	10.8	3.89	-	6.9	11.5	59.3	0.53	1.91	0.006	0.99	10.16
Jambose	13.82	24.34	3.82	-	1.1	4.3	36.52	-	-	0.16	0.33	8.01
M.trimera	-	-	0.05	-	-	-	825	Trace	Trace	14.44	Trace	44.91
Sapida	-	-	0.014	-	-	-	1200	11900	300	1700	4900	2800
Khoonphal	-	-	0.014	-	-	-	1200	Trace	Trace	16.64	12.01	49.96
Wild fig	10.01	9.955	4.17	-	5.1	12.75	48.2	0.76	-	-	0.48	2.51
Carambola	12.38	5.55	0.50	0.072	-	5.25	41.72	0.275	Trace	Trace	-	Trace
Bilimbi	9.28	5.1	0.5	0.048	1.6	8.16	46.722	0.258	0.035	Trace	-	Trace
Alligator apple	88.10	1.85	1.00	0.039	-	9.18	45.45	0.176	Trace	Trace	Trace	0.407
Pandanus sp.	9.44	3.54	6.65	0.83	2.01	11.55	15.025	0.067	Trace	Trace	1.65	Trace
Chalta	5.15	4.45	0.75	0.96	2.25	9.62	-	-	-	-	-	-
West Indian cherry	7.82	4.45	0.50	1.168	0.15	8.75	-	-	-	-	-	-
Soursop	-	-	6.50	25.0	-	0.75	-	-	-	-	-	0.5

Therapeutic value of underutilized fruits of Andaman

The tropical, costal, humid and eco-zones of Indian peninsula like Andaman and Nicobar Islands, Tamil Nadu, Kerala, Assam, Orissa, west Bengal have vast variety and diversity in tropical fruit plants, many of which are of evolutionary climaxes in specific niche. Value of underutilized fruits in traditional medicine is well known. These medicines are safe and environmentally friendly. According to WHO, about 80% of the world's population relies on traditional medicines for their primary health care. India being one of the world's 12 mega biodiversity countries, enjoys export of herbal raw material worth U.S. $ 100-114 million per year approximately. These plants have close association with local beliefs and rituals and are used in health care needs in rich ethnic life of our people. Most of the trees have reminded semi domesticated due to lack of research support for improvement as well as unorganized exploitation.

While many species have become rare and endangered due to large scale urbanization, indiscriminate deforestation or due to extension of cultivation under high yielding areas. These underutilized fruits although having nutritional, commercial, medicinal and commercial importance are ignored and yet to be exploited to full potential. In general, fruits are rich sources of Vitamins and Minerals. Use of various kind of seasonal fruits helps in keeping human beings healthy by fulfilling their various requirements.

Table 4. Bio-chemical composition of unexploited wild fruits of A&N Islands

Name of the species	Fruit Wt.(g)	Juice (%)	TSS (°Brix)	Acidity (%)	Vit C (mg/100g)
Annona glabra	235-300	25-30	5.90	0.14-0.16	3.14-3.54
Morinda citrifolia	147.93	54.60	8.45	0.12	139.09
Morinda trimera	24.6	41.60	5.0	0.08	125.9
Annona muricata	700	-	13.0	2.01	48.0
Dillenia indica	465	-	10.50	2.90	5.10
Malphigia glabra	5.00	36.11	5.44	1.18	3000-4000
Baccaurea sapida	5.00	30.00	4.50	0.80	33.8
Baccaurea ramiflora	2.00	40.80	14.80	0.37	42.64
Averrhoea bilimbi	50.87	81.17	4.25	4.67	13.50
Averrhoea carambola	40.87-50.50	50.21	3.05	0.75	12.50
Passiflora edulis	69.76	22.93	16.00	5.09	26.80
Mangifera andamanica	18.30	42.73	8.6	0.37	98.50
Mangifera griffithi	12.0	3.06	11.0	0.128	78.50
Mangifera camptosperma	80.82	4.59	6	1.25	146.5
Uvaria sp.	12.38	10.38	8.25	1.69	115.34
Emblica officinalis	3.58	41.89	18.50	1.50	13.00
Malphigia glabra	5.00	36.11	5.44	1.18	4514
Garcinia cowa	34.83	47.77	13.80	0.17	5.40
Anthocephalus chinensis	11.63	34.39	6.04	0.11	9.83
Mimusops elengi	7.58	33.95	18.50	1.50	5.20

Need for commercialization

The total geographical area of the Andaman and Nicobar Islands is 8249 sq.km of which about 86% of the land is covered under thick forest and only 14% has been cleared for rehabilitation purpose including agriculture. The area under agriculture activities is about 46,000 ha which accounts for 6% of the total area. The land resources for agriculture purpose are very limited and there is no scope for further expansion. In this situation, strategies for increasing the income of the Islands farmers per unit area of available land are needed and this can only be achieved through agricultural crop diversification.

Changes in pattern of domestic demand and, to some extent, export demand in the wake of trade liberalization, resulted in changes in resource use and increasing diversification of enterprises. States which diversified the crops sector in a big way have attained relatively higher growth in the net state domestic product of agricultural sector during the past two decades. Crop diversification from traditional crops to crops which is having great export potential like rambutan, mangosteen, longan, avocado and durian etc., is the new pathway for income growth in agricultural and rural sector.

There are areas of marginal and waste lands, which are suitable for cultivation of underutilized fruit species. However, poor adoption of underutilized fruit cultivation has reasons such as,

» Lack of awareness about the potential economic benefits
» Non –availability of good quality planting materials
» Lack of technology for production, management and enhancing the fruit production
» Poor marketing network
» Lack of technology for value addition through processing

Though some attention has shifted towards these crops in past few years, there is further need to carry out field demonstrations to provide first hand exposure to the Island farmers for popularizing these species in field.

Scope for commercialization

Tremendous scope lies in the introduction, evaluation and exploitation of these tropical minor fruits at a commercial level in Andaman and Nicobar Islands. These minor fruits are in great demand in the national and international market and are growing well in tropical countries with the same agro-climatic conditions as Andaman and Nicobar Islands. Some of these fruits can be grown as intercrop in coconut and arecanut gardens. Hence, underutilized fruits can play a major role as a component of the livelihood strategies of Island farmers.

These minor fruits have tremendous economic potential because of its great demand both in the domestic and export market because of their nutrition content, therapeutic value and resistance to biotic and abiotic stresses. While the major producing countries are continuously expanding their research and development activities on economically important underutilized fruits, several international organizations are also engaged in the research and development of minor fruits. Commercial orchards of minor fruits would require technology inputs for production, postharvest, processing including grading, packaging, cold storage equipment and marketing system. These standardized technologies would facilitate the development of employment opportunities and livelihood options for Island farmers (Singh et al., 2012b).

Constraints of minor fruits sector

Product seasonality and short shelf life are the biggest problems of this minor fruits sector. Fruit species with potential for further commercial production need to be identified and research efforts must be directed towards their inherent problems. Some of the constraints for cultivation of minor fruits in these Islands are listed below (based on the priority and importance). These include,

1. Lack of marketing information on season wise rates, and product specification
2. Lack of location specified production technology
3. Lack of technical knowledge about cultivation
4. Unawareness about the handling of fruits
5. Lack of knowledge about value addition
6. Non- availability of improved planting material
7. Lack of infrastructural facilities

Constraints in marketing of major producing countries of minor fruits include narrow production base, absence of growers' associations, lack of marketing finance, lack of infrastructural facilities, absence of marketing network and lack of gardening and standardization.

Potential of minor fruits in Andaman and Nicobar Islands andFuture strategies

These Islands have congenial agro- climatic condition for horticulture crops. Due to land limitation high value horticultural crops has to be encouraged to increase productivity and make horticulture commercially viable.Because of high world demand due to the versatile uses of minor fruits, there exists a great future for Andaman and Nicobar Islands, with its suitable climatic conditions especially on the highlands, to embark on a large scale planting of rambutan, Mangosteen, durian and avocado for export, especially to nearby countries such as Singapore and Malaysia. Rambutan, Mangosteen, durian and avocado are tree crops requiring sophisticated management and propagation techniques for profitable commercial production for export. However great care must be exercised to avoid the introduction of grafted plants with transmissible diseases.

Providing access to information on various aspects of production, harvest, post harvest, processing, utilization and marketing of underutilized tropical fruits and also promoting and generating awareness of the species to the farmers is the first and foremost step for commercial cultivation of minor fruits. Information on production techniques, suitable varieties, management, harvesting, post harvest technologies etc., can provide farmers with the tools they need to increase their income, food and nutrition security and sustainable livelihood. However, the information itself must first be made available and then the pathway of information dissemination forged. Through the research, review and gathering process, areas of research canbe identified where information is lacking and priorities for future research can be established.

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Under-exploited and nutritionally rich wild fruits of Uttarakhand

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The Himalayas in general and Uttarakhand in particular is a gold mine of floral and faunal diversity. Households of this area fulfil their daily needs and other requirements from god gifted forest products including wild fruits. Seasonal wild edible fruits and vegetables are the additional food supplements for the locals in the Himalayan region. Uttarakhand is one of the Himalayan States of India located between 28^{o} 4' to 31^{o} 27' north latitude to 77^{o} 34' to 81^{o} 2' east longitude in the eastern most part of the western Himalayas. The state has subtropical, sub temperate, temperate, alpine and polar climatic regions. The climatic variation and higher rainfall makes it rich in diversity for flora and fauna. This state occupies an intermediate position between Himachal Pradesh in the west and Nepal in the east. The vegetation of both the regions can be seen in this part. The entire state is mountainous except Haridwar and Udham Singh Nagar districts and southern parts of Champawat and Nainital districts. This southern plain lands of the state exhibitmixture of Himalayan flora and flora of upper Gangetic plain. It is a well known fact that this region is a reservoir of plant resources. The flora of Uttarakhand has been explored and worked out by several workers for taxonomic and phyto-geographical interest. However, a few works have been done on wild edible fruit plants of the region.

The wild edible fruits satisfy substantially the food requirements of the economically poor population in rural areas. Many of the wild fruits which are gathered by local people are attaining market value in recent years. The information on such plants may help in adding variety to the monotonous diet and fulfil requirements of minerals and vitamins etc. They maintain the diversity in the food system which has sustained the hill people for generations from calamities such as crop failure etc. The diversity of these fruits is depleting due to human interference, infra-structural development and deforestation. A lot of efforts have been made for cultivation of commercial fruit crops but no efforts have been made for domestication, conservation and utilization of these under-exploited, nutritionally and medicinally rich fruits. It will be worth to assess productivity, food and market values of some local wild edible fruits. This will help in improving the socio-economic conditions of the people of this region along with conserving the environment and a very fragile eco-system. Some potential wild fruits growing in this region have been described here.

Kaphal *(Myrica esculenta* Hook.)

Kaphal *(Myrica esculenta* Hook.) is a small, moderate-sized evergreen tree of Myricaceae family which may attain 3-15m height. It is found abundantly in the sub-tropical Himalayas at an altitude of 900-2100m. The tree bark is grey and rough with deep vertical wrinkles. The leaves are lanceolate to oblong-obovate and crowded at the end of branches, glossy above, glaucous beneath with entire margin.

The flowers are minute and unisexual. The male flowers have pale brown reddish branched axillary catkins which are produced in clusters whereas the female flowers arise in short axillary spikes. The flowering takes place in the month of February to March and the fruits mature in month of April to June. The fruits are ellipsoid or ovoid drupe with solitary seed, 2-5g in weight and dark red or purplish colour at ripe stage. The fruits have a pleasant, acid- sweet taste and are used as fresh or for preparation of a refreshing drink. The fruits contain high amount of water soluble anthocyanin and vitamin- C. The fruits fetch god price in the market ranging from Rs 150—300 per kg but have short self-life. The wood of the tree is not good for timber purpose but used as fuel wood because of which trees are cut every year.

Hisalu *(Rubus ellipticus* Sm.)

It is anevergreen, large, spreading shrub of Rosaceae family. It is found abundantly throughout the hills in open slopes and scrub forests from 1000-2200m. It has multiple stems coming out of soil from single roots system. The stem is green at young stage and purple at maturity with lot of prickles. The leaves are trifoliate. Leaflets are elliptic-obovate or ovate, green, glabrescent with bristles. TheFlowers are white produced in dense axillary fascicles or short terminal forming a compound inflorescence. The flowering takes place in the month of February to April. The fruits mature in month of April to June. The fruits are yellow or golden yellow and round. The fruit is juicy, pleasant, sweet and well flavoured having numerous small seeds. The fruits which are rich source of vitamin C (9mg/100g) are used as dessert and for making jam.

Kala Hisalu (*Rubus biflorus* Buch.)

Kala Hisalu is a spreading deciduous small shrub of Rosaceae family. It is commonly found in in moist-shaded forests at an altitude of 1600 to 2800m. The stem is greyish white to purple in colour and less dense than Hisalu. The stem has sharp and strong prickles. The leaves are compound with 5-7 leaflets. The leaflets are ovate or cordate, glabrous above and white-tomentose beneath. The flowers are white, axillary, solitary or few forming umbelliform cymes. The flowering takes place in the month of April to June and the fruits mature in month of June to July. Fruits are globose, purple and black at maturity having acid sweet taste which is used as fresh.

Chook/ Dhur-chuk (*Hippophae rhamnoides* L. (Fam.)

Commonly known as sea-buckthorn it is a dioecious, usually spinescent deciduous shrub or a small tree of Elaeagnacae family. It grows up to a height of 13m and found growing in the river beds of the drier ranges of the state at an altitude of 1600-3300m. Leaves are small, linear-lanceolate in shape, stellately pubescent above when young with, dense short stellate tomentum beneath. Flowers are very small, greenish or yellowish. The flowering takes place in the month of April-May and the fruits mature in month of September to October. Fruits enclosed by a succulent receptacle, ovoid, 0.6cm long, orange-yellow or scarlet: seeds oblong, testa crustaceous, shiny. The fruit is acidic and is made into a jelly with sugar. A syrup is also prepared from it which is used in respiratory complaints: a decoction is used for cutaneous eruptions. The fruit is a rich source of vitamin C (1250mg/100g), carotene (6-8mg/100g) and also contains vitamin B. The fruit contains malic acid, citric acid and tartaric. The leaves and flowers are used for treating arthritis, gastrointestinal ulcers, gout, skin rashes and lowering blood pressure.

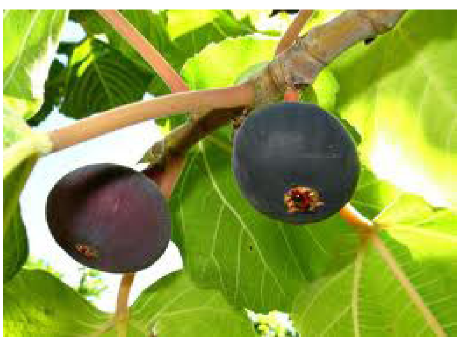
***Diploknema butyracea* H J Larn (Fam.Sapotaceae) (Chiura, phuwara, chura).**

It is a medium to large deciduous tree attaining a height of 10-25m. The bark of tree is dark grey. The leaves are 20-35cm long, 7.5-15cm broad, crowded near the ends of branches, ovate to abovate -oblong, entire margin , glossy green above, pubescent beneath. The flowers are white, crowded near the end of branches on tomentose, drooping peduncles. The flowering takes place in the month of January-March and the fruits mature in month of June-July. The fruits are ellipsoid, green, smooth, shining, 2-4.5cm long, enclosing 1-3 seeds: seeds glossy brown, 1.75-2cm long with whitish, almond-shaped kernel. The tree is commonly found in the eastern parts of sate and scattered elsewhere up to 1500m. It is fast growing and found chiefly along the sides of ravines in hills and in shady valley. The fruit is a berry, blackish in colour, with a thick soft, sugary pericarp and characteristic sweet odour. The pericarp, forming nearly 70 per cent of the weight of the seed is edible and contains saponin. The fat is extracted by crushing either the seeds as a whole or the separated seed kernels into a cream-like paste and squeezing out the oil through a cloth bag. The yield of oil is 42-47 per cent of the weight of the seeds. It has the consistency of ghee, has a white colour, pleasant taste and odour, and good keeping qualities. Chiura butter is used mostly as a substitute or as and adulterant of ghee. It may be employed in the manufacture of soap and candles and as lamp oil. An ointment prepared from it is said to be useful for rheumatic pains. The fruit also contains saponin. The oil cake is used as a substitute for soap and as a fish poison, and is also employed in insecticidal preparations.

Timil (*Ficus auriculata* Lour.)

Timil is a small, evergreen or sub-deciduous, spreading tree of Moraceae family. It is commonly found growing in ravines and river banks up to 1800m. The leaves are broadly orbicular elliptic or oblong, subcoriaceous, glabrous above, pubescent beneath.The flowering takes place in the month of March-April and the fruits mature in month of June-July. The fruits are formed in short clusters on short, thick leafless branches. Fruits are pubescent when young and turn pink or reddish with pale tubercular spots at maturity. The fruits have nectar type edible substance at the time of maturity which is sweet and tasty. The inner core of the fruit with nectar is edible.

Bedu (*Ficus palmate* Forsk.)



It is small deciduous or sub-deciduous tree of Moraceae family. It is commonly found in open places particularly along thebanks of streams and rivers up to 1800m. Leaves are orbicular or broadly ovate, entire, sometimes palmately lobed, dentate or serrate, scabrid above, tomentose beneath. The flowering takes place in the month of March-June and the fruits mature in month of May to October. The fruits are usually solitary, axillary, solitary or in pairs, sub-globose or pyriform, dark purple or pink when ripe. The ripen form is edible though the flavour is strong and dis-agreeable. The fruits are demulcent and laxative. They are used in disease of the lungs and the bladder. The tree also yields latex. The wood is white and hard which is used for building purposes.

Ban-nimboo (*Glycosmis arborea* (Roxb.)

It is an evergreen, glabrous shrub of rutaceace family. The leaves are alternate or sub-opposite and leaflets opposite or alternate, variable in size and shape. Flowers are whitish or yellowish in pubescent or puberulous axillary and terminal panicles. It flowers and fruits almost round the year. The fruits are depressed, globose, dirty-yellowish or pinkish. It is found in abundant in forest throughout the sub-Himalayan tract up to 600m.

Guyaa*(Viburnum continifolium* D.)

Commonly known as smoketree leaved plant it is a large deciduous shrub of Caprifoliaceae family which grows in the Himalayas at an altitude of 1200–3300m. The bark of stem is grey and leaves are ovate, elliptic or sub-orbicular, base cordate or rounded, entire or slightly crenulate, dark green above, densely white-tomentose beneath. The flowers are white, tinged with pink.The flowering takes place in the month of April-June and the fruits mature in month of September to October. Fruits are drupes, oblong, first red then turn black, shining, glabrous, compressed, 5-6 mm size. The ripe fruit is sweet and edible which is used as fresh and dried. The fruit juice is credited with vermifuge properties.

Kilmora *(Berberis aristata* (Fam.)

Kilmora is a large, erect deciduous spiny shrub of Berberidaceae family, which reaches up to a height of 1-2.5m. It is commonly found in forested areas at an altitude of 1800-3000m. The leaves are abovate or elliptic, prominently veined with spinous tooth. The flowers are bright yellow, arranged in drooping racemes.The flowering takes place in the month of April-June and the fruits mature in month of June -July. Fruits are ovoid to oblong-ovoid, blue to black in colour. The fruit is edible and is sometimes given to children as a mild laxative. The dried berries are also eaten. The roots rich in alkaloid content and a principal source of berberine are used to lower the blood pressure. The root extract is also used to cure stomach infection, piles, ulcers, fever, constipation, jaundice and eye related problems.

Ghingaru (*Crataegus oxyacantha* L.) (English Hawthorn)

Ghingaru is a thorny shrub commonly found in abundance in forests and open places at an altitude of 1500- 2500 m above msl. The stem is greyish to purple brown in colour and hard. The leaves are simple, linear-oblong or oblong-lanceolate, crenate, shining, green above, glaucous beneath and crowded at the ends of short lateral branches. Flowers white in many flowered, terminal corymbs.The flowering

takes place in the month of April-May and the fruits mature in month of July-August. Fruits are produced in branches, orbicular to ovoid in shape, small, smooth, glabrous, attractive scarlet red coloured. The fruits are edible. There are several forms differing in foliage, flower and fruit characters. They are made into preserves.The fruit has high vitamin C content (up to 1.5 mg/g) and serves as a valuable source of vitamin. The fresh fruit contains citric, tartaric and crataegus acids. The seeds contain amygdalin and emulsion. The fruit also contain sugar, gums and tannins.The liquid extract of the fruits reported to have a cyanogenetic glucoside which is a cardiac tonic and a remedy for heart diseases. It reduces blood pressure and relaxes the uterus and the intestine. The wood is very hard and used for making sticks.

Mehal (*Pyrus pashia* Buch.)

Mehal or Kainth is a small, deciduous tree of rosaceae family. It is common in open field borders and forest margins from 1000-2400m. The tree reaches up to a height of 5-8 m. The stem is greyish brown and rough. The leaves are lanceolate or ovate-lanceolate, crenate, upper surface glabrous, shining, lower pale and glaucous. Flowers are white, large in corymbose cymes. The flowering takes place in the month of February-March and the fruits mature in month of October to November. Fruits are globose, brown ultimately becoming black and rough. The fruits are astringent in taste when immature Even the ripe fruits are sour -sweet with some astringency. This is widely used as rootstock for pear.

Chilgoza *(Pinus geradiana* L.)

Chilgoza is a gymnosperm fruit plant which grows wild in the higher regions (3000-4000m) of cold and arid Himalayas. This plant is rarely seen in Uttarakhand. It is a nut fruit, described as low volume having high protein. The fruits are auctioned to the local people. The villagers harvest and sell the nuts in the market. The selling price has increased twenty times in the past ten years. Chilgoza is a very good species for social forestry, and is planted in forest development projects in high hills.

Indian Hazelnut, Kabasi,*(Corylus colurna* L./ *Corylus jacquemontii* Decne.)

Indian Hazelnut is a wild plant of the mid and high hills (2000-3500m) of the Himalayas. The tree is small or medium-sized and deciduous. Leaves are ovate or obovate, irregularly lobed or toothed, silky pubescent on nerves beneath. Flowers emerge before the leaves. Male flowers are arranged in drooping spikes while female flowers are cone-like, small, ovoid produced in pairs.The flowering takes place in the month of April-May and the fruits mature in month of August to September. Fruits are compressed, globose and hard. The nuts are collected from fruits and sold in the market .Hazelnut is already a commercial nut in the western countries of the world and the introduction of commercial varieties will make it an important crop.

Apart from the wild and under-exploited fruits discussed above a number of other fruits are also found in this region having nutritional and medicinal value. Some of them are Ganiakaphal (*Fragaria nubicola* Hook.), Giwain (*Elaegnus parviflora* Wall. Ex. Royle), Kothalu (*Rubus paniculatus* Smith.), Syaru (*Debregeasia velutina* Gaud.), Bel (*Aegle marmelos* L. (Correa.), Chiura (*Aesandra butyracea* Roxb.), Pangar (*Aesculus india* Colebr. Ex Camb.), Dhaun (*Artocarpus lacucha* Buch.), Rasuat (*Berberis lycium* Royle), Khan Pangar (*Castanea sativa* Mill.), Lisora (*Cordea dichotoma* Forst.), Gular (*Ficus racemosa* L.), Sahtoot (*Morus alba* L.), Amla (*Phyllanthus emblica* L.), Anar (*Punica granatum* L.), Bahera (*Terminalia bellirica* (Gaertn.) Roxb.), Harar (*Terminalia chebula* Retz.), Khat-ber (*Ziziphus glabrerrima*), Jharberi (*Ziziphus nummularia* Burm. f.).

Most of the widely grown wild fruits having nutritional and medicinal value in the North-Western Himalayas including Uttarakhand are on the verge of extinction because of various factors such as different developmental activities as well as unsystematic de-forestration. The cultivation as well as protection of some common and wild edible fruit plants after properly evaluation may be initiated in different agro-climatic zones which will definitely help in improving the socio-economic conditions of the people of this region. It will be also helpful in their proper conservation thereby protecting the typical and fragile eco-system of the great Himalayas.

II-1

Conservation and maintenance of underutilized fruit crops

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According to IPGRI the conservation (both ex situ and in situ) of the genetic diversity ofunderutilized species is extremely poor: more than 80% of these "minor species" conserved ingene banks around the world (5,000 species as a whole). This is not a sufficient base upon which characterise, develop or restore thegenetic resource base of these species which may turn out to be very important for foodsecurity, income generation and environmental health. This fact indicates furthermore that thevast bulk of the genetic resources of underutilized species is in the hands of users and local communities. A successful and sustainable use of underutilized species relies on both theprovision of diversity for current uses and its maintenance for future deployment. Collections held in isolation from the main users are vulnerable to being lost or notmaintained, as the crop may be unimportant to the country holding the genetic resources. Atthe same time, should the genetic resources increase in value as a result of prospecting,research, and new market opportunities, it may be more difficult to ensure that the resultingbenefits are distributed to the farmers who maintained and developed the genetic diversity inthe form of land races. In order to encourage the continuation of these activities germplasmshould be able to flow from farmer to PGR programs and back.For these reasons, the link between ex situ collections and in situ users of genetic diversity isfundamental for underutilized species.

II-2

Promising underutilized fruit crops of Meghalaya, India

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Several indigenous fruit crops which are rare in other part of the world grow favourably in Meghalaya, due to its suitable geo-climatic conditions. These crops are *Myrica esculenta*, *Elaeagnus latifolia* Linn., *Myrica farquhariana* Wall., *Prunus undulata* Buch.-Ham., *Rubus elliptic*, *Viburnam foetidum*, *Sonchus oleraceous*, *smilax perfoliata*, *Rhus semialata*, *Docynia indica* Dcne., *Baccaurea sapida* Muell.Arg. / *ramiflorae*, *Prunus nepaulensis* Ser., *Pyrus pashia* Ham. and *Gynocardia odorata* R. Br. These fruit plants are not only nutritionally and medicinally rich but also hardy to adverse climatic conditions and can be the source of several desirable gene(s). In spite of their potential, these crops are harvested and marketed locally, and are unattended both at scientific and farmers level. To achieve sustainable growth in horticulture, and to ensure food and nutritional security, proper horticultural strategies must be adopted to popularize, improve their productivity and to conserve these diverse fruit plants from extinction.

II-3

Structure and diversity of wild edible fruit yielding tree species in ever-green forests of Kodagu - Central Western Ghats

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The district Kodagu is one of the second smallest districts in Karnataka state, present in the central part of Western Ghats, harbors various wild edible fruit species, which are playing very important role ecologically and also contributing to the economy of the local people. Many of the species would be integrated into coffee based agroforestry systems for sustainable use and conservation, as well as, preservation of the associated knowledge through the positive practice of the indigenous bio-cultural knowledge. This paper presents an insight into the different wild edible fruit trees species present in the evergreen forests of Kodagu district. Of the total tree species (105) enumerated 24 were wild edible fruit yielding species. Evergreen vegetation had diverse wild edible fruit species which have a wide scope for value addition to enhance income, knowledge and efficient utilization of natural resource and also commercial utilization because of its nutritional and therapeutic value.

II-4

Status and potential of underutilized fruits in eastern tropical region of India

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Underutilized fruits are characterized by their local availability from restricted geographical area of adaptation, lack in scientific production technology, limited availability of planting materials and scattered plantation. These crops are poorly documented for their distribution, biology, cultivation practices, needs, uses, poorly organized marketing system, and relying on indigenous knowledge (Roy, 2014). However many of them are of considerable economic importance in their respective regions. Beside their importance for nutritive value particularly in mineral content and antioxidant property, and a source of income, diversity of these fruits also has a cultural and social value. About 27% of the fruit production consists of a large number of minor fruits in India and there are nearly 150 consumable species of minor fruits in India (Majumder, 2004). The topical eastern region of India is blessed with the diversities of underutilized fruit crops due to climatic variation and topography. The minor fruits of this region are; jackfruit (Artocarpus heterophylus Lam.), Sita phal (Anona squamosa L.), Ram phal (Anona reticulate L.), tamarind (Tamarindus indica L.), bael (Aegle marmelos Corr.), chalta (Dillenia indica L.), rose apple (Syzygium jambos Alst.), watery rose apple (Syzygium aqueum Alst.), star fruit (Averrhoa *carambola L.*), star aonla (Phyllanthus acidus (L.) Skeel), wood apple (Feronia limonia (L.) Swingle), jamun (Syzygium cumini (L.) Skeels), Aonla (Phyllanthus emblica L.), Barhal (Artocarpus lacucha Buch-Hum), jungle jalebi (Pithecellobium dulce (Roxb.) Benth), ber (Zyziphus mauritiana Lam.), moulsri (Mimusops elengi L.), khirni (Manilkara hexandra Roxb.), Indian cherry (Flacourtia jangomas), kendu (Diospyros melanoxylon Roxb.), hog plum (Spondius pinnata L.) and Phalsa (Grewia asiatica L.).) Among them jackfruit, sita phal apple, tamarind, jamun and bael are more important due to their genetic diversity, use and market potential, whereas, other minor fruits are consumed and produced locally. Most of them are undescript, season-bound, scattered in distribution, marketed in fresh form and generally suffer from significant post harvest loss in case of marketable surplus. The present paper highlights the economic importance, future prospect and diversity of underutilized fruits of the region. In addition, the paper also highlights the research priority in underutilized fruit crops, commercial opportunities which is yet to be exploited through appropriate strategy on production, post harvest management and marketing including collection, characterization (morphological and molecular), evaluation and conservation of elite clones for crop improvement programme.

II-5

Effective spatial technologies for biodiversity conservation of underutilized temperate fruit crops in Gharwal region of Uttarakhand

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Uttarakhand has rich diversity of many underutilized fruit crops such as Chestnut, Filbert, Kaafal, Peacanut andRaspberry*etc*. Conservation of biodiversity is of great concern in present situation context for effective utilization of these resources in future prospects. Regular human interference and change in climate have threatened the diversity of these fruit crops. A Suitable initiative can be undertaken to conserveand protect it from extinction.Remote Sensing coupled with GIS technology can be better approach to mitigate it. Primarily systematic mapping of the fruit crops in their restricted area of occurrence can be perform using spatial technology. The potential habitat of the species based on mapping may be allocated. An inventory based on the graphical data recorded can be helpful for easy interpretation of complex nature of species distribution pattern. The system of information generated based on above data may be pooled into the respective software which can presented in form of graphical representation. Based on the availability of data, emphasis may be laid mainly on pockets of enriched regions of biodiversity. The diversity of fruits at particular eco-geographical region thus may be prohibited from external interference or disturbance. In context of Uttarakhand hills the above strategy may be fruitful as most of the land falls under mountain terrains. Thus, if a positive approach is undertaken towards it using both the spatial technologies, conservation of underutilized temperate fruit crops can be a better initiative for Gharwal region of Uttarakhand.

II-6

Diversity, distribution and economic importance of minor and wild edible fruits in tropical rain forests of India

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Minor fruits including the wild edible and under-exploited fruits have high species diversity in South-West peninsular Region and Andaman and Nicobar Islands . They are a good source of vitamins, minerals and anti-oxidants, thereby provide the much needed nutrition supplements to the tribals and forest dwelling communities. There are no reports of any organized attempt to collect and conserve this diversity *ex situ*. Being tree crops requiring space for *ex situ* maintenance, alternate strategies like cryo-preservation of recalcitrant seeds, *in situ* conservation and clonal bonsai garden are to be attempted. Among the wild edible fruits, *Salaciafruiticosa*, *Aporosalindleyana*, *A. villosa*, *Baccoureacourtellensis*, *B. ramiflora*, *Flacourtianamontana*, *Artocarpuschama*,*A.hirsuta*, *Syzigiumcaryophyllatum*and*Hematocarpusvalidus* are prime candidates for plus trees selection and commercialization. *Salacia fruiticosa* and *S. reticulata* have been conserved in cryo-bank at NBPGR, New Delhi. Based on an eco-geographic survey conducted in Indian Herbaria, distribution map for the important genera of wild and underutilized fruits have been prepared. NBPGR Regional Station located at Thrissur have collected and established 40 accessions in 25 species in the field genebank. These are valuable sources of genetic stocks for commercialization.

II-7

UNEP GEF TFT Project & Conservation India - A chittoor example

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Mango is one of the perennial fruit crops, which has large variability for several traits due to high heterozygosity and large diversity of varieties within India. The project of 'Conservation and sustainable use of cultivated and wild tropical fruit tree diversity: promoting sustainable livelihoods, food security and eco-system servicesin India' was started at the five sites viz., Pusa in Bihar, Malihabad in Uttar Pradesh, Amravati in Maharashtra, Chittoor in Andhra Pradesh and Sirsi in Karnataka. Three crops viz., mango, Citrus and Garcinia were taken for study under this project, 18 communities in all were taken for the study. Thirty-eight indigenous mango varieties from Chittoor region, 70 varieties from Pusa, 12 varieties from Amravati and 115 varieties from Malihabad were evaluated for fruit characteristics and the trait specific characteristics for each of the varieties was indicated. The steps followed at Chittoor in the conservation of indigenous varieties *ex situ*in diversity parks and linking them with the market are discussed.The strategies adopted, the lessons learnt that could be followed for the conservation of underutilized species are also discussed.

II-8

Evaluation of rambutan accessions under humid tropical conditions of Western ghats

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Rambutan (*Nepheliumlappaceumvar.lappaceum*) is an exotic fruits of South East Asian origin. It was introduced in India during id of last century. The cultivation of rambutan is gaining popularity since last few years in the Humid Tropical regions of the India. Around fifty accessions of Rambutan collected from various sources were evaluated for growth and yield parameters during 2011-13at CHES Chettalli. Among the accessions plant height maximum (5.6 m) in CHESR -IV-10. CHESR-III-11, CHESR-III-10 (4.6 m). CHESR-III-9(4.2 m).The plant spread(E-W) was highest CHES R-VI-8(4.5 m), CHESR-IV-11(3.65m). The plant spread(N-S) was highest in CHES-IV-11(3 m) , CHESR-VI-7 and CHESR-VI-9(3.65 m) ,CHESR-VII-9(3.65 m) for 7 year old plants. As for as yield is concerned, highest yield was recorded in CHES I-2(655 fruits), CHESR-XIV-10 (577 fruits). CHES -III-9 (562 fruits) , CHES IV-10(322 fruits). As for as fruit weight is concerned, itranged from 16.91 g to 49.69 g. Highest fruit weight (48.69 g)was recorded in CHESR-IX-10 followed by CHESRXI-12 (44.7 g), CHESRX-9 (40.9 g). The accessions such as CHESR-I-3, CHESRIII-9 ,CHESRVII-9 , CHESR IX-10 , CHESRXI-12 , CHESRX-9 recorded more than 30 g fruit weight. The highest yield was recorded in CHESRI-3 (21.4kg/tree), CHESR I-9 (21.95kg/tree), CHESR VI-9 (20.4kg/tree). The TSS range between 11.01to 21.8^{o}Brix,. Higher TSS was recorded in CHESR-I-3(21.4^{o}Brix),CESR-VI-9(21.5^{o}Brix)CHESR-VI-9(20.4^{o}Brix).The acidity ranged between 0.07 to 0.3%. The rind thickness ranged from 0.2cm from 0.7cm with the average 0.38 cm. Among the collections CHESR-I-2,CHESX-9, CHES-XI-11,CHESR-XIV,CHES-XIV-11 were found better with respect to fruit weight, yield than other accessions.

II-9

Physico - chemical analysis of elite rambutan (*Nephelium lappaceum* L.) types in kottayam district of Kerala

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Kottayam district in Kerala state have a good collection of Rambutan trees as a component of homestead. Hence a study was carried out during 2014 to identify the elite Rambutan (*Nephelium lappaceum* L.) collections from various homesteads of Kottayam. In this study 9 selections were identified as promising types based on morphological characters. The ripe fruits of 9 selections were analyzed to identify those with high quality to promote their propagation, improvement and conservation. The fruits were harvested during June and July 2014 and they were assessed for fruit weight, length, breadth, no. of fruits/Kg, percentage of pericarp, seed and aril, total soluble sugars, total sugars, Vitamin C and titratable acidity. Organoleptic study was also conducted in a group involving scientists and research scholars . The values revealed that there were significant variations among the collections in this particular traits. Individual fruit weight ranged from 23.46 g to 61.45 g registering 43.2 to 15.4 fruits/Kg, pericarp weight 0.22 to 26.0 g (42 to 43.56% of the total fruit weight) to average aril weight ranged from 6.57 to 31.68 g (51.55 to 26.65%), seed weight 0.25 to 4.03g (6.12% to 10.14%), TSS(16.2^0 to 19.8^0 Brix) and total sugar (12.62% to 17.36%). The fruits of selections KAU- NK -1, KAU- NK-3, KAU- NK -5 & N-18 showed better attribute in fruit weight, TSS and other desirable traits for export such as uniform red colour, firm aril which readily separates from the seed. Hence these selections can be recommended for their high performance and sustainable yield in Kerala.

II-10

Breeding passion fruit for quality and disease resistance- A relook

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Passion fruit wilt is one of the most important diseases, which causes sudden death of the vine leading to heavy loss and hence, the development of lines tolerant / resistant to this will be directly applicable to the field. Further availability of cultivar that yields high quality fruits would ensure increased area under this potential under exploited crop and development of juice industry.Breeding passion fruit cultivars that are disease tolerant / resistant, usually involves combining the best pomological characters of susceptible cultivars with disease resistance as an additional heritable character. Hence, in order to obtain ahigh

qualitydisease tolerant passion-fruit cultivar research program was initiated at IIHR, Bangalore. Large scale hybridization was effected between Cv. Kaveri and Yellow types collected from across the country including ornamental types as pollen parent. The performance of resulting hybrids was studied with respect to vegetative growth, flower types, flowering and fruiting, yield, fruit quality (including fruitweight, fruit size, pulp, internal colour, average seed number/fruit), total soluble solids (TSS) and commercialpatterns were analysed.Of the over 3000 hybrid seedlings of passion fruits analyzed, the mean fruit weight was 54.9 g and the TSS was 18.0° B. The fruit weight ranged from 10.5 to 127.8g and the TSS from 13.2 to 23.6° B. In addition No-spray plot technique was adopted to select the disease tolerant types. Some low acid sweet type accessions were identified for direct consumption as well based on fruit quality attributes. The best passion fruit cultivars which were shortlisted are being subjected to replicated trial for further selection and release for commercial cultivation.

II-11

Studies on variability in morphological and physico-chemical characters of karonda

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Karonda*(Carissa carandas*) is one of the main underutilized fruits of Indian origin which is known for its wide adoptability and nutritional values. Forty five collections of Karonda were evaluated at CHES Chettalli during 2011-13 to identify elite lines.The growth data revealed that the plant height ranged from 1.50m to 4.01m.Plant height was maximum in K-X-10 (4.1m) followed by K-IV-1 (3.6 m) and K-I-5 (3.5m). The plant spread (E-W) ranged from 1.50m to 5.80 m. The plant spread (N-S) ranged from 1.37m to 6.30m after 5 year of planting.The highest yield was recorded in CHES K-II-7 (21.14 kg), CHESK-V-6 (15.28 kg), CHESK III-4 (13.8 kg) and CHESK-VIII-1 (15.01 kg). The number of fruits ranged from 205 to 3145 fruits/plant.Higher average number of fruit/tree were recorded in CHES K-III-4 (3145 fruits), CHESK-VI-2 (2600 fruits) andCHESK-III-6(1800 fruits). The fruit weight raged from 3.24 g to 13.81 g. The collections CHESK- II-1,CHESK-II-7, CHESK V-6, CHES K-10,CHESK VII-11 recorded more than 10g fruit weight. The pulp content ranged from 62.53% in CHESK V-8 to 91.03in CHESK-II-7. The seedcontent ranged from 2.05%(CHESK-V-6) to 12.81%(CHESK-VII-3). The Total Soluble Solids range from 12.15º Brix in CHESK-VIII-1 to 17.05º Brix in CHES K-V-4 .Over all the accessions, K-II-7,K-V-6,K-VIII-1, K-VI-11,K-V-10 were found bigger in size sweet with less seed content. These may be use as table purpose while CHESK-II-6, CHESK III-8,CHESK V-2,CHESK VI-2 have smaller size with higher number of fruits. These may be used for pickle purpose.

Evaluation of jackfruit germplasm under Periyakulam conditions

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Jackfruit (*Artocarpus heterophyllus* Lam.) belonging to the family Moraceae, is a fairly large sized tree bearing largest fruit among edible known fruits. Archeological findings in India have revealed jackfruit was cultivated in India 3000 to 6000 years ago. It is native to Western Ghats of India and grown as wild in these regions. It is generally grown in the back yards and in the coffee and cardamom plantations, as shade tree in Western Ghats. The jackfruit is one of the three auspicious fruits of Tamil Nadu, along with mango and banana. The available scientific information on evaluation of jackfruit germplasm collected from various parts of Tamil Nadu under Periyakulam conditions was not done so far. Based on this background, a survey across Tamil Nadu was performed to collect the elite genotypes under All India Coordinated Research Project on Fruits to assess the variability in relation to growth and yield parameters. Based on this survey, eighteen jackfruit genotypes are maintained at college orchard of Horticultural College and Research Institute, Periyakulam. The above genotypes were evaluated during 2013 - 2014. The experiment was laid out in Randomized Block Design with four replications (each replication has four plants propagated by approach grafts) at the spacing of 10m x 10m under drip irrigation systems. Among the eighteen accessions maintained, the accession AH – 1 collected from Palur recorded the highest values for tree height (5.56 m) and canopy spread – North / South (5.44 m), East / West (5.88 m), the accession AH–2 collected from Muthandikuppam has shown early bearing and the accession AH–5 collected from Vridhachalam has recorded highest single fruit weight (11.36 kg) and number of carpels per fruit (105).

II-13

Characterization of jackfruit (*Artocarpus heterophyllus* L.) accessions

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Jackfruit, one of the important tropical fruit tree produces largest fruits and has got unique characteristics. It exhibits wide heterogeneity due to its cross pollination nature and seedling perpetuation. A preliminary survey was conducted in Central Kerala to explore the genetic variability in jackfruit and 30 promising accessions were conserved in the orchard of the Department of Pomology and Floriculture,College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala. Characterizations of the accessions were carried out at present here. Wide variability was observed in morphological and fruiting characters,they exhibit a wide range of variation in fruit yield, fruit weight, seed weight and number of flakes. The fruits also vary in sweetness, flesh colour and shape. The study showed that the tree shape varied from pyramidal to semi erect. Tree height varied from 7.5 m to 15.2 m. The height at first branching varied from 80 cm to 350 cm. The tree growth habit varied from erect to spreading, and also the branching pattern varied from erect to horizontal. The fruit shape varied from round to oblong. The flesh colour varied from creamy white to reddish. The result also indicated that fruit weight varied from 1.8 Kg to 24 Kg, 100 seed weight varied from 120g to 1250 g, number of flakes varied from 18 to 297 flakes, yield varied from 80 fruit/ tree/annumto 135 fruits/tree/annum , TSS varied from 18 ^{o}Brix to 25 ^{o}Brix.

II-14

Evaluation of jackfruit types at regional fruit research station, Vengurle

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Jackfruit, *Artocarpus herophyllus* Lam. belonging to family Moraceae is one of the most popular and widely grown evergreen fruit trees. In Jackfruit there are two types 'Kapa' (hard flesh) and 'Barka' (soft flesh). Now a day, for timber and furniture purpose, farmers used to cut the trees of Jackfruit. Conservation of this valuable germplasm is very much essential. For collecting and conserving the elite germplasm, the present investigation was carried out at Regional Fruit Research Station, Vengurle.The germplasm of 28 types of Jackfruit have been maintained at Regional Fruit Research Station,Vengurle. All the types have started fruiting. The maximum no. of fruits (>30 fruits/plant) were recorded in types DBSKKV J-6, DBSKKV J-7, DBSKKV J-10, DBSKKV J-11, DBSKKV J-13, DBSKKV J-18, DBSKKV J-20, DBSKKV J-27 and DBSKKV J-28. The maximum yield (>300 Kg/plant/year) was recorded in types DBSKKV J-7, DBSKKV J-10, DBSKKV J-11, DBSKKV J-18, DBSKKV J-27 and DBSKKV J-28. The highest weight of fruit (>10 Kg) was observed in types DBSKKV J-7, DBSKKV J-10, DBSKKV J-16, DBSKKV J- 17, DBSKKV J-23. The maximum weight of pulp (%) was observed in type DBSKKV J-6 and highest weight of seed was recorded in type DBSKKV J-7. The highest tree height (m) was recorded in type DBSKKV J-1 and no of branches in type DBSKKV J-4. The maximum T.S.S. was observed in type DBSKKV J-14 and highest sugar(%) recorded in type DBSKKV J-12. All this types are having hard flesh (Kapa types) and excellent quality.

Konkan Prolific – A new variety of jackfruit

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Jackfruit (*Artocarpus heterophyllus* Lam.) native to India is continuous in distribution in western coast. Being a crossed pollinated crop, there is a biodiversity in types of with respect to shape, size, firmness, quality, etc. The attempts have been made by the Regional Fruit Research Station. Vengurle to collect, conserve and evaluate the jackfruit types. As a result, the promising KKV/VGL/JF 9/93 type has released under the name "Konkan Prolific" as it is having heavy bearing tendency, precocity of bearing fruit characteristics like excellent quality, medium size (8 to 10kg/fruit weight) suitable for fresh consumption, processing quality and marketability. The pulp colour of the fruit is yellowish with white having TSS of 25^0 B. The fruit yield per tree is 420.56 kg. The harvesting season is April to June.

Molecular characterization of jack fruit selections of kuttanad region using RAPD technique

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*Artocarpusheterophyllus*Lam (Jackfruit)which belongs to the *Moraceae*family ,is believed to be indigenous to the south western rain forest of India.Jackfruit is an important component of homestead gardens in Kerala. There exists a lot of variability among jacktreessince most of them are raised from seedlings.A survey has been conducted in Kuttanad region to find out promising jack types during 2010-12 and selected six superior trees based on physico-chemical characters and organoleptic properties. Hence a study was undertaken to realizethe relationship among thesejackfruit selections during 2012-2014, using RAPD technique. DNA was isolatedfrom young leaves of six *A. heterophyllus*selections.Out of the thirty primers used for the analysis only tenproduced maximum polymorphic bands (OPA-1, OPA-2, OPA-4, OPA9, OPC7, OPD19,OPN-05, OPM- 16, OPG-03 and OPG-10).The primer OPA-1 gave the maximum number of bands and OPN-05 produced least. Among these, OPA-1 and OPA-9 gave most distinct banding patternfor Pathamuttom and Vaikkom-1 selections. Out of the total 58 bands scored, 36 were found polymorphic(62.07%). Jaccard's similarity coefficient between genotypes ranged from 0.33 to

1.00. The Shannon index value (i) for the polymorphic DNA is2.8554±0.4107.An UPGMA dendrogram was constructed using Treecon software and showed four major clusters, which followed geographical separation. Kumarakom-1 and Kumarakom-2 represented the 1st cluster, Pathamuttom and Vaikkom-1 represents two separate clusters and the last cluster was represented with Veloor-1 and Veloor-2 .Being horticulturally superior and genetically distinct, these cultivars are conserved in the RARS farm and are used for multiplication for commercial exploitation.

II-17

Polyembryony among jamun (*Syzygium cumini* (L.) Skeels) accessions

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Jamun is an evergreen tree commonly known as Java plum, belongs to the family Myrtaceae and species *Syzygium cumini* (L.) Skeels. Its centre of origin is Southeast Asia, India Myanmar and East Indies. Cultivated in tropics, as an evergreen tree with dense foliage and can provide lot of shade hence it is a very popular avenue tree. Jamun fruits are a good source of iron and are reported to possess a range of pharmacological properties like antibacterial, antifungal, antiviral, anti-inflammatory, cardioprotective, anti-diarrheal, hypoglycemic and anti-diabetic effects. Though widely spread all over the continent it has remained commercially underutilized. The seeds are polyembryonic however no systematic study has been reported. In the present we observed germination and polyembryony among seeds of 60 accessions. The seed germination varied from 23 to 100 percent. Observations recorded on polyembryony showed a range of 0 to 87.50 % where 0 indicates one seedling per seed and rest had more than one seedling per seed. Maximum of 6 seedlings per seed was recorded.

II-18

Performance of rose apple and watery rose apple under eastern tropical region of India

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Rose apple (*Syzygium jambos* L. Alston) and watery rose apple (*Syzygium aqueum* Alston) are native to Southeast Asia and naturalized in India. They belong to guava family i.e. Myrtaceae. The performance of rose apple and watery rose apple has been evaluated at the research farm of Central Horticultural Experimental Station, Bhubaneswar. They are small-to-medium-size tree with dense foliage and drooping branches. They bear white colour bisexual flowers in cluster of 4 - 12. Under eastern tropical region, January was the major flowering period in rose apple and watery rose apple. However sporadic flowering was also observed in May and October. The fruits of rose apple matured in 46 ± 3.5 days after fruit set. Fruits of rose apple were either round or oval in shape and turn to light yellow as they ripen. They had typical rose-like fragrance. Whereas the fruits of watery rose apple were conical, white and soft without any flavour. Rose apple and watery rose apple had 1-3 big seeds inside a fluffy cavity. Rose apple had the average fruit weight of 24 ± 4.5g and pulp content of 83.6%., whereas the fruit weight and pulp content of watery rose apple were 35 ± 4.6 g and 89.3% respectively. The moisture content in watery rose apple was higher (93.1%) than rose apple (81.2%). The TSS of rose apple and watery rose apple was 13.5 and 6.1 °Brix, respectively, whereas the pH was 5.8 and 4.2 respectively. Fruits of watery rose apple were more acidic (0.26%) than rose apple (0.1%). The average annual yield of a well grown tree was 15.5 kg. Air layering was the most common method of propagation with 80-85% success; however rose apple can also be propagated by seed due to its polyembryonic nature. Considering fruit maturity period, rose apple and watery rose apple may be exploited as subsidiary fruit crops with the major fruit crops of the region.

II-19

Evaluation of garcinia accessions for yield and quality under high rainfall zone of Tamil nadu

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Garcinia is much valued for its medicinal properties and it is a commercially grown tree spice in Kanayakumari District. A regular bearer cum high yielding Garcinia is not available for growers. Considering this, a trial was started with the objective of collection evaluation of Garcinia types for yield and quality. Eleven accessions were collected from different places viz. Devicode, Cheruvarakonam, Pallichal, Kuzhapuram, Surulode, Vazhekal, Arukani, Pathukani, Thadikarakonam, Kollencode and Zeropoint and planted during 1992 at Horticultural Research Station, Pechiparai and were being evaluated. The performance was studied and compared with Pechiparai local as check. It was observed that among the accessions GC-9 has recorded the highest yield of 72.5 Kg/tree. Fruit rind of this selection is rich source of HCA (28.6%) which is an important raw material in the manufacture of medicine/health tonic controlling obesity.

Characterization of malabar tamarind (*Garcinia gummigutta L.)* accessions at Kodagu region of Karnataka

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Malabar Tamarind *(Garcinia gummigutta L.*) is one of the potential underexploited underutilized fruits of Indian origin which is known for its anti-obesity and nutritional values. Forty nine accessions of Malabar tamarind were evaluated for growth, yield and fruit quality parameters at Kodagu region of Karnataka. The plant height ranged from 1.25m to 4.40m. The highest in GG-VI-2. The plant spread (E-W) ranged from 0.70 m to 3.25 m, with the maximum in GG-II-3. The plant spread (N-S) ranged from 1.10 m to 4.40m with the highest in GG-II-4. The flowering observations revealed that most of the plants are either male or did not flower thus they do not produce fruits and only few accessions produced fruits were characterized for its yield characters. Highest number of fruits was recorded in GG-V-1 (346 fruits/tree). The number of fruit/tree ranged from 61 to 346. Higher yield (28.2 kg/tree) was also recorded in GG-V-1. The fruit weight ranged from 47 g to 81.5 g. The maximum fruit weight was recorded in GG-V-1. The number of seeds per fruit ranged from 5.9 to 6.1 and Total soluble solids ranged from 8.2^0 Brix to 9.4^0 Brix in GG- VII-2. One accession (GG-V-1) was found promising. The fruit weight of this accession ranges between 75 to 85g. Fruits are dull yellow colored, 6-7 seeds/fruit, rind yellow, flesh white with 8 segments. The rind recovery is 62 per cent. The fruit contains 9.5^0 Brix total soluble solids . The average yield of this 12 year old tree is 400-700 fruits per tree.

II-21

Genetic resources of malabar tamarind (*Garcinia cambogia* (Gaertn.) Desr.) As an income generating crop for the farmers

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Farmers are always fascinated by crops which give them additional source of income without much effort. Malabar tamarind (*Garcinia cambogia*(Gaertn.) Desr.) is one such crop which can be selected by farmers considering its importance or use in food preparations and medicinal value. Its export potential

is also highowing to its use in anti-obesity treatment. NBPGR Regional Station, Thrissur is responsible for plant genetic resources activities in the southern peninsular India,and maintains 139 accessions of Malabar tamarind collected from Kerala, Karnataka and Goa. Of these, 108 trees in 65 accessions came to flowering which included 36 female and 72 male trees. Flowers of 108 trees were studied for 9 quantitative and 7 qualitative characters. All the 36 accessions of female trees were characterised for 21 fruit and 11 seed characters. The yield and yield attributing traits of the accessions were compared with the registered accessions namely IC244100-2 (INGR No. 04061) and IC244111-1 (INGR No. 04062). Elite lines were identified for various characters. IC244100-3 is found to be exclusively off-season (Oct.-Nov.) and can be recommended for regions where harvesting coincides with the southwest monsoon rains as in Kerala and Karnataka causing problems in processing of the harvested fruits to obtain dried rind. IC136677-1, IC136679-1, IC136681, IC244077-1, IC244081-2 and IC244083-1 bore fruits exclusively during the season and are short duration bearing and can be recommended for those farmers having sufficient drying and processing facilities. Dry recovery of rind of fruits which is a promising trait, was more than the mean of 7.83% in IC244106-2, 244101-2, 244081-2, 244097-3, 244096-2, 136677-1, 244086-2, 244115, 244101-3, 244110, 244075-1 and 244100-1, when the fresh fruit weight as a whole was taken in to consideration for calculating the percentage of dry recovery. Similarly, the time taken for drying isolated fresh rind of fruits to obtain dried rind was less than the mean of 9.13% in IC244084-1, 244101-3, 244110, 244075-1 and 244100-1. Considering genetic resources and identified elite lines in Malabar tamarind, there exists ample scope for the breeders to select trait specific superior lines and popularise among the farmers.

` **II-22**

Evaluation of kokum accessions for yield and quality traits in high rainfall zone of Kodagu

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Kodagu occupies a prominent position in Western Ghat region and home of several plant species, area known for its great biodiversity which is edible fruits, medicinal plants and vegetables. Many of the indigenous fruits still remained under exploited due to lack of awareness of the potential. Kokum (*Garcinia indica* Choisy), is a under-utilized perennial tree species and trees grow very luxuriantly in Kodagu rain forest. The fruit rind is a rich source of α Hydroxy Citric Acid (HCA), used as the main natural source for production of anti-obesity drugs, souring agent and food colour. Fruit juice is used for production of syrup, squash and RTS. Apart from economic importance, kokum trees form an excellent avenue. Trees are found wide spread in jungles, roadside, riversides and also coffee estates. However, there is no organized kokum plantations exists in the district but almost every farmer has a few plants of Kokum in estates. Health conscious and awareness among people, kokum syrup has huge demand from urban areas. With this back ground, extensive survey was conducted in Coorg. Kokum is a cross pollinated crop due to that each individual trees shows the variability. wide variation has been observed in Kodagu region among kokum trees and collections were taken up based on tree stature, fruit characters and quality of fruits. In forty different accessions of avocado were evaluated at Central Horticultural Experiment Station (CHES), Chettalli, Coorg, Karnataka. The experiment was laid out as a compact block of open pollinated seedlings. The trees were planted at a spacing of 8 × 8 m and standard package of practices were followed during the period of study. The population was evaluated for the characteristics of fruit and quality. Observation revealed that wide variability in terms of growth, yield and proximate characters of the fruits. The number of fruits were ranged from 84 to 1234 per tree. The highest number of fruits/tree was recorded in GI-V-4. The fruit yield (kg/ plant) ranged from 3.20 to 58.9 kg and it was highest in GI-V-4. The maximum fruit weight was noticed GI-V-8 (84.44 g) while minimum in G-VI-2(28.42 g). The seed weight ranged from 3.35 g (GI-VI-2) to 9.02 g in (GI-II-7). The rind weight was highest in GI-V-8 (52.55 g) and lowest was in GI-VI-2 (16.61 g). The TSS ranged from 11.9 to 16.4^{o} Brix. Among all the accessions, GI-V-8, GI-V-4, GI-VII-4, GI-VIII-5 were found promising with respect to yield and quality parameter. Two promising lines were indentified on the basis of the performance GI-VIII-5 is a high yielding promising seedling selection. Average fruit weight ranges between 50-60 g. Fruit are dull red in colour, 6-7 seeds/fruit, rind dark red, flesh white, 8 segments, juicy and acid sweet, seed attached to flesh. The rind recovery is 59.5 per cent. The fruit contains 14.1^{0}Brix TSS, 64 mg Vitamin C per 100 g pulp. The average yield is 1000-1200 fruits per tree. In GI-V-4 fruit weight ranges between 45 to 50g. Fruits are dull red coloured, rind dark red, flesh white, 8 segments, juicy and acid sweet, seed attached to flesh. The rind recovery is 48 per cent. The fruit contains 14.5^{0}Brix TSS and 36 mg Vitamin C /100g pulp. The average yield is 1000-1250 fruits per tree. The potential of these underutilized fruits are yet to be exploited as fruits for its nutritional and medicinal importance and need to be popularized.

II-23

Diversity, distribution and economic importance of the genus *Garcinia* L. in India based on an ecogeographic study in Indian Herbaria

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The genus *Garcinia L.* belongs to the family Clusiaceae. The genus comprises 240–250 species of dioecious evergreen trees, and is pantropical in distribution with high species diversity in South and South-East Asia. In India, the genus is represented by 36 species, of which 7 have 2 varieties each. Out of these 36 species, 16 are endemic and distributed in the Western Ghats, the North Eastern India and in the Andaman and Nicobar Islands. Eleven species occur in the southern Western Ghats, out of which 6 are endemic; 16 occur in North Eastern India, out of which 2 are endemic and 15 species are found in Andaman and Nicobar Islands out of which 7 are endemic. The comparatively less prominent species like *Garcinia cowa* can be promoted as a fruit crop similar to Mangosteen. Its habitat requirements are less demanding compared to the soil specifications and water requirements of Mangosteen. *G. indica* offers high variability with sweet fruits which can be used in a way similar to Mangosteen as it is also adapted to water stress conditions. *G.hombroniana* and *G. xanthochymus* are used as rootstocks for Mangosteen offering adaptability to stress soils. Dry rind of kokum and Malabar tamarind are used as spice, preservative and in veterinary medicine. Dried rind of Mangosteen is used in treating stomach disorders related to amoebic dysentery. Even though kokum and Malabar tamarind are more of a semi-domesticate nature, value added products like fruit juice, antioxidant formulations, edible butter etc. are available in the market. Because of the confused identity of *G.hombroniana*, which is sour and of poor quality, seedlings are sold as true Mangosteen by nursery-men and they need to be sensitized on the correct identity of true Mangosteen. A botanical key for field identification of economically important species and distribution map are also provided.

II-24

Characterization of yellow mangosteen (*Garcinia xanthochymus Hook.)* accessions at kodagu region of Karnataka

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Garcinia xanthochymus Hook. Syn. G.*tinctoria* Dunn., is commonly called as 'Yellow mangosteen' or 'False Mangosteen' one of the potential underexploited underutilized fruits of Indian origin which is known for its medicinal values. The growth, yield and fruit characteristics of 103 accessions of *Garcinia xanthochymus* were recorded at Central Horticultural Experiment Station at Chettalli, Kodagu, Karnataka. The plant height ranged from 1.20 m to 3.60m while the plant spread (E-W) ranged from 0.60 m to 2.35 m. The plant spread (N-S) ranged from 0.60m to 2.35 m. The fruit weight ranged from n97.5 g in GX-I-7 to 175.5 g in GX-II-5. The number of seed /fruit were 1.0to 2.0 which are lesser as comparison to other Garcinia species. The seed weight was 6.0 to 14.8 g which was more than other Garcinia species studied. As far as TSS is concerned, it ranged from 11.0^{0} Brix to 14.2^{0} Brix with highest in GX-IV-1.Titrable acidity ranged between 5.0 to 9.8 percent. Among all the accessions GX-II-5,GX-I-1,GX-IV-I were found better than other accessions with respect to yield and fruit quality at Chettalli condition.

Evaluation of avocado accessions for yield and quality Traits

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Avocado is the most nutritive among fruits and regarded as the most important contribution of the modern world to human diet. Avocado is mainly used as fresh consumption, salads and milk shakes. The pulp is rich in fat and widely used in the preparation of cosmetic industries. It is grown very limited scale and back yard cultivation in Karnataka, Tamil Nadu, Kerala, Maharashtra and Sikkim. In Coorg, is an emerging fruit crop with high demand from traders in Tamil Nadu, Kerala and Karnataka. Avocado is grown as home stead trees or as isolated trees in coffee plantations in parts of Coorg. With this back ground, extensive survey was conducted in Coorg. Wide variation has been observed in Coorg region among avocado trees and collections were taken up based on tree stature, fruit characters and quality of fruits. In thirty-two different accessions of avocado were evaluated at Central Horticultural Experiment Station (CHES), Chettalli, Coorg, Karnataka. The experiment was laid out in progeny row trial using the compact block of open pollinated seedlings. The trees were planted at a spacing of 6 × 6 m and standard package of practices were followed during the period of study. The population was evaluated for the characteristics of fruit and quality. Observation revealed that wide variability in terms of growth, yield and proximate characters of the fruits. Plant height was observed higher in PA XVI-2 (8.9 m) followed by PA IV-1 (6.1m) whereas lowest in PA-II-2. The fruit colour ranged from maroon red, dark green and most of the accessions pulp colour is yellowish green. As far as yield traits was concerned highest number of fruits (460) were recorded in PA-X-2 followed by PA-VII-1 (445 fruits) and 352 fruits in PA-III-1. Fruit weight ranged from 122 to 871 g. The highest fruit weight (871 g) was recorded in PA-II-1 followed by PA-VII-1 (625g), while lowest weight (122g) was recorded in PA III-2 and the average weight of fruit was 410g. Higher pulp content was recorded in PA-II-1(699.7g) and PA-VII-1(563.7g). In regard to, TSS was highest in nursery plant (8.8° Brix) followed by 8.5° Brix in PA III-2. Among all the accessions, PA-II-1, PA-VII-1, PA-III-1 and Nursery were found promising with respect to yield and quality parameter. Available variability in avocado paves way for genetic improvement in future. Further, Avocado cultivation in these regions and it has a huge potential for the domestic supply even for the exports.

II-26

Evaluation of custard apple genotypes for economic traits in arid condition

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Sixteen genotypes of custard apple were collected from different sources and maintained for evaluation. The experiment was conducted from 2005 to 2009 in the orchard of Regional Research Station, Aruppukottai in order to identify the ideal genotype which performs best under arid condition. Randomized block design was adopted with sixteen treatments replicated thrice at a spacing of 6 x 6 m. The pooled results revealed that higher fruit yield was observed in custard apple genotypes, Courtallam (12.6 kg/tree), British Guinea (10.9 kg /tree) and Aruppukottai Local (10.8 kg /tree). Balanagar and Washington 10700 recorded higher fruit weight of 163.4 g and 160 g respectively. The genotype collected from Courtallam registered the higher pulp weight (112.6 g) and Total Soluble Solids (26.7^0 Brix).

II-27

Strategies for conservation, improvement and utilization of Soursop (*Annona muricata* L.) accessions in Tamil Nadu

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Soursop, botanically known as *Annona muricata*L. is a commercially under-utilized perennial tree species. It is native of tropical America and its distribution is limited to tropical regions in India and Tamil Nadu. It is grown only to a limited extent in Tamil Nadu. It belongs to family Annonaceae.Soursop has been found to contain acetogenins, a class of natural compounds with a wide variety of biological activities. These compounds contain some acetogenins having anti-tumoral, insecticidal, antibacterial, immuno-suppressant, pesticidal or antihelminthic properties.In order to meet the demand of the market for the above plant throughout the year in all areas, it has become necessary to multiply the superior genotype available in nature. So,astudy was taken up to document the trees available in Tamil Nadu and identify a superior genotype with high fruit and alkaloid content. Several villages were surveyed in four selected districts of Tamil Nadu *viz.*, Vellore (dry zone), *Kanyakumari(*wet zone), Coimbatore and Salem districts (intermediate zone) for identifying naturally availablesoursop trees of seedling origin.

Totally, 55 accessions were surveyed, of which 22 accessions falling in the age group of 7-8 years were selected and documented.Among the 22 genotypes studied, regarding tree shape, 14 (63.63 %) were conical, 2 (9.09 %) were spreading and 6 (27.27 %) were semi spreading. Regarding trunk ramification,17 accessions possessed grey colour whichaccounted to 77.27 % and five accessions exhibited dark grey colour, amounting to 22.73 %. The variation in fruit weight was tremendous with a very wide range from 0.89 kg to 3.05 kg. The most promising accession in terms of fruit weight was AM 20.With regard to yield performance, in a 2 year evaluation study, two accessions *viz.*, AM20 and AM 22stood out from others recording 99.05 and 79.80 kg of fruits per tree. Forty five morphological characters were recorded from 22accessions and subjected to Principal Component Analysis (PCA) and Factor Analysis (FA), followed by Cluster Analysis. With respect to **PCA** *each character contributed a high percentage of variation.*A dendrogram of evaluated characters showed nine distinguished clusters. The Soursop accessions were found to have considerable genetic variability demonstrating the importance of analyzing each genotype in a collection.

II-28

Genetic variability in Graviola (*Annona muricata L)* - Cancer killer plant

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Graviola (*Annona muricata L)* belongs to the family of Annonaceae, is a widespread small tree and has its native in central America. It is a popular fruit tree that is cultivated throughout the tropical regions of the world. It is a common plant in the house compounds of southern peninsular India. Intensive chemical investigations of the leaves and seeds of this species have resulted in the isolation of a great number of acetogenins. The isolated compounds display some of the interesting biological or the pharmacological activities, such as antitumoral, cytotoxicity, antiparasitic and pesticidal properties. Roots of these species are used in traditional medicine due to their antiparasitical and pesticidal properties. The extract of the plant parts is effective against 12 types of cancer and it is 10,000 times powerful than chemotherapy. The greatest advantage with graviola is that it selectively hunts only the cancer cells, but not the healthy cells. Surveys were conducted thoughout the Kanyakumari district to record the variability existed in the population *in situ* and to identify a type with good quality and yield potential. The studies revealed that a wide variation was exists among the types studied. The documented variability in biometrical observations are plant height (3-10m), Leaf length(8-20cm), Leaf width (4-8cm), fruit length (15-40 cm), fruit width (8-42 cm), fruit weight (50g -5kg), TSS (18 – 26^{o}Bx), no of seeds (22 – 130), No of fruit/ tree (15-50), and Yield/tree (40-120kg). The fruit colour ranges from greenish yellow to lemon yellow and the leaf colour varies from yellowish green to dark green. Based on the intensive evaluation 10 promising types were identified and were planted at Horticulture Research Station, Pechiparai for further evaluation and selection.

Effect of foliar application of hormone and nutrients on yield and quality of Aonla cv. NA-7.

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Field experiment was carried out to find out the effect of foliar application of hormone & nutrients on yield and quality of Aonla. cv. NA-7 at Soil Conservation Research Station, Awashi Tal.Khed Dist. Ratnagiri, under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The plant height increment (0.92 m), canopy spread E-W(0.85 m) and N-S (0.91 m) with 48.78% fruit retention, fruit volume (40.51 ml), fruit weight (41.29 gm) and yield (111.75 kg) per plant was recorded maximum and minimum fruit drop (50.81%) with foliar application 2% boron (T_6). The minimum average fruit weight, yield per plant and TSS were recorded with control (water spray).

Genotypic evaluation in aonla in arid ecosystem

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Ten genotypes of aonla were collected from different sources and maintained for evaluation. The experiment was conducted from 2005 to 2009 in the orchard of Regional Research Station, Aruppukottai in order to identify the ideal genotype which performs best under arid condition. Randomized block design was adopted with ten treatments replicated thrice at a spacing of 6 x 6 m. Higher fruit yield was recorded in the genotypes EO 9 and EO 3 (17.3 and 17.2 kg/tree) respectively and fruit weight was found higher in EO 9 (21.2 g). Higher Total Soluble Solids was recorded in genotype EO 9 (8.93 ^{o}Brix).

Diversity studies in tamarind (*Tamarindus indica* L.) ecotypes using morphological markers

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Tamarind (*Tamarindus indica* L.) is a monotypic genus tree belonging to the family Leguminosae. Tamarind is also called as 'Indian date', a multipurpose tree known for drought tolerance and used primarily for its fruits, which are eaten fresh or processed, used as a seasoning or spice, or the fruits and seeds are processed for non-food uses. Morphometric and molecular analysis was used to indicate the potential of each tree and the scope for improving the desirable and economic characters through selection. In India, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Maharashtra and Karnataka are the major tamarind growing states. In Tamil Nadu, tamarind is extensively cultivated in Ramanathapuram, Sivagangai, Virudhunagar, Theni, Salem, Madurai, Dindigul, Dharmapuri, Tuticorin and Vellore Districts. Tamarind genotypes were available at forest areas and it will be eroded to human and animal interference and also natural calamities. The exploration was taken up to collect the tamarind genotypes and planted in the college orchard. The present investigation on "Diversity studies on tamarind ecotypes using morphological markers" was carried out at Horticultural College and Research Institute, Periyakulam and analyse the genetic divergence among tamarind genotypes was aimed at. Thirty one genotypes were used for this study. Observations on tree height (m), tree spread (m), pod characters such as flesh weight (g), pod length (cm), pod circumference (cm), average pod weight (g), shell weight (g), fibre weight (g), number of seeds per pod and number of pods per kg and yield character *viz*., number of pods per tree were recorded. Statistical analysis for morphological traits was conducted using software programme NTSYS pc version 2.02e. The collected data on morphological traits were analysed and constructed a dendrogram using UGPMA method. In the present study a significant difference among the tamarind genotypes. Among the 31 genotypes evaluated, TI-23 showed the highest genetic divergence followed by TI-11. TI-13 also showed another higher genetic divergence among the tamarind genotypes. This might be due to genotype TI-23 recorded the highest values in all the growth, pod and yield characters. Pod characters, TI-23 recorded the highest pod length (19.87 cm), pod circumference (9.80 cm), average pod weight (39.49 g), number of seeds per pod (12.67), flesh weight (11.69 g), fibre weight (1.27 g) and shell weight (8.34 g). Regarding yield characters, genotype TI-23 recorded the highest yield per tree (332.17 kg per tree). From the conclusion of the present study revealed that TI-23 showed the highest genetic divergence and it can be used to further evaluation programme and utilized in hybridisation with using of desirable traits of interest.

II-32

Performance of tamarind germplasm in Venkatagiri - Nellore District

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A total of 40 accessions of Tamarind germplasm collected from various sources in the country are maintained and evaluated for growth , yield , adoptability at Citrus Research Station, Pellur , Venkatagiri Dist. Some of the accessions performed very well and some did not perform well. Among the various accessions PTS-18, PTS-31 & 32 performed well in this area. The accessions unfavorable to this climate possessed low average mean for various characters in the present study. Since considerable variation exists in the species there are enormous opportunities for varietal improvement.

II-33

Exploration and collection of red tamarind genotypes in Tamil Nadu

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Tamarind (*Tamarindus indica* L.) is a monotypic genus tree belonging to the family Leguminosae. Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Maharashtra and Karnataka are the major tamarind growing states of India. In Tamil Nadu tamarind is extensively cultivated in Ramanathapuram, Sivagangai, Virudhunagar, Theni, Salem, Madurai, Dindigul, Dharmapuri, Tuticorin and Vellore Districts. Tamarind genotypes were available at forest areas and foot hills of Tamil Nadu. Desirable traits of tamarind to identifying the characters are long pod, short pod, colour of the pulp, taste of the pulp, colour of flowers etc. This will showed the difference one among them. In Maharashtra, sweet tamarind pulp is used for making juice and used for their diet in traditionally. In Tamil Nadu also sour tamarind juice is used for their diet. The red tamarind pulp is used for extracting natural color with will be used for natural colorant in diet. In Tamil Nadu, red tamarind called as "Raththapuli". Red tamarind genotypes are pulp deep red in color during unriped stage and even after ripened but taste is sour taste in both stages. With this backround, present investigation on "Exploration and collection of red tamarind genotypes (*Tamarindus indica* L.) were carried out at Horticultural College and Research Institute, Periyakulam during the year 2012-13 to exploration and collection of red tamarind genotypes from different parts of Tamil Nadu was aimed at. An exploration was made into Rajapalayam of Virudhunagar district to identify and collected one genotype from the farmers' field. An another exploration was made during the year 2012-13 at Theni districts of Tamil Nadu and collected three red tamarind genotypes from the farmers field. In the same

year one more exploration trip was conducted to Dindigul district of Tamil Nadu and collected two red tamarind genotypes from the farmers' field. These six accessions were grafted and grafted plants were planted at college orchard during the year 2014 for further evaluation.

II-34

Genetic studies in tamarind (*Tamarindus indica.L.)*

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Study on 52 genotypes of tamarind revealed a wide range of variability for all the traits investigated. Higher values of genotypic and phenotypic coefficient of variation were observed for pod length, mean fruit weight, seeds per pod, pod girth, flesh content and ascorbic acid content. Heritability was higher for mean fruit weight, flesh content and pod girth. These estimates indicated the scope for improvement in tamarind through selection.

II-35

Biodiversity of bael (*Aegle mormelos*) in Bundelkhand

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An under-utilised medicinal fruit plant, Bael (Aeglemormelos) is commonly grown in the country. It belongs to the family Rutaceae and has several nutritive and therapeutic properties. It is indigenous to Indian subcontinent and originated from Eastern Ghats and Central India. In India, the plant is widely cultivated in U.P. and Bihar. In general, bael plants are not cultivated at large scale commercially in Bundelkhand, M.P. The available fruits in the market mostly collected from forests and hedges of the fields and gardens. Now these valuable resources are diminishing and needs collection and conservation. Keeping in view the importance of bael plants, significant research, breeding and development efforts are being made to convert existing local landraces into disease free varieties with wide adaptation and promising commercial potential. The fruits collected from different parts of Bundelkhand region differed significantly with respect to morphological characters such as shape, weight, volume, rind thickness, pulp weight and number of seeds. The pulp colur ranges from yellow to orange. This plant shows substantial inter- and intra-specific genetic diversity in the region and already has demonstrated its potential for wider adoption and commercial exploitation.

II-36

Bael - A wonder fruit

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The bael fruit (*Aeglemarmelos)* belonging to family Rutaceae is also called Bengal quince, Indian quince, golden apple, holy fruit, stone apple. Sometimes it is called elephant apple, which causes confusion with a related fruit of that name, *Feronialimonia.* In the Hindu culture, the leaves are indispensable offerings to the 'Lord Shiva'. The leaves and twigs are lopped for fodder.A cologne is obtained by distillation from the flowers. The fresh ripe pulp of the higher quality cultivars, and the "sherbet" made from it, are taken for their mild laxative, tonic and digestive effects. A decoction of the unripe fruit, with fennel and ginger, is prescribed in cases of hemorrhoids. It has been surmised that the psoralen in the pulp increases tolerance of sunlight and aids in the maintaining of normal skin color. It is employed in the treatment of leucoderma. Marmelosin derived from the pulp is given as a laxative and diuretic. In large doses, it lowers the rate of respiration, depresses heart action and causes sleepiness. The unripe bael is most prized as a means of halting diarrhea and dysentery, which are prevalent in India in the summer months.A decoction of the flowers is used as eye lotion and given as an antiemetic. The bark contains tannin and the cournarin, aegelinol; also the furocourmarin, marmesin; umbelliferone, a hydroxycoumarin; and the alkaloids, fagarine and skimmianine. The fruit, roots and leaves have antibiotic activity.

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Performance of wood apple germplasm in Venkatagiri - Nellore District

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A total of 10 accessions of Wood apple germplasm collected from various sources in the country are maintained and evaluated for growth, yield, adoptability at Citrus Research Station, Pellur, Venkatagiri Dist. Some of the accessions performed very well and some did not perform well. Among the various accessions PWAS 2,9 performed well in this area. The accessions unfavorable to this climate possessed low average mean for various characters in the present study. Since considerable variation exists in the species there are enormous opportunities for varietal improvement.

Longan (*Dimocarpus longan*) - A potential fruit for nutrition and health security

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Longan is subtropical, medium-sized tree evergreen tree that can grow up to 9 to 12 m in height. It produces edible fruits mostly eaten fresh and canned in their own juice. It can also be preserved dry, either intact or after removal of the pericarp. The dried flesh is black, leathery and smoky in flavour and is used mainly to prepare a refreshing drink. Besides fruits, the longan tree also yields a hard and useful timber. The analysis revealed that the fruit contain carbohydrate 15.14 g, vitamin C 84 mg, calcium 1 mg, magnesium 10 mg, phosphorus 21 mg, potassium 266 mg, zinc 0.05 mg per 100 g edible portion of the fruit. Longans are good source of vitamin C. Longans are identified in the wet evergreen forest in the Western Ghats region of Kerala which is one of the hot sports of plant diversity. There is a need of further research on the evaluation of physico-chemical and nutritive values of the fruit in the state, to explore all possible natural population, regeneration, selection of elite strains and documentation and standardisation of cultural practices for domestication of this tree.

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Evaluation of elite apricot (*Prunus armeniaca* L.) varieties under high chilling region of Pulney hills

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The apricot is an underutilized temperate fruit belonging to the family Rosaceae. The fruit is versatile, very attractive and an excellent source of Vitamin- A, C and E, potassium, iron and β-carotene. Apricots are cultivated world-wide mainly for their high-quality fruit, which is consumed fresh, processed by the food industry, or preserved by drying. Even though plenty of potentiality exists in high chilling regions of South India the research work is much confined pertaining to apricot. In this view, the high chilling apricot varieties were introduced and evaluated to study the performance at Horticultural Research Station, TNAU, Kodaikanal. In this investigation, five varieties of apricot *viz.,* CITH No.1, CITH No.2, CITH No.3, Harcot and New Castle were evaluated and growth parameters were recorded. The results

revealed that the highest values for all the morphological parameters *viz.*, plant height (1.33 m), stem girth (9.78 cm), canopy spread (EW- 1.51 m and NS-1.85 m) and number of branches (6.71) were recorded in the var. CITH No.1 followed by the var. CITH No.3.

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Studies on kiwi (*Actinidia deliciosa* chev.) varieties under Kodaikanal condition

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Kiwifruit or Chinese gooseberry is known as 'China's miracle fruit and 'the horticultural wonder of New Zealand'. A ripe kiwifruit is having delicate flavour with pleasant aroma, high nutritive value particularly vitamin-C (65.5 mg/100 g) and vitamin-A (175 I.U/100g) with high antioxidant property. The commercial cultivation and vast potential of kiwi fruits is in mid hills of Himachal Pradesh, Jammu & Kashmir, Arunachal Pradesh, Sikkim, Meghalaya and hills of Manipur. In Tamil Nadu, Upper Pulney hill is a potential area in view of conducive climatical factors to exploit kiwi. In this point, an evaluation of kiwi cultivars has been carried out at Horticultural Research Station, TNAU, Kodaikanal. Five cultivars namely Hayward, Allison, Bruno, Monty and Abbott were evaluated to study the yield and quality parameters. The results revealed that the var. Hayward registered the highest values in yield and quality parameters *viz.*, fruit weight (112.85 g), fruit yield per plant (28 kg), number of fruits per plant (80 nos.), fruit length (8.1 cm), and highest Total Soluble Solids (7.02" Brix). The high fruit diameter (17.1 cm) and days to maturity (172 days) were observed in var. Bruno. The present study concluded that the var. Hayward recorded the higher score for appearance, taste, flavour and over all acceptability followed by Bruno and Allison.

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Survey and evaluation of persimmon (*Diospyros spp.*) in the temperate zone of Kodaikanal hills

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Persimmon (Diospyros spp.) is a deciduous fruit tree that is believed to have originated in China and being cultivated in different parts of the world. The fruits are more attractive with a good source of β-carotene, potassium, sugars, Vitamin-C and antioxidants. In South India, it is confined to small packets as home

trees or in orchards particularly in high altitude regions of Nilgiris and Kodaikanal. In persimmon, there is abundant scope for genetic resources and species diversification in global prospects. To know well and utilize those resources, the fundamental and essential works are survey, collection, identification, classification and evaluation. In this view, an investigation on survey and evaluation of Persimmon species at high altitude region of Kodai hills has been carried out. As a result, three Diospyros species viz., Diospyros kaki Thunb., Diospyros lotus L. and Diospyros virginiana L. were identified and assessed its growth and yield parameters periodically. The growth parameters like canopy spread, leaf characters, shoot number and flowering habits were registered for all the species and concluded that the growth and development was good under temperate region of Kodaikanal. But, the yield parameters considerably varied depending on the species. Among the species Diospyros kaki Thunb. recorded the highest values in number of fruits (80-90), fruit length (9.22 cm) and fruit girth (15.10 cm), fruit weight (220.36 g) and yield per tree (20 kg) when compared to other related species. Diospyros lotus L. recorded the minimum fruit size with a value of 4.7 cm (fruit length), 9.2 cm (fruit girth) and 19.51 g (fruit weight).

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Morphological and Molecular characterization of governor's plum (*Flacourtia montana* J Graham) – a less known fruit

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Governor's Plum *(Flacourtia montana* J Graham) is a less known fruit with high attributes belonging to family Salicaceae. It is endemic to Western Ghats and distributed in South, Central and South Maharashtra Sahyadris. It is found as under storey trees in evergreen to semi-evergreen forests having dioecious flowering habit and produces red colored single seeded fruits. The present study reports preliminary characterization of 17 seedling accessions introduced from Western Ghats region of Kerala using morphological/ phenological characters on leaves, flowers and fruits. In order to correlate the morpho-characterization data molecular characterization was carried out on the same accessions to link traits with gene sequences. To achieve this, protocols for DNA isolation and PCR were optimized. The phenotypic characters of accessions along with molecular characterization using DNA markers along with possible genetic interrelationships of the accessions will be discussed, which will help in identifying accessions for clustering of trait specific germplasm.

Seabuckthorn (*Hippopheae rhamnoides* L.): The golden bush of Himalayas

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Seabuckthorn (Hippopheae rhamnoides L.) is one of the most important under exploited fruit of the high altitude cold arid zones of Himalayas in India. The major natural growing areas include Ladakh in the state of J & K, Lahaul - Spiti in Himachal Pradesh, Gharwal in Uttarakhand and also in limited patches in Sikkim and Arunachal Pradesh. The plant bears orange-yellow, small, soft, juicy, highly acidic fruits which cannot be consumed as fresh fruit. Traditionally, the thorny bush was considered a menace with its dried twigs mainly used for fencing fields. Local traditional healers 'Amchi', use certain parts of the plant in the preparation of their herbal formulations. Various studies conducted have shown its immense importance because of its food, forest, fodder, environment protection, medicinal, cosmetic and nutraceutical values. Fruits of seabuckthorn are a rich source of vitamins and other organic acids and nutrients. Major vitamins available in ripe fruits are Vitamin C (600-1400 mg/100g), Vitamin E (162-255 mg/100g), Vitamin A (11 mg/100g), Vitamin B_1 (0.04 mg/100g), Vitamin B_2 (0.56 mg/100g) and organic acids (2-4%). It possess anti-oxidants which impends aging process and memory loss, reduces high blood fat content, risk of coronary heart problems and angina, improves microcirculation of blood capillaries and nourish skin and hair. It also contains essential amino acids such as lysine and microelements such as iron, cobalt, selenium, molybdenum, etc. Oil content in sea buckthorn seeds varies from 10-20% while the fruit pulp contains 2-4%. Oil of seabuckthorn contains several bioactive substances like β-carotenoid (249 mg/100g), Vitamin E (203 mg/100g) and Vitamin K. The oil has immense medicinal potential as well. Sea buckthorn leaves are nutritive fodder for cattle and sheep/goats, as they are a rich source of protein (18-22%), 1.41-5.29% ether extract, 8.76-11.67 crude fiber, 6.7-8.16% total ash, 0.16-0.23 % total phosphorous, 1,52-2.23% calcium, 10.028 mg/kg copper, 23.52 mg/kg zinc, 0.18-0.94 % acid insoluble acids, 8.19 mg/100g Vit 'E', 1.81 % flavanoides and 495.7mg/kg iron and fat (4-5%) and other micronutrients for the animals besides it has medicinal value. A product namely Herbal Tea has been developed by DRDO contains sea buckthorn leaves as one of its major constituents. The small sized fruits are highly perishable and cannot be consumed fresh due to their highly acidic taste. It therefore, becomes imperative to develop processing procedures in order to ensure its scientific utilization for developing food products. Value addition techniques for preparation of various products have also been standardised.

Seabuckthorn is a non -climacteric fruit which ripen uniformly over a very short period. Fruit maturity can be judged on the basis of fruit colour, total soluble solids, acidity and days after full bloom. Sink-float method for judging maturity indices has not proved to be an authentic method. Average fruit weight of ripe fruits varied from 126.33 mg to135.0 mg , content of juice from 61.42 to 72.07 per cent, pH of fresh juice from 1.49 to 5.7, total soluble solids from 12.33 to 20.75 per cent and acidity from 3.40 to 4.01 per cent. Method for pulp extraction and storage were studied. It has been observed that pulp recovery varies from 61.42 to 72.07 per cent depending upon the method used for extraction and stage of fruit maturity. Seabuckthorn squash having 25% pulp, 48 - 50^{O} Brix TSS and 1% acidity and nectar having 20% pulp, 15 ^{O} Brix TSS and acidity have been standardised. Seabuckthorn jam was prepared in combination with fruits like apple, mango, etc. Seabuckthorn pickle has been very successful at the cottage industry level. It is prepared from semi ripe fruits and preserved in vinegar or edible oils. Production procedures for products viz., blended juice, sauce, chayavanprash have also been standardised where maximum nutritive value is retained despite storage and processing. With the development of processing technology for preparation of herbal beverages from fruits of seabuckthron and subsequently transfer of technology for commercial production, has opened up the avenues for its commercialization. Seabuckthron beverage is perhaps the most sought after health drink in Indian Market and are available in the trade name of "Leh Berry", "Power Berry", "Siachen Berry" "Multivit" etc. It has also been recommended and used in the hospitals, schools, Indian Railways, Airlines and sports, besides its inclusion in the high altitude special ration of Indian army. The commercialization of the beverages has not only conserved the natural plantation of seabuckthron, which otherwise was reducing, but has also improved the economy of remote hilly regions of the country. The technology has created demand for fruits and pulp of seabuckthron which ultimately are generating work opportunity for ladies and unemployed youth in harvesting of fruits and processing of pulp. A large number of primary pulping units have been established by cooperative societies, non-government organizations and private entrepreneurs, which are collecting fruits from farmers and after pulping the fruits, pulp is sold to processing industries for further value addition. Leaves and seeds are other parts of the plant which are high in demand for its use in tea manufacturing and oil extraction, respectively.

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Dragon Fruit - A new introduction crop to India: A potential market with promising future

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Dragon Fruit (*Hylocereus* sp.) is a perennial, known as red pitaya , have recently drawn much attention of growers worldwide, not only because of their red or pink colour and economic value as food products, but also for their rich antioxidative activity from the betacyanin. It strengthens the human immune system and is used in the treatment of diabetes. Medicine made from flower and stem promotes blood circulation. Fruits can be processed to juice, ice cream or wine. It belongs to family of Cactaceae consists of climbing or epiphytic cacti with angular stems and mostly white, fragrant, night-blooming flowers which is native to the Central and South America. One of the widely grown varieties and most commonly available is the *H. undatus* (red pitaya with white flesh). Other varieties that have been commercialised are the *H. polyrhizus* (red pitaya with red flesh) and *H. megalanthus* (yellow pitaya). The skin is covered with bracts or scales hence the name ”dragon fruit”. They are currently being grown commercially in South East Asia and the USA. The plant is adapted to tropical or arid climates with rainfall of 30-40 inch and any kind of soil with organic matter. Flowers, white inside and greenish yellow with purple dyes on the outside. They are scented and open at night and last one only night. Fruit is oblong shaped, distinguished with red or yellow skin with large sales and fruit pulp is either white or red. At present, very little knowledge available on production aspects. With these background, Central Horticultural Experiment Station (CHES), Chettalli, Coorg, Karnataka was under taken a evaluation studies on dragon fruit in relevance to adaptability and production aspects. Dragon fruit plant prefers a dry tropical climate with an average temperature of 20-29^{o}C, but can withstand temperatures of 38-40^{o}C, and as low as 0^{o}C for short periods. Rainfall requirements are 500-1400 mm with alternating wet and dry seasons. Dragon Fruit is propagated through seeds or cuttings. As the Dragon fruit is a climbing cacti, the vines have to train to climb concrete or wooden posts, distanced 3m between posts and 4m between rows with iron round bar on top to support the plants and trellis. Trellis is generally 5 - 8 feet high. pacing of plants is an average of 8-10 feet apart. A combination of organic and 100g of complete fertilizer (19-19-19) is applied every three to four months. Regularly prune the plants to obtain an open and manageable umbrella shape canopy which will induce new shoots for the next cropping season. Optimal time to harvest of fruit was one month after pollination at full colour development. The present paper discusses the importance of fruit, and cultivation aspects. plants are relatively free from harmful pests and disease. Currently, market prices varied between Rs. 200-300 per kilo of fruits. Dragon fruits have the huge potential market and expected to be a profitable new crop for farmers.

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Studies on some aspects of flower biology, pollination behaviour and genetic improvement in Mahua (Bassia latifolia Roxb.)

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Mahua botanically *Bassia latifolia* Roxb, is an indigenous tree of high economic value distributed in the tropical, subtropical and humid tropical regions of the country forming livelihood support to the tribal populations. Mahua is a potential fruit tree for organized orcharding in the years to come especially for utilization of degraded rocky and other problem soils. It is well-adapted and a popular plant species with valuable multifarious uses. It is very hardy to different environmental and soil stress conditions and requiring little maintenance and care. It provides an outstanding green cover even for waste and marginal soils. There is a need to explore the possibilities of identifying dwarf Mahua genotypes with good flower and seed quality for commercial exploitation of this species. Moreover, with proper selection of superior genotypes, and post harvest processing, there exists potential to obtain from it industrial alcohol, high quality potable alcohol, and bio fuel. Thus, it can be a valuable source of renewable, low cost energy and could be a sustainer of the environment. Mahua is a characteristic tree of the dry regions , and found distributed widely in north and central India. It commonly grows in eastern Uttar Pradesh, Madhya Pradesh, Maharashtra, Bihar, Orissa, Andhra Pradesh and Gujarat. In Rajasthan, it is also found growing on the waste lands particularly in southern parts of the state. Some species are endemic to the Western Ghats also. *B. malabarica* grows in the Western Ghats ecosystem from Kannara to Travancore and also in the Himalayas. The tree is very well known to the rural folk across the country since ages. The trees of *Basia latifolia* and *B. longifolia* grow up to an altitude of 1,200m and annual rainfall of 750-2500 mm. The trees of *B. butyracea* grow in the Himalayan districts up to an altitude of 4,500m. Though it is a very hardy tree, plants do not survive under waterlogged conditions. Approach herkogamy demonstrated by spatial separation of sex organs, existed in the species as an out-crossing mechanism allowing gene flow and genetic introgression in natural stands thus contributing to the prevailing diversity. Flower biology studies carried out at Central Institute for Subtropical Horticulture (CISH), Lucknow indicated that pollen of *Bassia latifolia Roxb* was 45-55 μm in size, anemophily perhaps coexisting with geitonogamy appeared to be the principal mechanism of pollen transfer. Thus, the flower biology studies demonstrated floral attributes accounting for cross pollination resulting in genetic introgression and generation of appreciable diversity in natural stands, emphasizing needs of its characterization for profitable utilization. Survey was carried out by CISH, Lucknow in the hotspot districts of Lucknow, Rae Bareily and Faizabad in U.P. and Panchmahal (Godhra), Anand and Vadodara districts of Gujarat to identify the elite germplasm among the existing natural stands. Twenty four superior accessions were collected and planted in the field gene bank at CISH, Lucknow and analyzed for their physicochemical and nutraceutical parameters. The accessions exhibited appreciable variability for economically important traits starting with flower trait itself, implying scope for further selection of superior types. The flower weight varied from 1.187 to 2.207g, length from 1.87 to 2.18 cm, diameter from 1.42 to 1.72 cm, TSS from 18.2 to 26.4 0B. The juice content ranged from 44.78 to 65.43 % whereas the pomace percentage varied from 24.17 to 37.94 %. Maximum total antioxidant value was observed in the accession CISH M-4 (44.48 mg AEAC/g) using Ferric reducing antioxidant potential, while CISH M-6 showed minimum value (9.25 mg AEAC/g). The phenol content was maximum (9.53 mg/g) in CISH M-4 whereas it was minimum (7.66 mg/g) in CISH M-1. The accessions with desirable floral traits, high pomace yield and nutraceutical attributes need due focus in genetic improvement of the crop including conservation of CWR (crop wild relatives), as large scale deforestation and urbanization have lead to genetic erosion of Mahua diversity which needs to be restored for sustainable livelihoods of a large segment of the tribal population in the endemic areas.

Phytosociology and physical characteristics of fruits of *Artocarpus hirsutus* and *Elaeocarpus serratus* in vazhachal forests of Western ghat, Kerala

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The present study was carried out to determine the phytosociological attributes and to evaluate physical characteristics of edible fruits of *Artocarpus hirsutus*, and Elaeocarpus serratus in the Vazhachal Forest Division of Thrissur district in Kerala. Artocarpushirsutus an evergreen tree belongs to the family Moraceae commonly known as wild jack tree. The fruits well known as bread fruit are yellow and ovoid covered with spines, and contains numerous white seeds. The mature ripened fruits are pleasantly sweet and edible. Elaeocarpus serratus commonly called as Ceylon olive belongs to the family Elaeocarpaceae. The fruits are ellipsoid to round, with a stony endocarp. The mature fruits are usually edible or pickled. Phytosociological studies were carried out for two specis and Pogalappara, Sithan and Poringa areas of Vazhachal Forest Division in Kerala. With respect to different areas of study, it is observed that in Pogalapara area, the IVI value for Artocarpushirsutus, Elaeocarpus serratus, were 47.86 and 14.17 respectively whereas in Sithan area, the IVI values registered as 76.66 and 36.84 respectively. In Poringa area, the IVI values for Artocarpushirsutus, Elaeocarpus serratus were 39.63 and 11.99 respectively. Physical characteristics of Artocarpushirsutus fruits showed measn fruit weight and fruit volume as 111.15 g and 83.94 cm3 respectively. Mean number of seeds per fruit was found to be 14.14. Mean percentage of pulp, peel, seed and core were recorded as 11.80, 54.66, 10.18 and 11.98 per cent respectively. Physical characteristics of Elaeocarpus serratus fruits showed mean fruit weight and mean fruit volume as 5.13 g and 8.3 cm3 respectively. Mean percentage of pulp, peel, seed and core were recorded as 54.58, 11.69 and 35.08 per cent respectively. Based on the above study regarding the distribution and physical composition, it substantiates the significance of underutilized fruits like Artocarpushirsutus, and Elaeocarpus serratus for commercial exploitation and further widens the scope for value addition of such fruits involving rural communities who are the major users of such species.

Performance of citrus germplasm in Venkatagiri - Nellore District

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A total of 117 accessions of citrus germplasm collected from various sources in the country are maintained and evaluated for growth, yield , adoptability at Citrus research Station, Pellur ,Venkatagiri Dist. Some of the accessions performed very well and some did not perform well. Among the various accessions Coderina Fina. Rough lemon 14.09.2013 Emmikapuli.Attaro small grape fruit, Pummelo Rabab Tonga. Calamandrin.Sunk mandarin performed well in this area. The accessions unfavorableto this climate possessed low average mean for various characters in the present study.

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Midimaavu (Wild Mango): Its distribution, population ecology and conservation

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Midimaavu is a type of wild mango, exclusively used for pickle preparation. The entire un-ripened fruits are harvested from the forest areas and used in pickle making. The pickles made from midimaavu can be stored up-to 3 years without any preservatives. Although, Midimaavu look like wild or cultivated mango but fanatical observations help in distinguishing midimaavu from rest. The local midimaavu collectors in central Western Ghats can easily identify them. The Midimaavu possess characteristics smell and several unique traits, based on which local people have classified and have named several midimaavu varieties. Sirsi (Uttara Kannada) and Rippanpet (Shimoga) are considered as 'hotspots' of Midimaavu. Further, it is predicted that Midimaavu could be another species of genus *Mangifera* and restricted to central Western Ghats. Further, in recent years due to increased demand for midimaavu pickle, anthropogenic pressure on midimaavu populations has increased at alarming rate. In this study, we documented the distribution of midimaavu populations through systematic field survey. The population's demographic status was assessed by laying 10x10 m random quadrates' and 1x1 m nested quadrates. The demographic analysis revealed that typical reverse "J" shaped curve is not observed in many populations. The density and regeneration per adult analysis indicated that most of the populations studied are suffering due to poor regeneration. There was strong correlation observed between geo-coordinates and density, suggesting the midimaavu prefers specific habitat requirement thus restricted to certain locations. Overall the study indicated that midimaavu populations are suffering due to anthropogenic pressure and need conservation attention.

Comparative study of antioxidant potential of some underutilized edible trees

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In order to feed the burgeoning population, new sources of food are being explored. Of these, one of the options is to utilize underutilized edible plants that may provide the nutrient rich food for the future. However, these plants lack potential market value owing to their less preference over the cultivated foods. Unfortunately, due to lack of attention, such plants are gradually becoming rare and endangered. It is thus important to conduct studies on these plants in different ecosystems. In the present work, antioxidant activity of underutilized edible plants like *Dillenia indica*, *Moringa oleifera*, *Artocarpus lakoocha* and *Annona squamosa* were explored. For this purpose, water extract of the fruits of test plant species were subjected to determination of antioxidant potential through total antioxidant activity, DPPH (1,1-diphenyl-2-picryl hydrazyl) radical scavenging test, hydroxyl radical scavenging test and ferric ion reducing antioxidant power test. The fruit extracts of test plant species possessed significant antioxidant activity. The antioxidant activity increased with the increasing concentrations of extract. Upon investigation, phytochemical analysis of plant extracts indicated their role in providing antioxidant activity to the plant. The study concludes that underutilized plants possess good antioxidant potential.

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Passion fruit -A unique fruit with multipurpose uses and scope in India

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The Passion fruit (*Passiflora* sp.) has about 400 species out of which two species *viz.*,'Purple' (*Passiflora edulis* Sims.) and 'Yellow'(*Passiflora edulis var flavicarpa* Denger) are the basis for entire passion frui tproduction is native to Brazil. In India, passion fruit has been grown in the Nilgiris in the south and in various parts of northern India *viz.*, Meghalaya, Manipur, Mizoram, Nagaland and Sikkim covering only an area of 18,020 hectares and production1,00510MT.Passion fruit with its unique and delicate flvour is widely used in beverages,squash and cordials. The Passion fruit having a central cavity filled with aromatic pulp, which is made up of juicy out growth from the seed (aril), is rich in vitamins A and contains appreciable quantities of vitamins A, B and C. In general, per 100 g of edible portion of Passion fruit contains 75 g moisture, 2.2 g protein, 21.2g carbohydrates, 64 mg phosphorus, 28 mg

sodium, 13 mg calcium, 348 mg potassium and 700 IU vitamin A. It is rich in alkaloids, flavonoids and carotene. Fruit is valued as antiscorbutic and stomachic. Flesh is prescribed as sedative to relieve nervous headache, asthma, diarrhea, dysentery, neurasthenia and insomnia.Passion fruit juice is rich in flavour and pleasantly aromatic, which is an excellent additive toother fruit juices or it may be used for preparing quality squash. Passion fruit juice can be boiled down to a syrup which is used in making sauce, gelatine dessert, candy, ice cream, sherbet, cake icing, cake filling, etc.Due to increase in demand from processing industry, the cultivation of passion fruit has picked up in north-eastern states. Adoption of improved cultivation practices and post harvest processing technologies will increase the yield and profitability from passion fruit cultivation. Processing and storage of fruit pulp needs to be investigated further. The release of kaveri variety has greater scope in increasing production as they are tolerant to brown leaf spot, wilt, and collar rot, root-knot nematode and thrips with an average yield of 25 tonnes of fruits/ ha.However, being a high value nutritious fruit, there is a need to popularize its cultivation among farmers in India

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Potential underutilized tropical fruits crops of India

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The important fruit crops grown commercially in India are mango, banana, citrus, guava, grape, pineapple, papaya, Sapota, litchi and apple which comprise more than 75 percent of total area under fruit cultivation. There are quite a large number of indigenous and underutilized fruit crops, which are being used by the local inhabitants. In fact for people living in villages, these underutilized fruits are the only source of protective food to meet their vitamins and minerals requirements in their poor diet. Because of their curative properties, these fruits have been used in Indian system of medicine such as Ayurvedic and Unani since time immemorial. Apart from their nutritive and medicinal values quite a few of these underutilized fruits have excellent flavour and very attractive colour. In spite of these quality attributes most have not undergone any conscious phase of domestication and human selection. Their cultivation is very restricted and they grow mainly wild. Being tolerant to biotic and abiotic stresses, these fruit species are suitable forgrowing in the disaster and drought-prone areas .India has a rich heritage of indigenous fruit types. Although some fruits have already been recommended for commercial planting, it is apparent that there are a lot more fruit types that await future exploitation. The more familiar ones include: Jackfruit (*Artocarpusheterophyllus*), Bael(*Aeglemarmelos*), Jamun (*Syzygiumcuminii*), Carambola (*Averhoa carambola*), Aonla (*Emblicaofficinalis*), Karonda (*Carissa carandas*) and Phalsa(*Grewiaasiatica*). Present status of these fruits in India and future research needs will be discussed.

New variants in clove (*Eugenia caryophyllata)*

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Clove (*Eugenia caryophyllata*) is an important tree spice largely cultivated in Kanyakumari, Tirunelveli, Madurai, Dindigul and Salem districts in Tamil Nadu. As original number of introductions was few, clove tree appears to be uniform type and no distinct varieties/cultivars have been recognized. Thus continuous self pollination and the narrow genetic base result in homozygosity of clove. Two variants namely King clove and Liliput clove have been identified from the population in the clove tracts of Kanyakumari. These types differ in tree habit, leaf size, clove size and colour. The King clove has higher leaf size, bud size and boldness by two to three times than the normal ones. However, the green bud yield ws 40% lower than the commercial clove. On the other hand, the Liliput clove had smaller leaves and buds and half the boldness of the existing types. The yield potential of Liliput clove is 80-85% lower than the cultivated types. Despite the fact that these two types yielded relatively lower, they can be exploited breeding programmes.

II -53

Evaluation of elite pummelo (*Citrus maxima*) lines for yield and yield contributing parameters and fruit quality under Coorg conditions

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Pummelo (*Citrus maxima*) , the largest citrus fruit in the world with sweet flesh and thick rind. In India, it is grown on a limited scale, in few localized pockets in Karnataka, Tamil Nadu, Bihar, Uttarakhand and Himachal Pradesh. There is no commercial variety of pummelo fruits available in our country. The elite seedlings are used for source of mother by the growers and these are heterogeneous with lot of variability. In order to identify suitable superior lines, sixty-five accessions of pummelo were collected from different sources and planted at Central Horticultural Experiment station (IIHR), Chettalli, Kodagu, Karnataka. These progenies were evaluated for growth, yield and fruit quality parameters for last 12 years. The results showed that there were significant differences in plant height, plant girth, and tree spread among different accessions evaluated. The plant height ranged from 2.48 m in CHESP-48 to 8.10 m in CHESP-28. Maximum plant spread (E-W) (8.22 m) was observed in CHESP -10, and minimum plant spread (E-W)

(1.05 m) was observed in CHESP -32. Maximum plant spread (N-S) (8.90 m) was recorded in the CHESP -6 and minimum plant spread (1.12 m) was noticed in CHES P -18. The highest number of fruits were recorded in CHESP-9 (218.7) followed by CHESP-43 (188.7). The highest fruit yield was recorded in CHESP - 42 which was 245.2 kg/tree. This is followed by CHESP - 8 (223.9kg). The fruit weight ranged from 0.563kg in CHESP-2 to 1.398 kg in CHESP-35. The polar diameter and equatorial diameter of fruit was highest in CHESP-35 (17.52 and 15.73 cm). Numbers of seeds per fruit were lowest (18.9) in CHESP-4 and the highest in CHESP-53(73.10). Total Soluble Solids ranged from 7.88°B (CHESP-48) to 10.83°B (CHESP-58 SL). Among the 65 accessions of pummelo evaluated under humid tropic region of Coorg, CHESP -8, CHESP-9, CHESP-42 and CHESP-43 were found superior than others for most of yield and quality characters.

II-54

Ambarella- an under exploited medicinal fruit

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Ambarella *(spondiasdulcis* or *spondiascytherea*) is also known as golden apple or hog plum. It belongs to family Anacardiaceae. It is one of the underexploited fruit containing more beneficial effects. Despite being tropical the Ambarella has proven to be quite hardy and are very fast to become established in the subtropics and fruit begins to appear after only three years. This fruit commonly found in Malaysia. The tree thrives in humid tropical and sub tropical areas up to 2 mts height in a single season. It grows in all types of soils. young trees are sensitive to cold. Ambarella has so many uses. This pleasant tasting acidic fruit has pine apple mango flavor and crunchy texture. Fruit is rich in iron and vitamin –c. It has some value in aiding diabetes, heart ailment, and urinary troubles. It's also loaded with niacin, vitamin A, ascorbic acid, and carotene which boost the immune system and fight against cancer. It is used for making pickles, relishes, soups and stews. Fruit peel is potential source of pectin. Then it can be used in the preparation of jams and jellies. Value added product of this fruit is nectar, it is popular and widely consuming beverage in world wide. Best maturity stage for the nectar production is the stage of fruits completely matured.

II-55

Evaluation of malayan apple (*Syzygium malaccense*) lines for growth, yield and fruit quality

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Malayan apple or Malay rose apple /water apple, the most beautiful tropical fruit tree in Myrtaceae family. The fruits are oblong shaped, waxy skin, dark red and some varieties have white and pink skin. The fruits are crunchy, often juicy with a mild sweet flavor and used for preparation of jam and wines. In CHES, Chettalli, 29 Malayan apple accessions were collected from various parts of the country and assembled during the year 2004. Among the twenty nine accessions evaluated, accession CHESM-I/1 recorded the highest plant height (8.0 m) and plant girth (68.0 cm). Maximum plant spread (E-W) (8.0 m) was observed in CHESM –II/1 and minimum plant spread (E-W) (0.80 m) was noticed in CHESM –VIII/2. Maximum plant spread (N-S) (8.20 m) was recorded in the CHESM –II/I and minimum plant spread (0.6 m) was observed in CHESM –VIII/2.The highest number of fruits were recorded in CHESM-III/4 (8269 fruits/tree) and the lowest fruit was noticed in CHESM-III/1 (45 fruits/tree).The fruit weight ranged from 45- 92 g. Malayan apple germplasm accessions maintained at Chettalli having different colours of fruits like pink, red, dark red, green and white .With regard seed characters, number of seeds per fruit varied from 3.2 - 5.80 and seed weight was 4.6 g in CHESM-I/3. Among the 29 accessions of Malayan apple evaluated, accession CHESM-I/3 recorded the highest Total Soluble Solids (TSS) of 10.6°B. Further evaluation is required to get suitable accession in terms of yield and quality for humid tropic region on Coorg.

II-56

Underutilized fruits of the southern Western ghats of Nilgiri Biosphere

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Nilgiri Hills means blue hills (Neelam- blue and Giri- hill or mountain) is one of the most spectacular natural mountains ranges in South India; the Nilgiris are situated at the confluence of the Western and Eastern Ghats as the Sahayadri Hills, comes under Nilgiri Biosphere Reserve. Western Ghats of India, one of the eight hottest hot spots of the world is known for its rich biodiversity. Nilgiris at an elevation of

900 to 2636 meters above MSL. Its latitudinal and longitudinal dimensions being 130 KM (Latitude: 76.0 E to 77. 15 E). The region generally receives 2000- 7000 mm of rainfall and is rich in natural resources. The Nilgiri district in Tamil Nadu is a central focal point and is termed as the manipulation zone in the overall bioregion. Nature has bestowed Nilgiris with magnificent forests with varied and colourful plants and animal life. There are quite a large number of indigenous and underutilized fruit crops, which are being used by the local inhabitants. In fact for people living in villages, these underutilized fruits are the only source of protective food to meet their vitamins and minerals requirements in their poor diet. Because of their curative properties, these fruits have been used in Indian system of medicine such as Ayurvedic and Unani since time immemorial. Apart from their nutritive and medicinal values quite a few of these underutilized fruits have excellent flavour and very attractive colour. In spite of these quality attributes most have not undergone any conscious phase of domestication and human selection. Their cultivation is very restricted and they grow mainly wild. Being tolerant to biotic and abiotic stresses, these fruit species are suitable for growing in the disaster- and drought-prone areas.Nilgiris has a rich heritage of indigenous fruit types. Although some fruits have already been recommended for commercial planting, it is apparent that there are a lot more fruit types that await future exploitation.In this region, there are wastelands of acidic soils, marshy and marginal lands, which are unfit for supporting cultivation of high input demanding crops. Such lands can easily be put to use for growing low input crops in order to diversify the present day agriculture, which is so inevitable in view of the increasing population pressure and fast depletion of natural resources as well as the growing and changing human needs in the region.The average productivity of the horticultural crops is just half of the national productivity. As the hill farming of vegetables is proving un-remunerative in the undulating topography of hilly tracts, which is deprived of irrigation facilities, despite government of India's has been putting forth endeavours to uplift the region, vast potential remains unexploited. It becomes possible to exploit the untapped potential of the region through location specific horticulture and subsequently expanding the area under horticultural crops. Production of underutilized horticultural crops can also be increased through adoption of scientific technologies. Apart from nutritive value, underutilized horticultural crops are particularly more important for medicinal properties and famous for the retentive value in Ayurvedic medicine. Mostly people are familiar with the medicinal properties of locally grown horticultural crops. Many of the indigenous temperate fruits have still remained underexploited due to the lack of awareness of their potential market demand and low and erratic bearing in many cases. These species have multipurpose uses as fruits, vegetables and also have therapeutic and medicinal properties. To safeguard the existing diversity of underutilized fruits and to achieve sustainable development based one use of available genetic wealth, promotion and conservation of these species is of immense importance. There is a need to future evaluate these identified genotypes and release the cultivar for respective areas.

The Nilgiris, being rich in plant diversity, has a very large number of non traditional or underutilized horticultural crops. In view of its importance from the context of diversity conservation the region is one of the 18 hot-spots of the world. Diversity among underutilised fruits in this regions is discussed below:Wild fruits gathering and exploitation of fruits is a common activity of the indigenous people in Nilgiri districts. A total of 28 species of fruits belonging to 11 families were identified from the mid and higher elevations. Out of 11 families identified the widely utilized species belonged to Annonaceae (1 sps.), Berberidaceae (1 Sps.), Elaeocarpaceae (2 sps.), Moraceae (3 sps.), Myrtaceae (3 sps.), Polygonaceae

(2 sps.),Rhamnaceae(1 sps.),Rosaceae (3 sps.)Rutaceae (1 sps.), Solanaceae (5 sps.), Ulmaceae (1sps.). Traditionally wild edible species have been meeting the protein, carbohydrate, fat, vitamin and mineral requirements of the local residents to a greater extent (Omo Ohiokpehai, 2003 and Sasi and Rajendra, 2012). These species have multipurpose uses as fruits, vegetables and also have therapeutic and medicinal properties. They also contain antioxidant which offer protection against many chronic diseases like heart disease, kidney diseases and certain type of cancers (Saxena, 1999).

The Western ghats region Nilgiri is bestowed with the most congenial climatic conditions for the production of under-exploited horticultural crops. Further cultivation practices and post harvest technologies have adequately been formulated only for those community utilized species in order to demand all over the year. Many of these indigenous temperate and temperate fruits have still remained underexploited due to lack of awareness of their market demand and low and erratic bearing in many cases. Besides this, quality seeds, varieties and hybrids of these horticultural crops could be produced and exported. The increase in area and production of these horticultural crops will not only provide nutritional security and save money on import but also export of fresh horticultural crops and seed in further expected to boost region economy. These horticultural crops also provide many fold employment opportunities in agro-based industries, packaging, storage, preservation, canning and transportation.

II-57

Conservation and performance of some bael (*Aegl emarmelos Correa.*) genotypes under rain-fed ecosystem of Eastern India

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Nine commercial bael genotypes of 10 years age were evaluated at research center Ranchi under ICAR Research Complex for Eastern Region, Patna during 2008-09. Out of these six genotypes viz. Pant Sujata, Pant Aparna, Pant Urbashi, Barabanki Collection, Begusarai Collection and HABL-1 brought forth commercial fruiting. The maximum fruit weight of 1.2 kg was recorded incase of Pant Aparna in both the years which was at par with Pant Urbashi. The genotypes Pant Sujata and Pant Urbashi accounted for the maximum pulp weight during 2008 and 2009, respectively. In both years the genotypes, Pant Urbashi exhibited the maximum skull weight. The minimum fruit weight and seed number were found in case of HABL-1. On the other hand genotypes, Barabanki Collection had the maximum seed numbers in the both years. Regarding fruit quality attributes, the genotype HABL-1 recorded the maximum T.S.S. of 37.0^{0}B and 39.0^{0}B in 2008 and 2009, respectively. In 2008, the genotype Pant Urbashi showed the maximum total sugar content of 12.14 percent but Pant Sujata had the highest total sugar content (14.3 percent) in 2009.The genotypes Pant Shibani, Deoria Collection and Godda Collection did not produce flower till 2008.

Antioxidant Potential of *Prunus mira*: An underutilized tree from Western Himalayas

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Prunus mira Koehne ex Sargent (commonly Behmi; wild peach) is a fruit tree growing wild in the dry temperate region of the Western Himalayas between 2500-3000 m. The fruit of the tree is sour, eaten raw, and dried and used for making alcoholic liquor used by the local tribals. The oil extracted from kernels is used for cooking and massage. However, no study has been undertaken to validate / investigate its usefulness. The present study investigated the antioxidant activity of the water extracts and oil of *P. mira*. It was assessed in terms of scavenging of hydrogen peroxide, and hydroxyl and DPPH radicals, FRAP activity, and the content of phenolics and flavonoids. The fruit extract exhibited strongest activity against hydroxyl radical, DPPH and FRAP; but, in case of hydrogen peroxide the leaf extract showed highest activity. The total phenolic and flavonoid content of different extracts of *P. mira* varied from (7.8±0.17 to 11.9±0.57 μg/g) and (8.4±0.26 to 62.8±0.20 μg/g). Further, chemical constituents of the fatty oil were analyzed by GC-MS and it that revealed oleic acid (56.1%), linoleic acid (30.3%) and palmitic acid (6.60%) were the major constituents. The results suggest that *Prunus mira* can be used as a source of natural antioxidant.

II-59

Analyzing the Genetic Relatedness of Midimaavu with Mango (*Mangifera indica*): A Study using Chloroplast Intergenic Spacer Region (Cp DNA *rpl20-rps12*) Sequences

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Mango (*Mangifera indica*), one of the commercially important fruit crops of family Anacardaceae, which is native to tropical and subtropical regions. Mango exists as a domesticated and also a wild entity in the complex biotic community of the ecosystem. Certain varities of mango called Midimaavu are known for whole fruit mango pickling and serving as important economical source. Information on genetic diversity, relatedness between or within species, population and genotypes of Midimaavu serves as an important prerequisite for conservation and also for utilization of these varieties for further breeding purposes. Hence the present study was conducted to identify the genetic diversity and relationship between the Midimaavu and the other domestic mango cultivars. The intergenic spacer rpl20-rps12

region of chloroplast DNA was utilized for identification of genetic diversity and relatedness of Midimaavu genotypes at molecular level. Using this DNA marker twenty nine Midimaavu genotypes, collected from different parts of Karnataka were analyzed. The Chloroplast rpl20-rps12 region was amplified from extracted total genomic DNA using PCR. The amplified region was sequenced. Sequences of rpl20-rps12 region were aligned (multiple alignment) with Clustal W. Closely related species sequences were obtained from the Gen Bank using the BLAST search tool. Phylogenetic analysis was carried out using MEGA-4 and following Neighborhood Joining (NJ) tree algorithm. The phylogenetic analysis revealed that there are two major groups. The first cluster had most Midimaavu genotypes and the second cluster for the *Mangifera indica*. However, a few Midimaavu genotypes grouped with the *M. indica* cluster. Based on the chloroplast rpl region sequence analysis we could conclude that Midimaavu could be a different species of genus *Mangifera*. However, the result needs to be strengthened with some more DNA sequence analysis.

II-60

Myristica prainii King seeds - an alternate source of myristic acid

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Myristica prainii King, a member of the family Myristicaceae, is an evergreen tree used in tribal medicine. Its fruits are red, ovoid, edible and resinuous in flavor. Fresh fruits were collected and pericarp, mace and nut were separated and dried. Dried seeds yielded 35% oleoresin. The fatty acid profile of nuts was determined by GC-MS. It contained 78-83% myristic acid, 7.7-8.2% myristoleic acid and 5.8-7.4% palmitic acid. The fatty acid profile was compared with that of *M. fragrans*. The medicinal uses of its constituents are discussed. The results indicated that the butter from *M. prainii* seeds can be a substitute for *M. fragrans* .In Indonesia bark is used to treat sprue. Its pharmacological properties are unexplored. Dry recovery of the nuts was % . The nuts were extracted with petroleum ether and the extract was concentrated and fatty acid profile was determined by GC- MS. Lauric acid is reported first time in *Myristica fragrans*. *M.fragrans* contains more saturated fatty acids compared to *M.prainii*. Myristolenic acid , the second most abundant comp. in *M.prainii*, is absent in *M fragrans* .Identified as oleic acid in *M.fragrans* & elaidic acid in *M.prainii* and both are isomers.

Diversity fair – A tool for locating trait specific indigenous mango varieties

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Mango (*Mangeferaindica* L.) is known as **'King of Fruits'** owing to the delicious quality of fruit rich in vitamins and minerals. The Indo-Burma region is said to be the origin of mango. The diversity in mango comprises of native landraces, local selections and elite cultivars of mango. The collection and conservation of this diversity in a systematic manner is extremely important from the point of view ofbreeding as the large genepool of varieties have not been fully evaluated. Many of the native varieties are still not known since they are existing as seedling trees. It is believed that there are about 1000 varieties of mango in india and only about twenty five are being cultivated on a commercial scale. The cultivated varieties are susceptible to biotic or abiotic stress. Collection, conservation, evaluation and screening of this large germplasm would help in locating the source for biotic stress as well as for some desirable traits. However, locating such types from this large indigenous genepool is extremely difficult through surveying. One of the methods that is very widely practiced is to locate indigenous mango varieties through diversity fairs wherein farmers display the local varieties. Two diversity fairs,one at the Indian Institute of Horticultural Research, Hesaraghatta (IIHR). Bangalore on 3rd of June and another at Chittoor on 7th of June were organized with the objective of locating indigenous varieties having desirable traits and exposing the farmers to the large diversity.. In the diversity fair at IIHR four hundred and sixty varieties of mango were displayed. Six KVKs, Universities and NGOs participated and exhibited their local/ Indigenous Varieties and its value added products.Several coloured indigenous varieties and pickling varieties viz., Appemidi with pickles prepared out of these varieties were put on display. The grafts of Appemidi were also distributed on the occation. An interaction meeting was held between the farmers and scientists where in the importance of maintaining local indigenous varieties and the problems associated with the cultivation were discussed. The importance of using fruitfly traps and other IPM practices were discussed along with the fertigation practices. In the diversity fair at Chittoor, 125 farmers attended and displayed 145 indigenous mango varieties**.** Most of the varieties displayed by the farmers had excellent peel colour and good quality. An interaction meeting between the farmers including MDST members and the 'State Department of Horticulture' represented by the 'Horticultural Officer' was also organized. The horticultural officer mentioned about the facilities that are being provided by the department. Mango harvesters developed at IIHR were distributed to the farmers. Farmers expressed satisfaction for the distribution of fruit fly traps. The community farmers set up two sales points on the Bangalore – Tirupati highway for selling the indigenous varieties. The varieties were packed in 2.5 kg and 5 kg boxes.

SESSION III

PRODUCTION TECHNOLOGY OF UNDERUTILIZED FRUITS

LEAD PAPERS AND ABSTRACTS

Rambutan (*Nephelium lappaceum* L.) and prospects of its genetic improvement

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The rambutan (taxonomic name: Nephelium lappaceum L. Syn: Euphoria nephelium DC. and Dimocarpus crinita Lour.) is a medium-sized tropical tree of South east Asia belonging to the family Sapindaceae to which its close relative the litchi (Litchi chinensis) an equally desirable fruit, owing its origin to China also belongs. Apart from litchi it is closely related to several other edible tropical fruits the longan, pulasan and mamoncillo. It is native to the Indonesian Archipelago, more precisely Indonesia and Malaysia (different other edible Nephelium spp. could also be found in wild) from where it spread westwards to Thailand, Burma, Sri Lanka and India, and northwards to Vietnam and the Philippines. The earliest record of rambutan trees show that they were cultivated by the Malayan jungle tribes around their temporary settlements, a practice followed to date. Many years ago, Arab traders introduced it into Zanzibar and Pemba. There are limited plantings in India, a few trees in Surinam, and in the coastal lowlands of Colombia, Ecuador, Honduras, Costa Rica, Trinidad and Cuba. Some fruits are being marketed in Costa Rica. The rambutan was taken to the Philippines from Indonesia in 1912. Further introductions were made in 1920 (from Indonesia) and 1930 (from Malaya), but until the 1950's its distribution was rather limited. Then popular demand brought about systematic efforts to improve the crop and resulted in the establishment of many commercial plantations in the provinces of Batangas, Cavite, Davan, Iloilo, Laguna, Oriental Mindoro and Zamboanga. Seeds were imported into the United States from Java in 1906 (SPI #17515) but the species is not grown in that country.

In the vernacular, rambutan is popularly known as rambutan (in French, *ramboutan* or *ramboutanier;* in Dutch, *ramboetan);* occasionally in India, *ramboostan.* To the Chinese it is *shao tzu,* to Vietnamese, *chom* or *vai thieu;* to Kampucheans, *ser mon,* or *chle sao mao.* There are other local names in the various dialects of Southeast Asia and the East Indies with other important fruit crops such as litchi and longan also native to South East Asia (Tindall, 1994). The edible portion of the rambutan fruit is a pulpy, juicy and translucent white sarcotesta, which arises from an integument surrounding a single oblong seed. Currently, Thailand is the leading producer of rambutan worldwide (Zee *et al.,* 1998); however, Indonesia, Malaysia, Australia and some countries in the western hemisphere also produce this fruit commercially. As with many other tropical fruit crops, though it is grown in many countries, there is little information especially in the area of genetic improvement and best management practices and optimum growing conditions for rambutan. For example, little is known about the adaptability of rambutan to highly acidic soils. The prevailing status could be attributed largely to its status of a homestead, underutilized crop and awaiting genetic improvement for key market traits and post harvest management and value addition.

Taxonomy

Sapindaceae, also known as the soapberry family, is a family of flowering plants in the order Sapindales. There are about 140–150 genera with 1400–2000 species, including maple, horse chestnut, and litchi. Sapindaceae members occur in temperate to tropical regions, many in laurel forest habitat, throughout the world. Many are laticiferous, i.e. they contain latex, a milky sap, and many contain mildly toxicsaponin with soap-like qualities in either the foliage and/or the seeds, or roots. The largest genera are *Serjania*, *Paullinia*, *Acer* and *Allophylus*. The genus ***Nephelium*** under which rambutan and its relatives comes is being discussed here.

Several botanical names were originally used for rambutan, including ***Nephelium glabrrum***, ***Nephelium chryseum*** *and* ***Nephelium sufferrugineum***, but these synonyms are at present rarely used. Three botanical varieties of ***Nephelium lappaceum***have been identified mainly, on the basis of variation in leaflet characteristics (van Welzen and Verheij, 1991).They are:

a. var. lappaceum: leaflets are widest above the middle , midrib sparsely pilose below , nerves strongly curved. This variety is distributed in Thailand, Malaysia, Indonesia and the Philippines and is common in cultivation.

b. var.pallens **:** leaflets are widest at or below the middle , the midrib is usually glabrous below and the nerves are slightly curved. The distribution ranges from China, Thailand, Laos, Cambodia, Vietnam, Malaysia, Indonesia and the southern Philippines.

c. var. xanthioides : leaflets are widest at or below the middle, the midrib is shortly hairy below and the nerves are slightly curved. Distribution appears to be limited to Borneo.

Inflorescence

The inflorescences of rambutan are erect, widely branched, bearing many flowers and are produced mainly on shoot tips. The flowers are either male, with the stamens being well developed or hermaphrodite. The hermaphrodite flowers may be either basically female, with small short stamens and anthers which do not dehisce or male with undeveloped stigmas. Val mayor *et al*., 1970 had classified rambutan trees into three groups, according to their flower characteristics.

a. Male trees, producing only staminate flowers. These are usually 40-60% of any seedling population.
b. Trees producing hermaphrodite flowers which are functionally female
c. Trees producing hermaphrodite flowers, some of which are functionally female and some are functionally male. This type of tree is most commonly found in cultivar selections;
d. the percentage of male flowers is low and may be in the range of 0.05 – 0.90% (Almeyda, *et al*., 1979; Chin and Phoon, 1982; Tindall, 1994).

The male flower (m)

The male flower is borne on male trees which are not productive. The flowers are borne in clusters on terminal panicles of about 30 cm long. They are greenish – yellow without any petals. All parts of the flower, except the yellow nectaries are covered by a fine pubescence. There is no functional ovary and flowers with 5, 6 and 7 stamens are found in each panicle. The yellow nectaries form a ring around base of the rudimentary ovary. Each flower measures approximately 5mm across by 2mm high when fully opened. The flowers are arranged in an anticlockwise spiral along each inflorescence and at each node there may be between 7 – 9 buds. The central bud is the largest and opens first, followed by those on the outer most sides, while the youngest buds are next to the central bud. There may be between several hundred to approximately 5,000 buds on a male panicle. An average sized panicle has approximately 3,000 buds, and at peak of its blooming, up to 500 flowers may open per day.

The hermaphrodite flower (hfm or hff)

The hermaphrodite flowers are borne on terminal panicles to those of the male flowers. Each panicle may have approximately 200 – 800 flowers. An average panicle may bear approximately 500 flowers and, at peak blooming, approximately 100 flowers may open each day. Hermaphrodite flowers are arranged in a similar manner to the male flowers but with only 3- 5 buds being produced at each node. The greenish yellow flowers are apetalous but the predominantly female flowers have a well developed bilocular ovary by a bifid stigma. Flowers with unilocular or trilocular ovaries with the corresponding number of stigma lobes are occasionally produced. Six well developed stamens arise from the base of the ovary but these stamens are non-dehiscent. All parts of the flower, except for the yellow nectarines, are also covered with a fine pubescence. Each flower is approximately 5mm tall and 4mm wide.

Cultivars that produce only functionally female flowers require the presence of male trees. Male trees are seldom found as vegetative selection has favored hermaphroditic clones that produce a high proportion of functionally female flowers and a much lower number of flowers that produce pollen. The flowers are small, 2.5-5 mm, apetalous, discoidal, and borne in erect terminal panicles (clusters) 15-30 cm long, perfect but functionally staminate or pistillate, in axillary or terminal panicles. Up to 100 flowers in each female panicle that may open each day during peak bloom. There are over 3000 greenish-white flowers in male panicles, each with five to seven anthers and a non-functional ovary. Male flowers have yellow nectaries and 5-7 stamens. There are about 500 greenish-yellow flowers in each hermaphroditic panicle. Each flower has six anthers, usually a bi-lobed stigma, and one ovule in each of its two sections (locules) (Free, 1993; Tindall, 1994). The flowers are receptive for about one day but may persist if pollinators are excluded (Tindall, 1994).

Flowering behavior

In Malaysia , the rambutan flowers twice a year during the months of March – May and August – October, usually in response to a period of dry weather followed by occasional showers(Shaari *et al.*1983). Weather conditions and the status of the stored food reserves within the trees have a strong influence on the flowering and fruiting of the rambutan. Of the two seasons, one is normally a major fruiting season although, in poor years, no major harvests may be obtained. In poor years, many trees fail to flower the second season, indicating the lack of stored food reserves and possibly an unfavorable carbohydrate / nitrogen ratio. Endogenous hormone levels are also assumed to undergo a significant change prior to the onset of flowering , including : abscisic acid levels increase in concentration , indole acetic acid oxidase activity increases , leading to reduced auxins transport. Endogenous gibberellic acid activity may decline and ethylene synthesis may be stimulated. Each flowering season usually lasts from 5-15 weeks.

Flower biology

Rambutan is a terminal bearer and new shoots are potential sites for future fruiting. Shoots that had previously fruited will develop new vegetative flushes soon after harvest. These flushes usually consist of four lateral shoots that arise below the dried panicles. For non-fruiting shoots, new flushes arise from the terminal buds only. The percentage of new shoot formation in non-bearing and previously- bearing twigs were 57% and 22% respectively (Van Welzen and Verheij 1991).

Rambutan is androdioecious with separate male and hermaphrodite trees. Now a day's male trees are uncommon as it is being propagated by vegetative means. Flowers are borne on terminal or axillary cymose inflorescences. Flowers are apetalous, greenish white in colour about 2 mm in diameter. Calyx has four to six pubescent lobes. Male flower has five to seven stamens which arise from the disc between the lobes of the nectaries. Each stamen has a whitish tomentose filament with a yellowish bilobed anther. The anther lobes split along a longitudinal line to release large amounts of pollen. At the centre of the flower is an abortive ovary which is highly pubescent. Hermaphrodite flower has six to seven stamens but the anthers do not dehisce to release the well developed pollen grains inside. Functionally it serves as a female flower. The ovary is two or three lobed and bears bifid or trifid stigma .The outer surfaces of the ovary and stigmas are pubescent while the stigmatic surface is highly papillose. Only the nectaries are not pubescent. Male pollen grain is sticky and is barrel shaped, swelling upon wetting to about 20 microns and reveals three narrow colpi. The exine is finely patterned with minute fusiform depressions.

Rambutan flowers open at all times of the day but the majority of them do so at about 6.30 hrs. The first sign of anthesis is the parting of the calyx in the male flower whereas in the hermaphrodite flower this is indicated by the recurving of the bifid stigma. Flowers in which anthesis occurs in the afternoon will fail to complete opening until dawn the following day resulting the majority of male flowers present in the morning. Open flowers do not wilt, but abort on the same day when the filaments have shriveled. Open flowers usually persist on panicles for 7-10 days if insects are excluded. The stigma remains active for a day, becomes dull on the second, and later turns from brown to black. Majority flowers open early in the day and 100 flowers may open in a female panicle each day during peak bloom. Both male and female flowers are faintly sweet scented and have functional nectaries at the ovary base. Female flowers produce 2-3 times more nectar than male flowers. Nectar sugar concentration ranges between 18 and 47 percent and is similar between the flower types (Tindall, 1994). Rambutan flower is an important nectar source for bees in Malaysia (Phoon, 1983). Nectar is secreted at anthesis where as anther dehiscence in the male flower begins at about 8.30 hours onwards. Initial fruit set may approach 25 percent but a high level of abortion contributes to a much lower level of production at harvest (1-3%). The fruit matures 15 to 18 weeks after flowering (Tindall, 1994). The greenish white stigma is receptive at anthesis and remains so for a day after which it turns brown.

Reproductive biology

Rambutan produces either male or bisexual flowers. The anther development in both types of flowers is the same but those in bisexual flowers do not dehisce even though their pollen is viable. The anther is tetrasporangiate and its wall development conforms to the basic type. Cytokinesis in micropore mother cells is simultaneous, forming tetrahedral tetrads. The mature pollen grains are tricolpate and two-celled. Only pollen grains from the male flower germinate in the conventional media.

The ovule is anacamphlotropous, bitegmic, crassinucellate and the micropyle is formed by the inner integument only. The embryo sac development is of the monosporic polygonal type.Flower anthesis is at 9.00 – 11.00 am and pollination is entomophilous. The average normal flower and fruit drop are 40% and 90% respectively. The endosperm development is *ab initio* nuclear and cell formation commences at the micropylar end, proceeding towards the chalaza.The outer layers of the outer integument differentiate into the edible flesh of the fruit. The testa is formed mainly from the inner part of the outer integument and the few remaining layers of the inner integument at the micropylar region.The seed is non-endospermous and shows hypogeal germination. In fresh seeds, the average percentage germination is 96%, of which 2% of the seedlings give multiple shoots.

Floral development

New vegetative flushes are produced soon after harvest and, on shoots which have already borne fruits; these flushes are produced by lateral shoots situated below the desiccated panicles. Approximately four lateral shoots are produced by each twig. On shoots which have not previously borne fruits, new flushes arise from the terminal buds only. The rate of growth slows during dry weather and flowering normally begins early in the rainy season. Of the new shoots formed on previously non-bearing twigs, about 57% produce flowers and fruits the following year and, on previously bearing twigs, only about 22% produce flowers (Van Welzen and Verheij, 1991).

Flowering sequence

The sequence of flowering of the different flower types in a panicle has been studied in the Philippines. In the cultivar **'*Seematjan*'**, only hermaphrodite functionally female flowers are produced throughout the flowering period while, in the cultivars '***Maharlika***' and ***'Seenjonja',*** both hermaphroditic functionally female and hermaphroditic functionally male flowers are produced in the same panicle. About 99.94% of the flowers in the 'Maharlika' panicle are functionally female, the rest are functionally male. In the cultivar ***'Seenjonja'***, the percentage of functionally hermaphroditic female flowers is about 99.55%. Once flower buds have been initiated, the flower passes through several developmental stages, resulting in the production of the mature fruit.

Pollination Requirements

Cross-pollination is a necessity (Chin and Phoon, 1982; Lim, 1984, 1992) because pollen is absent in most functionally female flowers (Zee, 1993). Although apomixis may occur in some cultivars, research has shown that rambutan, like Litchi, is dependent upon insects for pollination (Free, 1993; Zee, 1993). In Malaysia, where only about one percent of the female flowers set fruit, research revealed that no fruit is set on bagged flowers while hand pollination resulted in 13 per cent fruit set. These studies further suggested that pollinators may maintain a fidelity to either male or hermaphroditic flowers (trees), thus limiting pollination and fruit set under natural conditions where crossing between male and female flowers is required.

Pollinators

Aromatic rambutan flowers are highly attractive to many insects, especially bees. Those commonly found visiting rambutan flowers include bees (*Apis spp* . and *Trigona spp*.), butterflies, and flies (*Eristalis spp*. and *Lucilia spp*.) (Chin and Phoon, 1982;Lim,1984). *Apis cerana* colonies forage on rambutan flowers that produce large quantities of honey. Bees foraging for nectar routinely contact the stigmata of female flowers and gather significant quantities of the sticky pollen from male blossoms. Although male flowers open at 0600 hrs, foraging by *A. cerana* is most intense between 0800 and 1100 hrs, tapering off rather abruptly thereafter. In Thailand, *A. cerana* is the preferred species for small scale pollination of rambutan (Free, 1993; Lim, 1984; Tindall, 1994). Generally, the presence of a male tree is necessary to pollinate the flowers of trees that are predominantly female (or hermaphrodite functioning as female). However, in Cuba, some trees have sufficient numbers of flowers of both sexes to yield regularly large crops without interplanting.Among the pollinating insects, *Apis cerana* was found to be the predominant one followed by *A. florea*, *Trigona spp*., ants and wasp. The peak hours of visit by the pollinating insects to the flowers were between 7:00 am to 10:30 a.m. The visit of *Apis cerana indica, A. florea and Trigona spp*., however continued beyond 10:30 am in CHES - 4.Many insects visit rambutan flowers. The main pollinators are flies (*Diptera*) and bees (*Hymenoptera*) . Among the Diptera ,*Lucillia* sp. are abundant, particularly when the orchards are situated near manure heaps or poultry farms. A very high density of flies , up to 20-30 per panicle, may be observed collecting the nectar throughout the day. Among the Hymenoptera, honey bees (*Apis cerana* , *A.dorsata*) and stingless bees (*Trigona* spp.) are major visitors. The visiting pattern of bees shows a peak during the morning hours when nectar and pollen are being actively collected by the bees. By noon very few bees are observed visiting the flowers.

Pollination recommendations and practices

Honey bee colonies placing in rambutan orchards is an important and practical recommendation for assuring adequate pollination and fruit-set. The bees can be present in the orchards continuously throughout bloom. Although no specific number of colonies per hectare of rambutan can be recommended in the absence of more definitive data, strong (>8 frames with bees and brood) colonies should be provided at a minimal rate of one (or the equivalent) per 0.4 ha. From 1965 to 1967, agronomists at the College of Agriculture, University of the Philippines, studied the growth, flowering habits and yield of the Indonesian cultivars, '***Seematjan***', '***Seenjonja***', and '***Maharlika***'. They found that all the '***Seematjan***' flowers were hermaphrodite functioning as female (***h.f.f.***) and it was necessary to plant male trees with this cultivar. '***Seenjonja***' and ***'Maharlika'*** flowers were mostly hermaphrodite functioning females ***(hff)*** with a very few hermaphrodite functioning as males (***hfm***.) in the same panicles, and they concluded that, though self-pollination is possible, planting of male trees with these cultivars should improve production potential .

Genetic improvement of rambutan (*Nephelium lappaceum* l.) : prospects

Rambutan is primarily consumed as a fresh fruit, but is also frozen, juiced, canned and dried in limited quantities. The cultivated species of this *Sapindaceae* member are medium to tall trees and the family derives its name from the content of saponine which occurs in the seeds of the non edible species. Seeds of the some fruits are still used in the manufacture of soap for example soap nut (*Saponaria detergens*). The Sapindaceae is a relatively large family, containing at least 125 genera and 1000 species, which are widely distributed in the tropics and warm tropics. The most widely cultivated fruit trees in this family include litchi (***Litchi chinensis***), rambutan (***Nephelium lappaceum***) and longan (***Dimocarpus longan)***. The other minor edible closely related fruits, mainly cultivated for domestic consumption in homesteads include akee (***Blighia sapida***) and pulasan (***Nephelium mutabile***). The lotong (***Nephelium cuspidatum***) and bulala (***Nephelium intermedium***) are widely distributed in South East Asia, but are not normally cultivated although their edible fruits are harvested from the wild and sold in local markets for domestic consumption.

Criteria for genetic improvement

According to the Malaysian rambutan industry appraisal, the criteria for genetic improvement of rambutan depend upon the requirements of stakeholders of rambutan industry and the same is applicable to other rambutan producing agro-ecologies as well. They include:

Sl. No.	Stakeholder	Criteria of genetic improvement
1	Grower	» Compact ideotype , dwarf / dwarfing rootstocks ; HDP / canopy management systems » Hermaphrodite trees-sexual homozygosity, since trees can be either male or hermaphrodite » Varieties-high yield ; dual purpose (table as well as canning (e.g., **R 162 of Malaysia**) ; good fruit bunching habits ; good fruit size (30-40g) » High yield of good quality (freestone ; high TSS ; good shelf-life); » Regularity in bearing; potential for off-season bearing » Aril freely separable from stone (freestone varieties) comprising a high proportion of the total fruit weight (high pulp : stone ratio) » Resistant to pests and diseases » Uniform ripening and early maturation; good shelf-life » Adaptation to wider environmental conditions especially rainfall and soils

2	Retailer	Good post harvest handling features ; strong pericarp resisting bruising and withstand long distance shipments Long storage life ; reduced pericarp browning Pericarp and spintern which will not easily dehydrate Maintain attractive appearance during storage
3	Processor	Small seed, thin skin and thick, easily detachable aril (freestone varieties) for high recovery rate of the processed product Firm aril to withstand the processing operations Good sugar acid blend ,flavor ,texture and appearance retention after processing
4	***Consumer***	Good fruit size, attractive colour, and general appearance Readily separable edible portion (aril) from the seed –freestone varieties Good sugar acid blend, flavor and texture

Genetic resources

Related Genera

Rambutan has many botanically related genera within the family Sapindaceae which also produce edible fruits. These include the litchi (*Litchi chinensis*) , longan (***Dimocarpus longan***) , Alupag (***Euphoria didyma***) , akee (***Blighia sapida***), mamoncillo (***Melicoccus bijugatus***) , Kubili (***Cubilia blancoi***), Aglano (***Hedyachrasphilippinense***),Kalayo (***Erioglossum rubiginosam***) , Kumingi (***Litchiphilippinense***) , Lunao (***Otaphora fruticosa***) and Siday (***Pometia pinnata***) .

Related species

Closely related species within the genus *Nephelium* include the pulasan - ***N.mutabile***,now known as ***N.rambontan-ake*** , *the lotang -* ***N. eriopetalum***also known as ***N.cuspidatum***, the mata kuching - ***N.malaiense*** *, the bulala -* ***N. philippinense (N. intermedium)****, the aluoa -* ***N.xerospermoides, N.maingayi, N.chryseum,N.robustum***and***N. hypolencum***which is grown inThailand. The fruits of the lotang resemble those of rambutan but the habit of the tree is different. It has a long trunk; the leaflets are large, drooping with the hairy upper surface. Pulasan has a similar habit to rambutan but the fruits differ in that the spinterns are short and stumpy unlike those of rambutan which are long and filiform. The Bulala has shorter spinterns than rambutan and is sometimes sold in the Philippines market. The last three species mentioned are found growing in many countries of tropical Asia including Borneo, Burma, Indonesia, Malaysia, the Philippines and Vietnam.

Potential genetic resources

Majority of the cultivars now grown have originated from the wild variety *Nephelium lappaceum* var. *lappaceum* but it appears possible that the varieties *pallens* and *xanthioides* could be used in cultivar improvement programmes. Some wild seedless rambutan varieties are occasionally found and these could have a potential for fruit production for the canning industry. Seedless varieties of Pulasan are known in cultivation and could be used to hybridize with rambutan to produce new types of fruits. Hybrids of pulasan and other wild species with rambutan could also be used as rootstock material which could be more resistant, particularly to root diseases, than the rambutan.

It is well known that variability among rambutan trees is high because of cross pollination and propagation by seeds in many countries growing rambutan; numerous cultivars have been selected for high yield and fruit quality traits (Arenas *et al*., 2010). The international market recommends 30g for the categories '***Extra***' and ***1st Grade*** (***CodexAlimantarius***,2009 ; Kader, 2001) and the average fruit weight of the most popular and widely cultivated cultivars '***Rongrien***' and ***'Si Chomphu'*** from Thailand range from 31.3g to 40.0 (De Andrade *et al*., 2008).

Characterization of genetic resources

Many rambutan producing countries are not pursuing intensive crop improvement programmes for rambutan except Malaysia where 187 clones are reportedly registered. Salma (1983) characterized 31 rambutan clones based on growth habit and vigour, shape and size of leaf, flower, fruit and seed and isozyme banding pattern. Based on this it was surmised that isozyme pattern and fruit characteristics were the two most important identification approaches while leaf and seed characteristics were found less important which however, could serve as supplementary characteristics. The study proposed an identification key based on leaf and fruit characters and the author had expressed the same needs to be evaluated and validated based on wider number of clones as the majority of the clones in the study were distinguished based on single isozyme system or combinations of isozyme esterase, peroxidase and indophenols. The author opined that fruit characteristics viz., size, thickness of aril and pericarp, length of spin terns, shape of fruits, colour of pericarp ,texture and taste of aril and peeling quality are highly heritable and environmentally stable, hence could be adopted for rambutan variability characterization. The following is a representative barcode sequence, the centroid of all available sequences for this species.

With the availability of modern biotechnological tools, molecular characterization of rambutan genetic resources is underscored for genes identification for specific traits, gene pyramiding, association mapping, and identification of core collections in order to pave way for genetic improvement.

There is considerable genetic diversity available in rambutan arising from widespread sexual propagation, through variations existing in respect of tree forms and growth , leaf colour and size , flower type and number per panicle , fruit pericarp and spin tern colour , thickness and length , aril colour , texture , brix and acidity , adherence of aril to testa , seed size and form , susceptibility to pests and diseases. Quite a few of them have even attained variety status dominating the production scene.

Variety diversity in rambutan

Popular varieties in **Malaysia** include **R3** ('***Gula Batu'***), **R134, R156*('Muar Gading'*)**', **R160** ('***Khaw Tow Bak'***), **R161** ('***Lee long'***) and **R 162** ('***Daun Hijau'***). **R 162** has firm and crunchy aril, suitable for both table as well as canning purposes. Some of the older ones are, ***Chooi Ang***', '***Peng Thing Bee***', '***Ya Tow***', ‘***Azimat***’, and ‘***Ayer Mas***’. At around 1960, 10 outstanding rambutan were selected in an evaluation of 100 seedling trees of the unsurpassed **Indonesian** ‘***Seematjan***’, also ‘***Seenjonja***’, ‘***Maharlika***’, ‘***Divata***’, ***‘Marikit’, ‘Dalisay’, ‘Marilag’, ‘Bituin’, ‘Alindog’, and ‘Paraluman’*** Yellow-fruited rambutan is called ‘***Atjeh koonig***’ in Batavia. In Malaysia, ‘***Rambutan gading***’ indicates a yellow type. Among the many “*races*” of rambutan in Malaysia, the best “***freestone***” types are found in Penang. One race with a partly free stone is known as ‘***rambutan lejang***’. Burkill says that some rambutans are so sour that monkeys are reluctant to eat them. In 1950, the **Philippines** agriculturists undertook a program of selection and the creation of a Testing Plot at the Provincial Nursery, Victoria, and Oriental Mindoro. There they assembled 360 trees of which 140 were found to be bearing in 1960 and 196 (mostly males) were non-bearing. Observations of the bearing trees there and at the Arago Farm not far away, resulted in the selection of ***21 clones*** which they classified into 4 groups according to fruit size: 1) very large, 14 or less per lb (31 or less/kg); 2) large, 15 to 16 per lb (32-36/kg); 3) medium, 17 to 19 per lb (37-41/kg) ; small, 20 or more per lb (42 or more/kg). In **Singapore,** the predominant varieties grown are ‘***Deli Cheng***’, ‘***Jitlee*** ’. ‘***Deli Cheng***’was introduced from Indonesia and ‘***Jitlee’*** is a clone derived from ‘***Deli Cheng***’. ‘***Jitlee’*** is the preferred variety as its aril detaches from the seed coat and reportedly has longer shelf-life.In **Thailand,** ‘***Rongrien***’, ‘***Seechompoo***’ and ‘***Bangyeekhan’*** though are the common varieties, ‘***Rongrien***’; a chance seedling is the most popular one. Its pericarp colour is dark red, spintern is also red while its tip is green when the fruit is ripe ; pericarp, thin and the aril is firm , sweet, juicy and easily separates from the seed.‘***Seechompoo***’ is also a chance seedling having large sized fruits, red when ripe , aril is sweet and easily separates from the seed. Its pericarp and spintern however are prone to damage during transport. In **India,** one of the popular cultivars is ‘Homegrown N 18’, which is highly adaptable to Kerala, and is far superior to the existing cultivars. The crop was introduced during the world war-II by the Malaysian settlers where, over years genetic recombination found among the open pollinated progenies has resulted in selection of superior types. There is however tremendous scope for further genetic improvement of rambutan for key economic traits by harnessing variability available among the *Nephelium* species , allied genera and the variety diversity by adopting both conventional as well as modern biotechnological tools.

Genetics and crop improvement

Very few breeding programmes have been initiated up to present in rambutan, mainly due to the difficulties associated with such long-term programmes in fruit crops improvement. There is no absolute breeding barrier reported between cultivars or species within the genus except where seedless fruits are normally produced. The pollen of both litchi and longan though germinate on the stigma of rambutan but further developments are arrested in the embryo sac. Improvement has therefore been mainly based on selecting promising wild or cultivated forms and propagating them vegetatively. Selections made thus so far have been largely based on fruit and yield characteristics.

At Central Horticultural Experiment Station, Chettalli, two varieties – ***Arka Coorg Arun*** and Arka ***Coorg Patib*** were identified through superior progeny selections from open pollinated progenies and released for commercial cultivation. These two promising variants have both physical and chemical characteristics that place them among the most widely accepted varieties in the world.

Way forward

- » Introduction of germplasm that includemembers *of Nephelium* genus, related species and its allied genera and trait specific varieties from exotic sources
- » Risinglarge numbersof open pollinated progeniesand identify useful recombinants
- » Adoption of molecular toolsfor characterization of variability, gene and allele mining in *Nephelium* genus, related species and its allied genera for useful and economic traits, pyramiding of genes for key economic traits, association mapping and genetic introgression of economic traits including optimizing *in vitro* protocols
- » Rootstock breeding for rambutan is critical
- » Variety development in tune with the requirements of stakeholders of rambutan industry

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Advances in production technology of ber and karonda

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Ber (*Ziziphus mauritiana* Lamk) plants have ability to tolerate variour biotic and abiotic stresses. The plants have deep root system and are thony in nature, thereby plants survive under stress conditions. Flowering and fruiting of ber coincide with the availability of maximum rain water (monsoon rains), which is during July-September. During the dry hot summer (April-June) it undergoes dormancy by shedding its leaves, thus evading the injury of drought. It can produce fruits even under rainfed situation where average annual rainfall is 150-200 mm. The Rajasthan, Haryana, Uttar Pradesh, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu are the major ber growing states of the Country. In India ber occupied an area of 877000 ha with annual production of 894900 tons.

The ber fruits are considered as 'apple of desert'. The ripe fruits are eaten as fresh and after dehydration. Among processed products ber preserve, candy, squash, jam, nectar etc. can be prepared. The ripe fruits have cooling effect, laxative, remove burning sensation, thirst and blood impurities, whereas dried fruits are laxative and appetizer. The ripe fruits are rich in nutritive value, having 13-24 per cent total soluble solids and up to 160mg 100g -1 vitamin C (Morton, 1987; Sharma and Kore, 1990). The popular ber cultivar Gola contains 80-82% moisture, 12.5 carbohydrates, 17-19°B TSS and 0.40-0.70 acidity. The dried fruits are kept for a long time and are consumed in the off season. The leaves are also good source of fodder. The pruned wood is used as fuel wood.

Soil and Climatic Requirement

The ber grows on variety of soils from gravelly, shallow to deep aridisols. Plant can tolerate pH>9 and soil or water salinity to a limited extent. Hooda et al(1990) reported that Plants did not survive at 20 dS/m soil salinity, whereas there was 70 per cent reduction in yield at 15 dS/mwith no adverse effect on fruit quality. Jain *et al.* (1988) planted ber with 2.7 to 9 dS/m water salinity. Awasthi *et al.* (1994) reported that 62.5 per cent ber seedlings survived at 60.6 ESP but none of the grafted plants of Umran and Gola survived.

Normally ber prefers drier climate for quality fruits but it can also be grown well under tropical and subtropical zones of the country. Ber is highly drought tolerant. The trees can withstand to extreme high temperature. Some of the species of ber are also found growing in foothills of temperate region. However, temperature below freezing point is injurious to fruits as well as to the young plants. Moreover, the areas receiving annual rainfall of 400-650 mm are ideal for its cultivation. In humid areas, the incidence of pest and diseases are more.

Varietal wealth

About 126 varieties of ber has been released from different organizations. Among them cultivars Seb, Gola and Mundia have been recommended for growing under rainfed condition in regions having as low as an average rainfall of 150 mm because of their short period of fruit growth. Their fruits ripen before the depletion of soil moisture. Cultivar Gola is earliest in fruit ripening (end of December) in west Rajasthan, followed by Seb and Mundia three weeks later. Umran is a late fruit ripening cultivar, therefore, not suitable for rainfed areas having less than 500mm rainfall. The commercial cultivars grown in different states of India are presented in table 1.

State	Early – season	Mid – season	Late – season
Haryana	Gola, Seb, Safeda selected	Kaithli, Sanaur-5, Banarsi kadaka	Umran
Rajasthan	Gola	Mundia, Jogia, Ilayachi, Seb	Tikadi, Umran, Maharwali, Bagwadi
Punjab	Gola, Seb, Safeda	Dandan, Kaithli, Sanaur-2	ZG2, ZG3, Umran
Maharashtra	Gola, Badami, Shamber	Mehrun, Darakhi, Kharki	Umran
Uttar Pradesh	Delhi gola, Narma, Banarsi pebandi	Banarsi kadaka, Mundia, Sasni	Aliganj, Katha
Gujarat	Gola	Mehrun	Ajmeri, Randeri
Andhra Pradesh	Gola	Dudhia	Umran
Karnataka	Gola		Umran
Tamil Nadu	Gola		Umran

Recently following varities have been released from CIAH, Bikaner as under

Goma Kirti: It is high yielding, early maturing variety, good keeping quality which fetches good price in the market. By virtue of its earliness, it is tolerant to various pest and diseses mainly fruit fly, fruit borer and powdery mildew.

Thar Sevika: It is a hybrid between Seb x Katha. Thar Sevika is a early maturing variety, fruits are juicy, sweet and TSS content of 22-24%. Fruits after consumption do not cause throat soaring, which common in other cultivars. Average fruit yield is 30-32 kg/tree. The hybrid is also suitable for staggered picking which can be done upto third week of January.

Thar Bhubhraj: A local selection from Bhusawar area of Bharatpur (Rajasthan). It is also early maturing cultivar with average yield of 30-36 kg/tree. The fruits are ready to harvest from last week of December to first week of January. The fruits are juicy with TSS content of 22-13%.

Propagation

The commercial method of vegetative propagation is by budding. Different types of budding, T and I budding, ring, patch and forkert budding have been tried, but the best method, widely adopted is shield or T budding (Pareek, 1978). The ring budding is cumbersome, as it requires equal freshness and thickness of stock and scion. The most widely used rootstock is *Ziziphusrotundifolia,* locally known as *bordi.*Whereas,Z. *nummularia* is slow in growth and if used as rootstock, forms an inverted bottle incompatibility. The germination of Z. *rotundifolia* seeds takes 4-6 weeks due to hard endocarp. The seeds can be taken out by breaking the endocarp and such seeds take 7-10 days for germination (Pareek, 1978; Murthi and Reddy, 1989). Krishna and Kulasekaran (1984) soaked the seeds of Z. *rotundifolia* for 24 hours in 500ppm solution of GA3 and recorded 90 per cent germination.

By conventional method, it used to take about 13 month to raise a budded plant. While planting such plants high mortality was observed in the field. Pareek (1978) developed a method of raising budded ber plants in polythene tubes, which cut down the period to four months. In this method the extracted seeds of Z. *rotundifolia* are sown in polythene tubes (25 x 10cm, 300 guage), filled with a mixture of sand, clay, and farmyard manure in equal proportion, in the first week of April. The seedlings are budded when 90-day-old (in July) and buildings are ready for planting a month later. Monsoon period is the best time for budding in west Rajasthan. This method became so popular among the farmers of Jodhpur (Rajasthan, India) that they started raising ber nursery. More than half a million plants of ber are supplied to all the parts of the country and abroad. This has altogether changed the economic status of the farmers. It has also generated additional employment to landless unemployed who were trained in ber budding. This helped in the spread of ber plantation in south Indian states of Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra.

Orchard establishment

The planting of ber is done at spacing of 6m x 6m in rainfed situations and 7m x 7m or 8m x 8m in irrigated orchards. The pits of 2.0 fit^3 should be dug out before mosoon and filled with well rotten FYM and good soil. With the filling mixture, neem cake (500 g/ pit) should also be added in order to protect from termite problem. The pit filling should be done before prper onset of monsoon and planting may be done during monsoon. After planting mulching may be done with dry grasses.Proper moisture management and after care is very essential. Some time staking of plant and thatching is also required to protect the plants from frost/ scorching sun.

Water conservation is an important aspect of fruit production under rainfed condition. For establishment of young budlings in the field, a double walled pot know a *Jaltripti* has been found to save 75 per cent irrigation water (Gupta *et al.* 1991). The plant is planted in the inner pot (hollow at both ends) and the water is filled in the outer pot (sealed at the bottom). Since the pot is made of clay, water seeps through the wall of inner pot and thus available to the plants. The growth of plants grown in *Jaltripti* was better than those planted directly in the pit.

Bentonite is naturally found in abundance in Thar desert. It has also been used to conserve water in the pits planted with young plants. A layer of 2-3cm thickness of bentonite and sand (in equal proportion) is spread at the bottom of the pit. A cylindrical hollow frame having 3 cm less diameter than the pit is inserted into the pit. The space between the wall of pit and cylinder is filled with the mixture of bentonite and clay. The pit is filled with water and the cylinder is taken out. This forms a pot like structure, which does not allow the water to permeate both downwards and sideways. The pit is as usual filled for planting. This has been found very efficient in establishing plants during rainy season.

Plant canopy management

Tarning and Pruning is important aspects of ber cultivation. For initial three years, proper ttraining is done to provide a strong framework to the plant by allowing 3-4 well spaced branches in different direcetion on the main trunk. The sprouts from the rootstock and water suckers should not be allowed. Flowering and fruiting in ber takes place on current season growth. The time and severity of pruning will depend upon the agroclimatic conditions. In arid areas of North India, under rainfed orchards, pruning of 50-70 per cent current season growth has been found optimal. The pruning is normally completed during mid to end of May (before the beginning of the growth season). The severity of pruning in irrigated orchards improved the fruit quality (Gupta and Godara 1989); Syamal and Rajput 1989; Bajwa *et al.* 1987; Bisla *et al.* 1991). In irrigated orchards, the pruning intensity may be more and early pruning in the month after harvesting of fruits is advisable. In North India, the ber plant undergoes dormancy during summer but in South India it behaves evergreen. However, the pruning is done in the month of May in both the locations. To avoid any fungal infection, it is advised to apply copper oxychloride paste at the cut ends.

Irrigation

Mostly ber is cultivated as rainfed crop but irrigation scheduling gives better yield. In young plants, watering at weekly interval during winter season during first 2-3 months is essential for better establishment. Thereafter, irrigation at fortnight intervals in summer and monthly intervals in winter is given for about two years. For mature tree, in arid and semi-arid regions from June to October, there is no defcit of moisture being rainy season. During summer (April to June) plant enter into dormancy, hence no irrigation is required. However, from October to March, irrigating tree basins at 20-25 days intervals gives better yield. Drip irrigation can further economize water use and better yield.

Water harvesting has been practiced in Thar desert since ages. Natural depressions (known as *Khadins*) having large catchment areas collect water during rains and crops of wheat and mustard (*Brassica juncea*) are raised on residual moisture. Experiments conducted at CAZRI, Jodhpur (India) providing catchment area ranging from 31.5 m to 144 m per plant of ber having 0.5, 5 and 10 per cent slopes increased per plant yield from 18 kg (in control, without slope) to 29 kg in the treated plots. Runoff and soil moisture storage increased significantly with increasing slope and decreasing slope length and contributing area (Sharma *et al.* 1986). The study indicated that for 0.5, 5 and 10 per cent catchment slopes, slope length of 8.5, 7.0 and 5.12, respectively, resulted in the highest runoff generation and consequently higher soil moisture storage.

Nutrition

Proper attention is not given about nutrition of ber orchard but yield can be improved by proper application of manures and fertilizers. It has been worked out that 25 kg FYM and 400 g N, 200 g $P_2 O_5$ and 200 g K_2 O/ tree/ year is enough for a well grownup tree (8 years and above). Half dose of nitrogen and full dose of phosphorus, potash and FYM should be applied in the moth of June-July and remaining haft dose of nitrogen should be given in the month of September-October. The maures and fertilizers should be applied in the tree basins below the canopy spread, leaving 60 cm from the main trunk. After proper mixing of the maures and fertilizers, light irrigation should be given.

Ber based cropping systems

Being a deciduos plant and prone to pruning ber orchard provies good scope for integration of crops like cereals, pulses, oil seeds, vegetables, grasses, forest trees, fruit plants and medicinal and aromatic plants. Ber based cropping system is very common in arid region both under irrigated and rainfed conditions. The drought hardy crops like cluster bean, mustard, green gram, kachri, mateera, pearl millet and grasses like sewan, dhaman etc. are grown since long back under the farmers' field.

Under limited irrigation, Saroj *et al*. (2003) reported that various ground storey crops can be grown successfully with ber without any adverse effect on over storey component, rather growing of crops in initial years had better response in term of plant survival, growth and yield. The integration of different component into the system led to multiple benefits e.g. from ground nut dry pods, from cluster bean green pods (for vegetable) and from bet trees besides fruit; fuel and fodder can be obtained. The phytomass of different ground storey component was recycled in the same plot from where it was harvested in order to improve fertility status of the growing site. Overall, highest economic return was obtained wityh ber+ Indian aloe but from resource management point of view, bet+ cluster bean – mustard is very compatible and profitable combination suggested for this region Under rainfed conditions of Jhansi, Kumar *et al.* (2006) found that ber based horti-pastoral systems are very promising and suffested that Guinea grass+stylo is a compatible combination with ber. Different ber based cropping systems are in practice which are helpful in improving the socio-economic status of the people in various ecosystems of the country.

1. Agri-Horti system
2. Horti-Horti system
3. Horti-Postoral system
4. Horti-Silvi system
5. Horti-Silvi-Pastoral system

Harvesting and yield

Ber plants start fruiting after first year of plantation from budded plants while seedling plants take 3-4 years to come in fruiting. However, the commercial production starts from the third year onwards, hence in the first year fruiting should not be allowed. The fruits of ber do not mature after harvesting. It is, therefore, essential to harvest the fruits at an optimum stage of maturity. Usually the maturity is judged by external colour of fruits, specific gravity, TSS, acidity, TSS/acid ratio and heat unit summation, which vary with the variety, climatic conditions and management practices. Though, harvesting is difficult in ber due to spiny nature of the plant but the fruits are picked manually. Harvesting of fruits by shaking of branches are also adopted. Repeated harvesting is required. Since fruits do not attain maturity at a time.

The yield potential of ber plant varies with the agro-climatic conditions, variety and management parctices. In rainfed orchards of west Rajasthan an average yield per plant (more than five years age) ranges from 10 kg with 125 mm rainfall to 52 kg with 850 mm rainfall. But in south Indian states with the same rainfall the average yield per plant varies from 45-60 kg. However, in irrigated situations (with 4-5 irrigation) an average yield of 150-300 kg per plant (30-60 t ha^{-1}) can be harvested depending upon cultivar and location.

Marketing and economics

In north Indian states, the ber fruitsare available from January to April (4months). With the introduction of ber in the south Indian states viz., Tamil Nadu, Karnataka, Andhra Pradesh and Maharashtra; the availability of fruit has increased to 8 months (September-April). The fruit ripening commences in the first week of September in Tamil Nadu, end of October in Karnataka, November in Andhra Pradesh, December in Gujarat and during January to April in north Indian states (Rajasthan, Haryana, Punjab and Uttar Pradesh). This is mainly due to variation in flowering and fruiting season in tropical and subtropical climatic conditions prevailing in south and north Indian states respectively.

The marketing of ber fruits in India is done in two ways. Either the whole orchard is auctioned just before the fruit ripening begins or sold by the individual farmer in the regulated markets, locally known as "*Mandis*". In auction method, the farmer gets the whole price in advance and the trader who purchased through auction sells the fruit in regulated market. In these markets, the fruits are sold through middleman or commission agents (locally called *Adatiyas*). The wholesale price of ber fruit during the season varies from Rs.500/ q. However, to the consumers through retailers it is sold at double the price of wholesale. In the second method, the individual farmer carries the produce to the market and sells through commission agents. Generally, the produce is packed in gunny bags before carrying it to the market. But now-a-days 1-2 kg packs of nylon net are available in market which fetch about 25 per cent higher price.

Plant protection

Plant protection measures will depend upon the incidence of insects and pests which may vary at different locations. However, the major insect causing heavy losses in fruitfly. In India it is *Carpomyiavesuviana* Costa. The fruits are infested in "pea" stage; therefore, it is essential to spray any systemic insecticide at this stage of fruit development. The same should be repeated three weeks after the first spray. Powdery mildew (*Oidium sp.*) disease appears at the time of flowering and onwards. If the infection takes place during flowering, the fruit set is adversely affected. It may appear during fruit development causing white powdery patches on fruits, which turn as necrotic spots on fruit maturity. In either case spray of 0.1 per cent Karathane can save the crop from damage.

Karounda

Karounda (*Carissa congesta*) which is also called as pickle berry or christs thorn is neglected and an under utilized fruit. This grows well in regions of high temperature and in semi arid areas. Many places it is planted as decorative hedge or live fence as it is a thorny plant. The plant has dense foliage and thick branching of roots which is helpful in reducing the evaporation and thus helpful in moisture conservation and enriching the soil with organic matter with its easily decomposable leaves. The karounda fruit is a berrywith rich source of Vitamin C and iron content and other minerals. The fruit is mainly used for pickling. It has several medicinal properties such as in the cure of anaemia and has anti scorbutic property. The mature fruit contains high amount of pectin and therefore besides using it for pickling also can be used in the preparation of jelly, jam, squash, syrup, chutny and wines which could be of high economic value.

Soil and Climatic Requirements

Crop can be grown on wide range of soil types. Deep and fertile soils are well suited for the crop. On the basis of salt tolerance limit is has been classified as a medium salt tolerant crop. The crop is well adapted to varying climatic conditions from an altitude of 300 M to 1800 M in the Himalayas. Prolonged frost may for several days damage the plant. This can be well classified under dry land fruit crops (Tambe *et al*., 1993).

Varietal Wealth

So far a very few selections were made on the basis of size, yield and quality performance of single plants. Hence there are no well established cultivars of Karounda. A few selections developed and recommended for cultivation are Pant Manohar, Pant Sedarshan, Pant Suvarna, PK-3, PK-4, Maroon coloured, White-Pink blush, Konkan bold, Chess-K-2, CZK-2011, CZK-2022, CZK-2031, CISH Kr-11 etc. (Saroj and Swasthi, 2006).

Propagation

Karounda seeds have short viability. Freshly extracted seeds from ripe fruits give good germination. Delayed sowing of seeds reduces viability and low germination One year old seedlings could be used for planting. A few efforts to propagate with cutting with the treatment of plant growth regulators have given good rooting. Softwood grafting was also found successful and an useful technique for in situ propagation (Chundavat, 1990). Reports revealed that *C. carandus* could be successfully grafted on *C. carandus*, *C. graudiflora*, or *C. bisipnosa*... However the technique needs to be commercially exploited : Budding and inarching is also well practiced in the crop for successful propagation.

Orchard Establishment

Usually the crop is raised in boundaries as hedge or for fencing. Planting can be done at 1 to 1.5 m distance which may accommodate 300-400 plants per ha. Monsoon season is the most suited time of planting and orchard establishment. The plants need little irrigation as it is naturally growing type. However, it responds well for irrigation. Hence the water conservation structures in the basin of the plant helps in dry regions of cultivation. It has been observed well that plant responds well to applied nutrients through the judicious recommendations are not available as it was an underutilized fruit. In general 50 g N, 100 g P and 150 g K_2O with 10-15 kg FYM is recommended for better performance.

Usually Karounda plants grow on its own. The canopy will not have any definite shape until and unless it is trained. On removal of lower sprouts and growing plant erect with single or double stem and forming a semi globular canopy can be recommended to have uniform plant shape. This will help in both canopy to achieve yield. Weed management in Karonda orchard is an essential practice to get a better crop. Crop is well suited to be grown on inter or mixed crop and growing aonla and Karounda has been reported as profitable (Malviya & Singh, 1998).

Harvesting Yield

Crop comes to harvest in 2-3 years of planting. Fruit get ready for harvest in 100-110 days of fruit set. Colour change with specific gravity around 1.02 is a good indicator of the maturity of fruit. As flowering is continuous process 2-3 pickings are necessary. On an average 4-5 kg fresh fruits can be harvested from a plant. Under good management practices upto 10-12 kg/plant also was harvested (Parek, 1990). Both mature and ripe fruits are harvested depending on their use. There is no standard practice for grading and packing of fruits. The fruits harvested at maturity can be stored for 5-7 days at room temperature. When it is harvested at full maturity the storage life will be for only 1-2 days.

Pest and Diseases

Karounda generally believedto be free from insect attacks excepting a minor a few minor pests during initial stages of growth which can be managed with a general pesticide spray when noticed.Several diseases are noticed of which Anthraknose (*Colletotriclum inamdrii*) and Bacterial Canker (*Xanthomonus cavissa*) are reported. Anthraknose can be managed with the sprya of any copper fungicide or 0.1% copper sulphate. The canker problem can be managed by removing the diseased leaves and by immediate spray of phytomycin (200 ppm). Fruits of Karonda also get affected by fungal and bacterial diseases. Effective control measures are also to be evolved for all these minor problems as noticed.

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Potential of off season litchi cultivation in humid tropical zones of Western ghats

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Litchi the queen of fruits is native of Southern China. It is widely adapted to the warm subtropics, cropping best in the regions with brief cool dry frost-free winters and long hot summers with high rainfall and humidity. Litchi has spread to most tropical and subtropical parts world and commercial industries has been developed in several countries like, Taiwan, Thailand, India, South Africa, Australia, etc. In the main belts of northern and eastern states of India, litchi flowers in the month of February-March and fruits mature in the month of April (Tripura), May (Bihar, Jharkhand and UP), June (Uttrakhand and Punjab) and July Himachal Pradesh) considered as main season of litchi. Whereas, in some of the non-traditional litchi growing regions of Western Ghats (Kodagu, Wayanad, Iduki, Kodaikanal, and parts of Mharashtra) having higher altitude and moist-cool period during June-August, it matures during November- December. The main feature of litchi cultivation in these areas is off season production where litchi flowers in the month of August-September and produce fruits in the months of December –January. Being away from the mainseason, there is high market demand for this fruit. Further to that, in the climatic conditions of Wayanad and Kodagu, flowering in litchi plant starts in September and the fruits mature by November end which expands the fruit availability during the off- season in other parts of the country.The produce from these places could fetch premium price in the National and International markets due to festive occasions in many parts of the world and less competition with fruits in the market.

Brief history of litchi cultivation in Western ghats

The Litchi was introduced in Kodagu almost 75-80 years back with some of the Coffee planters started collecting plants from Assam, Bihar and UP and planted few of them in their backyards or plantations. Some of old plants may be seen in the coffee plantations of Mepadi, Kelpatat area of Wayanad. Thereafter several times litchi plants were brought from various parts of North India and planted in many parts of Werstern Ghats. Some of these plants fail to bear fruit and other plants produced good yield with at par quality. At Central Horticultural Experiment Station, Chettalli (Kodagu), litchi was introduced five decade ago when some plants were placed on the border of orchard as wind break and these plants produce good quality fruits at later stage stating the potential of crop in the region. Further, some of the plants were multiplied from these mother stocks and provided to local growers. But due to lack of improved method of crop husbandry and reservation of people for climatic reasons and other factors which might leads to crop failure the litchi cultivation could not pick up with required pace in this area. Apart from Coorg, litchi was also introduced in some parts of Wayanad in Kerala and parts of Tamil Nadu but the response was similar to Coorg. The problem of bats and birds due to high vegetation deters the growers to go for litchi crop in big way.

Physiography of Western ghats

Western Ghats are a unique mountain range that harbours an incredible diversity of flora and fauna. The Western Ghats hills lies in the east coast of Arabian seas and spread from border of Gujrat and Maharashtra, south of Tapti river and runs approximately 1600 km through states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (KanyaKumari) in southern tip of India. The region covers 1,60,000 sq km area under hills. The highest peak is 2695 m and average elevation is 1200 m asl. Major gaps in the western range are Goa Gap, between the Maharashtra and Karnataka sections, and the Palghat Gap on the Tamil Nadu and Kerala border between the Nilgiri Hills and the Anaimalai Hills.The mountains intercept the rain-bearing westerly monsoon winds, and are consequently an area of high rainfall, particularly on their western side. The dense forests also contribute to the precipitation of the area by acting as a substrate for condensation of moist rising orographic winds from the sea, and releasing much of the moisture back into the air via transpiration, allowing it to later condense and fall again as rain. The northern portion of the narrow coastal plain between the Western Ghats and the Arabian Sea is known as the Konkan Coast, the central portion is called Kanara and the southern portion is called Malabar region or the Malabar Coast. The foothill region east of the Ghats in Maharashtra is known as Desh, while the eastern foothills of the central Karnataka state are known as Malenadu. The Biligirirangan Hills lie at the confluence of the Western and Eastern Ghats. The Western Ghats consists of three major hill ranges which are as follows:Sahyadhris: The major hill range starting from the north is the *Sahyadhri* range.This range is home to many hill stations, including Matheran, Lonavala-Khandala, Mahabaleshwar, Panchgani, Amboli Ghat, Kudremukh and Kodagu. The range is known as *Sahyadri* in Maharashtra and Karnataka and as *Sahya Parvatam* in Kerala.The Nilgiri mountains are in north-western Tamil Nadu and are home to the town of Ooty. The Biligirirangana Betta south-east of Mysore in Karnataka, meet the Shevaroys (Servarayan range) and Tirumala range farther east, linking the Western Ghats to the Eastern Ghats.South of the Palghat gap are the Anaimalai Hills, located in western Tamil Nadu and Kerala. Smaller ranges are further south, including the Cardamom Hills. In the southern part of the range is Anamudi peak 2,695 metres in Kerala the highest peak in Western Ghats. The Western Ghats in Kerala and Tamil Nadu is home to many tea and coffee plantations.

Agro-climatic conditions of Western ghats

The peaks of the Western Ghats intercept the south-western monsoon winds, which bring heavy rain between June and September. An astonishing 2 to 8 metres of rain drench the Western Ghats each year, most of it falling in the short monsoon period. Climate in the Western Ghats varies with altitudinal gradation and distance from the equator. The climate is humid and tropical in the lower reaches tempered by the proximity to the sea. Elevations of 1,500 m and above in the north and 2,000 m and above in the south have a more temperate climate. Average annual temperature lies here is around 15 °C. In some parts frost is common, and temperatures touch the freezing point during the winter months. Mean temperature range from 20 °C in the south to 24 °C in the north. It has also been observed that the coldest periods in the south Western Ghats coincide with the wettest.Unbroken Western Ghats chain acts as a barrier during the monsoon season between June and September to the moisture laden clouds. The heavy, eastward-moving rain-bearing clouds are forced to rise and in the process deposit most of their rain on the wind-ward side. Annual averages rainfall in this region lies between 3,000–4,000 mm with localized extremes touching 9,000 mm. The eastern region of the Western Ghats which lie in the rain shadow, receive far less rainfall averaging about 1,000 mm bringing the average rainfall figure to 2,500 mm. Data from rainfall figures reveal that there is no relationship between the total amount of rain received and the spread of the area. Some areas to the north in Maharashtra while receiving heavier rainfall are followed by long dry spells, while regions closer to the equator receiving less annual rainfall, have rain spells lasting almost the entire year.

Weather analysis of wayanad and Chettalli

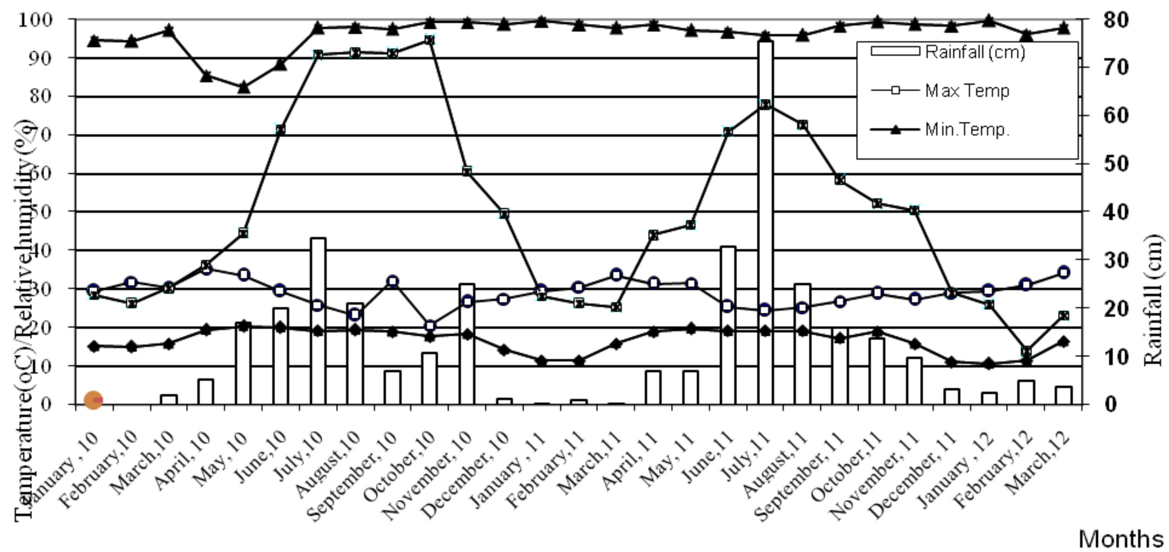
The average weather data on temperature, humidity and rainfall patterns of Wayanad district of Kerala over 3 years from 2009-2011 revealed that minimum monthly temperature ranged from 15.69 - 20.32^{0}C (Feb. and Aug.), maximum temp. 26.07-33.3^{0}C (July-Sept. and March), maximum RH 85.61-91.93% (Feb. and July), minimum RH 66.47-88.6% (March and July). The maximum precipitation occurred during June, July and August months. The variation between maximum and minimum temperature and relative humidity found to be the least during June to August months coupled with maximum precipitation during the period which creates cooler climatic condition required for conditioning of buds to bear panicle and could be the probable reason for triggering the plants from vegetative to reproductive phase and finally appearance of flowering panicles during September-October. Similar type of observations in weather data of Chettalli has also been recorded. Variation in flowering of ber at different locations has also been attributed due to difference in maximum and minimum temperature and morning relative humidity (Nath and Bhargava, 2000).

Average weather data of 3 years (2009-2011) of Wayanad district

Months	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Difference in temp (^{0}C)	Difference in RH (%)
	Min	Max	Max	Min			
January	15.71	29.74	87.80	70.83	6.10	14.04	16.97
February	15.69	32.18	85.61	74.00	17.68	16.50	11.61
March	17.82	33.30	87.63	66.47	27.75	15.48	21.17
April	20.13	32.27	89.77	72.37	143.80	12.13	17.40
May	20.07	31.04	88.93	74.10	73.80	10.97	14.83
June	19.87	27.33	91.37	82.13	569.63	7.47	9.23
July	19.57	26.07	91.93	88.60	981.99	**6.50**	**3.33**
August	20.32	28.28	91.35	87.60	320.51	**7.97**	**3.75**
September	20.18	26.07	90.08	83.59	198.59	5.89	6.49
October	19.40	27.61	91.17	80.67	275.68	8.20	10.50
November	18.67	27.47	90.10	78.04	185.37	8.80	12.06
December	16.50	27.80	85.80	72.30	24.84	11.30	13.50

Weather data of Chettalli

Fig.1. Climatic condition of CHES, Chettalli during April10- March,12



Average weather data (2010-2012) of Chettali, Kodugu

Month	Temperature		Relative Humidity		Rainfall (mm)	Diff. of (Temp.) (°C)	Diff of RH (%)
	Max.	Min.	Max.	Min.			
January	30.0	11.8	85.5	70.5	20.5	18.2	15.0
February	30.7	11.7	88.87	71.3	30.7	19.0	17.4
March	31.4	16.1	87.5	72.1	30.8	15.3	15.4
April	33.1	19.8	90.8	75.3	80.5	13.3	15.5
May	30.9	19.7	92.5	73.9	150.4	11.2	18.6
June	27.5	19.6	95.7	75.2	280.7	7.9	20.5
July	25.1	18.9	95.9	75.8	520.6	6.1	20.1
August	32.8	19.1	92.3	72.3	290.5	13.7	20.0
September	29.3	17.3	89.7	70.5	140.3	12.0	19.2
October	24.8	18.4	90.5	70.1	140.1	6.4	20.4
November	27.0	17.0	87.9	68.5	210.3	10.0	19.5
December	27.5	12.0	75.3	63.5	20.2	15.5	11.8

Soil of western Ghats

The soils of the region are rich in organic matter content with near normal pH which favours maximum plant growth but due to acidic nature some nutrients get fixed in it.

Constraints of litchi expansion in Western Ghats

The data collected from some of the litchi growers in this area also shown that the litchi has good potential to grow in this region. But there are few problem faced by the litchi growers of this area.

- » Irregular flowering in plants and poor fruit set
- » High infestation of insect-pests (mite, fruit and shoot borers)
- » Higher damage by birds and bats
- » Inferior quality of fruits due to untimely harvesting
- » Unavailability of suitable varieties and quality planting materials
- » Lack of location specific standard package of practices
- » Lack of information about litchi technologies in regional languages

Potential areas for off season litchi production

There is possibility of growing litchi crop in several humid subtropical areas of Maharashtra, Karnataka, Kerala, Andhra Pradesh and Tamil Nadu. However major potential areas for off season litchi cultivation are mentioned below.

States	Potential areas
Maharashtra	Mahabaleshwar, Panchgani, Amboli Ghat, Kudremukh, Palghar
Karnataka	Kodagu, Bangalore, Coorg, Chikmangalore
Kerala	Wayanad and Idukki
Tamil Nadu	Kodaikanal, Ootty, Ambalvayal and Kalpetat areas

Recommended package of practices for off season litchi production

Soil and climatic requirement

Litchi is grown successfully on a wide range of soil types, which include sandy loams, laterite, alluvial sand, and calcareous soil, but the best litchi orchards are seen in alluvial sandy loam soils with good drainage and access to the water table. The performance of orchards is very poor on clay soil with poor drainage. The water table should be at least 1.25 m deep. It can't stand water-logging for longer period. Litchi prefers slightly acidic to neutral soil. The trees grow best in a pH range of 5.0 to 5.5. The roots of litchi trees are found to have a symbiotic association with mycorrhizal fungi which improves the nutrient uptake by roots. Before planting, it is worthwhile to inoculate the soil in pit by mixing some soil from the root zone of litchi plantations.

The soil of Western Ghats are suitable for litchi cultivation as they are rich in organic matter but the rice field with high water table and clay soil should be avoided for litchi orchards. As litchi is sensitive to climatic conditions, flowering, fruiting, yield and fruit quality are very much influenced by the climatic conditions of particular area.

Litchi is highly specific to climatic requirement for growth and fruiting. Litchi prefers moist subtropical climate. Moist atmosphere, occasional rainfall, cool dry winter free from frost and hot winds are ideal for its cultivation. Seasonal variation in temperature is necessary for proper fruiting. The temperature should not go beyond $40^{0}C$ in summer and below the freezing point in winter. Good rain or adequate supply of irrigation water is essential for litchi cultivation. A constant rainfall at the time of flowering, however, interferes with pollination and affects fruit set.

The climatic conditions for flowering at higher altitude in southern India suitable because in most of the areas, minimum temperature remain less than $20^{0}C$ during June and July which is favorable for flowering of Litchi. Besides, least variation between maximum and minimum temperature as well as in relative humidity during these months coupled with maximum precipitation created cooler climatic condition which ultimately helpful in triggering the plants from vegetative to reproductive phase and favoring the flowering in litchi.

Selection of suitable cultivar

There are a large number of litchi cultivars grown all over India, but the difficulty is that the same cultivar may be known under different names at different places (Singh *et. al.*, 2012). The important cultivars for different litchi growing states in India are-

Bihar	:	Shahi, China, Purbi, Rose-Scented, Kasba
Uttar Pradesh	:	Dehradun, Muzaffarpur, Saharanpur
Punjab and Haryana	:	Saharanpur, Dehradun, Culcuttia, Muzaffarpur, Seedless Late, Rose-Scented
West Bengal	:	Bombai, China, Bedana, Elachi

These varieties are categorized in two main group namely Shahi and China. The Shahi group of varieties such as Early Seedless, Dehra Rose, Shahi,Rose Scented are performing better than the China group of varieties in Coorg conditions. The China group of varieties tends to produce fruits in alternate years in Coorg region. The evaluation of litchi varieties at Central Horticultural experiment Station, Chettalli revealed that yield was highest in cultivar. Dehradun (24.4 kg /tree) followed by Shahi (23.6 kg/tree) and Dehra Rose (23.15 kg/tree). The Average fruit weight was highest in cultivar. Dehra Rose (17.5 g) followed by cultivar Dehradun (15.57g). This clearly indicates that Shahi group of cultivars which otherwise produce regular and higher fruit yield has edge over the China group of varieties which produce late season fruits in non-consistent manner.

Propagation

Litchi is mainly propagated by air layering.It is the most widely accepted method for propagation of litchi on a commercial scale. Upright branches of 2-3 cm diameter and 30 to 60 cm long from well developed trees, free from pests and diseases, are suitable for layering. Treatment with IBA at 500ppm in lanolin paste on the upper end of the ring improved root formation. For enclosing the cut end, rooting media consisting of equal part of vermiculite, vermi-compost and coco-peat in polyethylene film is used for successful rooting in litchi layers. To raise the quality planting material of litchi, air layering should be done on selected mother plants. The freshly detached air-layered to be dipped in the 2% Rhizobacteria solution for 2 minutes and then planted in the poly bags 30 x 25 x 15 cm containing 2 parts RBS, 1 part vermi-compost, 1 par coco-peat (Purbey and Nath, 2013).

Nutrition

The nutrient management is also an important factor in litchi. Application of 600-800 g N, 200-300 g P_2O_5 and 400-600 g K_2O per plant is recommended for 12-15 year old trees. Fertilizers should be applied in 2 splits after fruit set and after harvesting. Excessive application of nitrogenous fertilizer before flowering should be avoided. Phosphorus application at the time of flower bud differentiation improves flowering and fruiting. The zinc deficiency in litchi may be corrected by basal application of zinc sulphate @ 50g per plant or spraying of 0.2% zinc sulphate in the month of July-August. To over come the deficiency of boron applies 50-60 g boric acid/plant in the same month and also foliar application of boric acid @ 1g/l sprayed during fruit development stage found beneficial. For newer areas, the doses need to be fine-tuned on the basis of local requirement.

Regulation of flowering and fruiting

The erratic flowering, less flowering and flowering in both seasons have been seen in litchi plants of Coorg region. These problems may be avoided by pruning of branches at the time of harvesting, giving moisture stress in the month of April-May. The girdling of branches and use of chemical such as paclobutrazol may be helpful to make the plants bear fruits regularly but experimentation is needed in established plantations. The shade regulation also important for regular flowering of litchi planted in Coffee plantations. Litchi is sun loving plant and more shade causes apical dominance,leakygrowth, reduced flowering and fruiting and colour development in fruits. A dry period of minimum 2 months after physiological maturity of shoots before flowering induces flower bud differentiation. The low temperature difference and high precipitation before flowering triggers the plants for phase change and make them flower.

Water management

Optimum soil moisture is critical for growth, development and fruit production. Certain physiological disorders like poor sex ratio, poor fruit set, heavy fruit drop and high fruit cracking, besides sunburn of the fruits can be minimized with proper water management.Frequent irrigation is necessary during the early plant growth.Irrigation should be done twice a week during dry and hot months for young plants and once a week for plants older than 4 years in age. Established orchards should be irrigated frequently during the fruiting period to ensure better performance of the tree. The orchard should also be irrigated after the application of fertilizers.

Use of PGR and chemicals

Litchi trees come to bearing at the age of 3-4 years with proper care and management while the seedlings take 8 to10 years to flower. During initial years of 4-9 years, litchi plants exhibited erratic bearing. The different litchi cultivars show variations in their flowering and bearing habits and may accordingly be classified as regular, irregular, shy bearing etc. So, for effective pollination and fruit- set of litchi, planting of several cultivars in as orchard is suggested. The flowers are mainly staminate, hermaphrodite and pseudo-hermaphrodite. Three to four spraying with Ethrel @ 150 ppm during June to September or two spray of Ethrel @ 400 ppm in the month of August- September or 2-4 mm wide girdling of primary branches in the month of last week of May to 2nd week of June is found effective to promote flowering in junior bearing litchi plants.

Training and pruning

In litchi pruning is not an essential operation. In the beginning training of the tree is necessary to give a definite shape but generally no pruning is required, only the diseased and dried portions of the branches should be pruned. While harvesting litchi, a portion of the twig is also cut off along with the fruits, so a light pruning is done during harvesting. The removal of the ends of the fruiting branches promotes new shoots and also flowering next year.

Provision of pollinators

Litchi is generally a cross pollinated crop and pollination is mainly done by insects, such as honeybees, flies, ants and wasps. About 20-25 boxes/ha of honey bees are sufficient to ensure the proper pollination and fruit set in litchi. Mostly bees are visiting on flower for collection of nectar during morning hours (6-11 AM). Though, litchi plants flower profusely but only 1 to 2.5 per cent of the total flowers set fruits. This may be due to lack of fertilization or embryo abortion or hormonal imbalance.

Plant protection measures

Among the insect- pests, velvet mite's fruit and shoot borers are major ones. The red velvet mite is one of the main reasons of unproductive of most of the trees in the region. The red mite infestation in more in the region due to high rainfall and higher humidity level. This need to be controlled to enhance flowering and fruiting.The tiny nymph and adults of this pests stick to the under-surface of the leaf and suck the cell sap. Young leaf turns yellow to greyish-yellow and a velvety growth develops on lower surfaces finally turns brown. The affected mature leaf shows curling, twisting and leathery. To control this, the affected portion should be pruned and burn to avoid spread. Two sprays of Kelthane (0.05 %) or Wettable sulphur (0.2%) should be done at 7-10 days interval. Two sprays of Dicofol 17.8 EC @ 3 ml/l or Propargite 57 EC @ 2.5 ml/l twice at 7 days interval on new shoots and again before panicle emergence.

The caterpillar of shoot borer, bore inside the newly growing shoot and feed on inner parts resulting in drying of the twigs. Similarly, small caterpillars fruit borer bore through the stalk end of the fruit, and feed on the seed and skin and fruits become unfit for consumption. The fruit borer infestation in these areas is also a major constraint of litchi cultivation pruning

and burning of affected twigs and spray of decamethrin (0.15%) minimize the infestation. First spraying of Diflubenzuron 25 WP @ 2 g/l during fruit development stage and last spray should be done at 15 days before anticipated fruit harvest.

Apart from insets, Birds, flying foxes, squirrels also damage litchi fruits. The extent of damage may be up to 100 per cent. Theuse of shade nets, bird nets and bagging the fruit bunches with muslin cloth bags helps in reducing the damage caused by birds and bats. Because of the early harvest due to birds and bats the problem generally the fruits were found acidic and small in size. This problem could be avoided from timely harvesting of fruits and application of micronutrients. These enhance fruit setting and reduce fruit cracking and improve fruit weight and quality.

Summary

The off season litchi cultivation may be a profitable venture in southern parts of the country having higher altitude area and has immense potential for area expansion and established market in European Countries around Crishmas. The quality produce during this period is limited and scarcity hence, the litchi needs to promoted in non-traditional areas with full technological support from National Research Centre on Litchi, Muzaffarpur to harness the untapped potential.

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Fruit crops based cropping systems in Western ghats of India

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India is blessed with vast rolling mountains of Western Ghat, stretching right from border of Gujarat and Maharashtra to Kanyakumari in Tamil Nadu, passing through Maharashtra, Goa, Karnataka and Kerala for about 1600km along the west coast. The lower parts proximal towards Arabian sea with abundant rainfall have the tropical and humid climate with well drained soils and moistenvironment, while the elevated region of the western ghats records the temperate climate. Being one of the hot biodiversity spots of the world, western ghat region is a treasure trove for four thousand species of flowering plants including 56 genera endemic to this region, besides its unusual diversity in other flora and fauna. Thus, the region is also a rich germplasm centre for a number of horticultural crops including tropical and subtropical fruits, vegetables, spices, medicinal plants, cereals, millets and legumes.

The heavy rainfall, hot and humid climate and well drained soils of mountainous undulating and sloppy terrain of the region is very much conducive for the cultivation of various fruit crops. These fruit crops yield comparatively four to five times more return per unit area than the traditional cereal crops. Alphonso mango based cropping systems of Sindhudurg district, Mankurad and Hilario mango of Goa, Jack fruit , Bread fruit, sapota and jamun in agroforestry / homestead gardens , Banana (Saldattim, Savorboni, Myndolim, Sakri, Amti, velchi local banana varieties of Goa) and pineapple in palm based farming systems, cashew and jack fruit of the agroforestery systems on the mountainous terrains, etc., in Karnataka and Kerala are the important fruit components contributing to the economic sustainability of the farming systems of the region. Rainfed Mango orchards on hilly terrains in Konkan area is a common site, while orchards on slightly undulated plains with fertigation have mango crop with other fruit components like pineapple as inter crop, banana in borders with somewhat intensive production practices. Kokum (Garcinia indica) is an indigenous fruit species native to the region which is spread across the Konkan region naturally forestry vegetation and in the cashew plantations, the fruits of which are collected for processing into various value added products and pharmaceutical products.

Of late, few exclusive orchards of this fruit have come up in South Goa districts. G. gummigatta, a relative of kokum is similarly found in Uttara Kannada and Dakshina Kannada districts of Karnataka and all over Kerala state under different farming situations for deriving additional economic benefits. Karonda and aonla (Indian goose berry) are other commercially and nutraceutically important fruits, the self sown trees or natural grooves of which are spread through the forestry areas in Konkan belt. At lower elevations in the valley areas, all along the western ghats, palm based farming systems (arecanut / coconut based production systems) are a popular traditional production systems that also have a number of underutilized traditional fruit crops like bilimbi, star fruits, rose apple, wax apple, pomelo, citron, annona fruits (Ramphal and sour soup), monkey jack, bread fruit etc., and jack fruits in the borders. These components along with local banana varieties impart considerable support to achieve sustainability and nutritional security.

Some of the peaks of western ghats like Niligirs in Tamil Nadu, are bestowed with temperate or cool climate in which a variety of sub-tropical and temperate fruits like Rambutan, Mangosteen, Avocado, Velvet Apple, Surinam Cherry, Persimmon, Egg Fruit, Longsat and temperate fruits like Strawberry, Peach, Plum, Pear and Apple also can be cultivated extensively under various farming systems. Other peaks like Coorg in Karnataka have popular mandarin based cropping systems, besides having a number tropical and subtropical fruits.

Underutilized fruit based cropping systems with special reference to Western ghats

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The Western Ghats regions of India a rich diversity of underutilized fruits, plays an important role in people's livelihoods and provides for a broad range of livelihood support including household income, food, employment, traditional medicine, timber and livestock fodder and also plays a role in the stability of ecosystems. Many of these species, although locally abundant and of major cultural importance are less well-known in other parts of the region and there is a lack of scientific knowledge about them and these species are therefore often referred to as 'underutilized'. Some strategies aiming at conserving these plant species are focussed on the promotion of their use and on farm conservation, including the strengthening of market systems. This will provide farmers with an economic incentive to maintain these species on farm. A group of plants producing edible fruits with great potential in different parts of world which are not at all being grown and utilized by other people in a very localized manner. In this article we describe the potential utilization of a few of these fruits by highlighting important cases from Western Ghats of India.

Reasons for poor popularity of underutilized fruit crops

Lack of awareness about the economic benefits and non-availability of good quality planting materials. Lack of technology to reduce the gestation period and enhance the fruit production.Lack of technology for value addition, through processing and poor market network. Most of these less known fruit trees establish through natural regeneration of seeds grow slowly without any nutrition, start bearing fruits after a long period and produce fruits of inferior quality. Fortunately suitable technologies have also been developed to improve the productivity of these crops in the last two decades. However there is further need to set up field demonstrations to provide first hand exposure to the farmers for popularizing these species in the field.

Advantages

There are quite a large number of indigenous and underutilized fruit crops, which are being used by the local inhabitants. In fact for people living in villages, these underutilized fruits are the only source of protective food to meet their vitamins and minerals requirements in their poor diet. Because of their curative properties, these fruits have been used in Indian system of medicine such as Ayurvedic and Unani since time immemorial.

The neglected and underutilized species

These species have been referred to by terms such as minor neglected, underutilized, underexploited, alternative, local, traditional and niche crops. However the two terms, underutilized and neglected, recognized and accepted. Neglected crops are those grown primarily in their centres of origin or centres of diversity by local farmers (some may be globally distributed), where they are still important for the subsistence of local communities but are neglected by research and conservation. The underutilized crops are those that were once more widely grown but are falling into disuse by the farmers and consumers for a variety of agronomic, generic, economic and cultural factors.

The Western Ghats tracts of India are bestowed with wide range of diversity in several fruits, which are growing wild/semi-wild, are unattended and underutilized. Most of these species have a wide adaptability as well as high degree of tolerance and hence can thrive well under most adverse situations. In spite of rich germplasm existing Western Ghats of India, for most of the underutilized fruits, no standard variety has been developed so far. Many of these fruits are nutritionally very rich and are of great medicinal value. These fruits hold promise for sustainable agriculture, particularly for small farmers by augmenting their income with the least risk. Our urgent task would be to develop/select suitable variety/genotype and to standardize production protocol and to popularize these fruits.

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Advances in jackfruit production technology

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Jackfruit is popularly known as poor man's fruit in the eastern and southern parts if India. It is reported to be originated in Western-Ghat regions of India and spread across tropical and subtropical regions of the world (Chandler, 1958; Popenoe, 1974; Purseglove, 1968; Haq, 2006). It is a common component in the multi-storey homestead farming systems in tropical parts of India. Jackfruit is a multiple fruit, a gigantic syncarp and is the largest tree borne fruit in the world. It contains a large number of bulbs or flakes and each bulb is a single fruit, with seed inside. The composite fruit may be as large as 20 kg or more. Jackfruits are broadly classified into two groups: soft pulp varieties having plenty of juice; and firm pulp varieties, which are crispy and less juicy. There are also intermediate types (SCUC, 2006). Different shapes (obloid, spheroid, high spheroid, ellipsoid, clavate, oblong, broadly ellipsoid etc.) of fruits are found in jackfruit. The fruits can have 10-500 flakes and seeds. The jackfruit tree is a multipurpose species which provides food, fuel, timber and medicinal extracts, and is a potential source of income for both the rural and urban people of the tropics and subtropics. It assumes the role of a secondary staple in certain areas that are particularly prone to variable climatic conditions which lead to food shortage (SCUC, 2006).

Jackfruits are eaten unripe at 25-50% of full size as a vegetable or ripe as a fruit besides use of its seeds in many culinary preparations.

Soil and Climatic Requirement

The jackfruit can be grown on a wide variety of soil. It flourishes in rich, deep soil of medium or open texture, sometimes on deep gravelly or laterite soil. But, it can also tolerate shallow, slightly saline, and infertile soils. It also tolerates high pH limestone soils and rocky soils. Soil drainage is of utmost importance. Sub-soil drainage congestion, rise in water table or flood severely damage the trees and may lead to death. It prefers well drained, deep, alluvial, sandy or clay loam soils of neutral soil reaction (pH 6.0-7.5). Jackfruit is essentially a tropical lowland tree, though it is adapted to a wider range of climatic conditions. In its natural habitat, it fruits up to 20°N and S in frost-free environments and bears good crop at 25°N and S of the equator. Warm humid plains are suitable for jackfruit. Quality of fruits deteriorates in higher altitudes. It also grows well in arid and warmer plains of South India. Cold weather and frost are harmful. High rainfall area experiencing 1500 mm or more annual precipitation is good for jackfruit. Prolonged drought, water logging conditions are not congenial for its growth and development. At 0°C the leaves may be damaged, and at –2° C, branches or the whole tree may die (Crane *et.al*., 2003).

Varieties

Jackfruit is mostly seed propagated. Allotetraploidy and crosspollination lead to highly heterogeneous nature of jackfruit (Mitra and Mani, 2000). Its innumerable types of fruits differ widely in density of spines, rind, bearing, size, shape, quality and period of maturity. There are two broad groups of cultivated types; soft fleshed and firm-fleshed. Local selections are named as 'Gulabi' (rose scented), 'Champa' (flavour like that of Champak), 'Hazari' (bearing large number of fruits). 'Rudrakshi' has common pummelo-sized fruits with smooth rind and less spines, whereas Singapore or Ceylon jack introduced from Ceylon, is highly precocious. Sometimes it produces light off-season crop between September and December. Muttam Varikka is another important variety producing fruits of 7 kg each and flakes of 3.6 kg (APAARI, 2012).

A lot of variability occurs in evergreen forests of the Western Ghats, Gorakhpur, Dewaria (40 kg-sized fruits) and Allahabad (small with white, juicy and soft pulp) districts of Uttar Pradesh. Some of these types produce small to medium sized fruits with small seeds and thin skin, offering a great potential for the varietal improvement. The selections, namely, NJT1, NJT2, NJT3 and NJT4 with large fruits and excellent pulp quality have been identified for table purpose, while types like NJCI, NJC2, NJC3 and NJC4, have small to medium sized fruit with thin rind were found to be better for culinary purpose (Chithirachelvan *et.al.,* 2012).

In South India (Kerala, Tamil Nadu and Karnataka), different forms of jackfruit (Varikka, Koozha, Navarikka) are available and the maximum diversity has been reported from Wynad Plateau of Western Ghats of Kerala. In Sikkim the varieties like Soft Flesh, Firm Flesh, Rudrakshi and Singapore etc. are also cultivated. Further, less gum type identified at IIHR also has great potential for commercial acceptability (Chithirachelvan *et.al.,* 2012).

Tamil Nadu Agricultural University (TNAU) has released improved Jackfruit varieties namely 'Palur-1' (in 1992), 'PPI Jack' (in 1996) and 'PLR (J)-2' (in 2006). 'Palur-1' is high yielding with medium height, less spreading and suitable for high density planting. In addition to regular bearing season (March-June), it produces fruits during off season (October- December) also. 'PPI Jack' yields 105 fruits per tree per annum (each weighing 17 kg) which accounts for 40.8 per cent more yield than local. 'PLR (J)-2' is having good quality and bigger sized fruits.

'Konkan prolific' is a prolific bearing jackfruit variety released in 2004 by the Regional Fruit Research Station, Vengurle. It is having an average yield- 420.56 kg/tree producing 73 fruits/ tree/year. 'Swarna' is a recently released jackfruit variety from the University of Agricultural Sciences in Bangalore, during 2010. 'Swarna' is a very good yielder that bears fruits in bunches on the trunk, primary branches and also on the secondary branches (Chithirachelvan *et.al.,* 2012).

Propagation

Seed propagation

The most common method of propagation of jackfruit is by seed. This method is suitable for cultivation of jackfruit trees for the purpose of fodder, timber, shade tree where the quality of the fruit is not very important. Hence, for true to type propagation of quality fruiting plants, vegetative method is preferred. For seed propagation, the seeds may be selected from a well ripened jackfruit obtained from a elite mother plant. Generally, 4-5 seeds are planted *in situ* so that the tap root can grow undisturbed. However, seedlings can be raised in pots or polybags. After one or two years the seedlings are planted at site. Special attention should be given to seedling taproots. If tap root got bent and kept flat too long, the taproot should be cut before transplanting (Wasielewiski and Campbell, 1998).

Jackfruit seed is recalcitrant type and it loses viability very quickly. Seeds should be sown immediately after extraction. The need for prolonging the viability of *A. heterophyllus* seeds gains attention both due to being a recalcitrant species and for the purpose of germplasm conservation. The viability of seeds can be prolonged to 32 weeks (with 48% germination) when stored at 20°C (Rekha *et. al.,* 2009). If they have been extracted for some days they should be soaked in water for 24 hours before sowing (Singh, 1969). Soaking seeds in NAA (25 ppm) for 24 hours or GA upto 500 ppm for 48 hours improves their germination and seedling growth. It was also reported that, soaking of seed in water for 24 hours improved germination. Germination starts within 10 days and 100% seeds germinate within 35-40 days. Shortly after germination, only the most vigorous seedlings are retained and the weaker ones are removed (Haq, 2006).

Vegetative Propagation

Since jackfruit seeds are not true-to-type, grafting of known varieties onto rootstocks is often done, especially for commercial production where a uniform product with the best market qualities is important (Elevitch and Manner, 2006). The following methods are used for vegetative propagation.

Grafting

Success of different methods of grafting varies with climatic condition prevailing in one region. At Jorhat (Assam), graft success was achieved only in epicotyl grafting. Results revealed that epicotyl grafting during the second week of July recorded 20% success in jackfruit under Assam conditions. In Palghar (Maharashtra) also, maximum grafting success (78.47%) was recorded in the epicotyl grafting. While the most effective vegetative propagation method at Kannara (Kerala), so far has been inarching where the graft success was 85%–90%. Similarly at Kovvur too, the inarching method gave 90% success (Table-1.). However, at Periyakulam (Tamil Nadu), softwood grafting using a four-month-old rootstock under 50% shade showed maximum success (Patil *et.al.,* 2014). In South India, inarching of jackfruit is successful using *A. hirsuta* or Rudrakshi as rootstocks.

Epicotyl grafting involves grafting with mature, plump, terminal scion shoot on germinating jackfruit seedling of about 8 to 10 weeks by wedge method during April-May could be successful. Epicotyl grafts attain saleable size within a year. The grafts become ready for planting in one or two years after grafting.

Table 1. Success rate (%) of different grafting methods in Jackfruit at different AICRP Fruits centres

Methods of Grafting	Success (%) of grafting across different centre					
	Jorhat	Kannara	Kovvur**	Mohanpur	Palghar	Periyakulam
T_1 - Inarching	-	85	90	51.4	-	42.0
T_2-Softwood grafting (4 MOS*)	-	12	-	54.5	25	46.0
T_3 - Softwood grafting (3 MOS)	-	10	-	38.2	27	37.0
T_4 - Softwood grafting (2 MOS)	-	15	-	33.0	35	30.0
T_5-Epicotylgrafting(20-23 *)	20	25	-	31.1	78.47	28.0
CD at 5%	-	-	-	6.20	-	4.05
* MOS = Months Old Seedlings & DOS = Days Old Seedlings.						
** Vaneer grafting – 65%						

(Patil *et.al.,* 2014)

Other vegetative methods: Among different methods of budding, forkert budding, chip budding and patch budding may be used successfully for the propagation of jackfruit. Stooling or Mound layering found to be successful in jackfruit and treatment with IBA improves rooting of layered shoots. Soil mounding upto 10 cm height around the basal shoots for 15-20 days is a pre-requisite. After that, the soil is removed and a ring of bark is removed from etiolated shoots. Application of IBA (5000 ppm) in lanolin paste is recommended and callus formation will take place within 10 days. Earthing up has to be done once again. After a month's time, rooting will occur. For cuttings and layering Treatment with IBA and NAA markedly improves the root formation in air-layering of shoots like girdling and etiolation (APAARI, 2012).

Micro-propagation: In jackfruit, new plantlets are successfully raised from nodal explants and shoot apices cultured on MS medium supplemented with various concentration of cytokinin for shoot proliferation and sub-cultured on similar medium supplemented with different concentrations of auxin for root regeneration.

Spacing

In jackfruit plantations, fairly wide spacing should be adopted between trees in order to reduce competition for light, water, and nutrients. Commonly, the square system is followed for planting. Hexagonal system may be followed in less fertile soil. In fertile soil, spacing up to 12 m x 12 m accommodating (70 plants/ ha) will be sufficient for this fruit crop (APAARI, 2012). On average soil, trees may be planted at 10 m apart. Higher density of planting can be practiced in lighter and poorer soils; shorter spacing in fertile soil will lead top crowding of trees. Haq (2006) recommended a spacing of 8 m X 8m for grafted plants and 12 m x 12 m for direct seeded or seedling plants. Spacing of 8 m X 8m could accommodate 150 plants a hectare, hence which is highly suitable for HDP. However, for timber production, closer spacing should be used to inhibit side branching by shading and promote long, straight trunks. Spacing of 2 m x 3 m or 3 m x 3 m may be given for timber purpose (Elevitch and Manner, 2006).

Planting and Aftercare

For planting jackfruit, 1 m^3 pits are dug at least 10 days before planting. About 30 kg well-rotted farmyard manure is mixed with the soil of each pit and the pit is refilled. Chlorpyrifos may be applied in the pit to avoid insect attack. *In situ* planting of 3-4 seeds per pit leads to stronger plant (APAARI, 2012). After planting, the soil is pressed firmly to avoid water-logging in pits during rainy season. The best time for planting, whether direct seeding or transplanting, is at the beginning of the rainy season. If water is available, direct seeding may be done in early summer so that the seedlings are established before the beginning of the rainy season. The rainy season ensures plenty of water and generates a favourable environment for the establishment of trees in the field (SCUC, 2006). In addition, transplanting is best when carried out in the late afternoon to early evening rather than in the heat of the day (Morton, 1987).

In the case of budded/ grafted plants, care should be taken not to cover the graft union with soil. Shade should be provided for initial 2-3 weeks. Prolonged dry weather after planting may lead to the death of plants. The taproot should not be distributed while planting to avoid damage to plants. Partial shade should be provided for better growth and establishment of transplanted seedlings. Seedlings are best grown in 30–50% sunlight, with sun exposure increasing to 100% as the tree matures (Crane *et.al.*, 2003 ; Hossain and Kamaluddin, 2011).

The young plants should be protected from stray goats and cattle and should be adequately guarded by providing gabions for about two years. Gabions may have to be replaced after a year. Hand watering of young plants during summer is necessary for assured survival and good growth of plants during initial stage of crop. In cooler regions, protection against frost at least during first few years is safe. Cleaning of basins by spading and ploughing of orchards should be followed as a routine measure. Frequent weeding and mulching are necessary to achieve normal plant growth (APAARI, 2012).

Training and Pruning

Jackfruit does not respond well to indiscriminate pruning and it is not commonly practiced. Young trees do not need pruning in the first year. Pruning of the first lateral branches should be carried out in the second year, to slow down the upward growth and enhance the spreading of the canopy (SCUC, 2006). Jackfruit tends not to self-prune, instead retaining side branches along the main trunk. Even when side branches are pruned off, fruiting branchlets continue to sprout on the lower trunk (Elevitch and Manner, 2006). One or two pruning of shoot tips during summer causes lateral bud break and makes the tree more compact. Grafted trees have a dwarfing tendency but produce a large number of branches from the beginning. These branches should be continuously pruned to get a reasonable trunk. Thereafter, branches may be allowed to remain but removal of vigorously growing upright shoots is recommended. Inner branches of the canopy should be removed to allow more light and air within the canopy (APAARI, 2012).

Regular pruning of weak, dead and diseased branches and removal of parasitic plants at the end of the rainy season is recommended. This prevents insect infestation and disease infection. Tree height and size may also be controlled, if desired, by pruning (SCUC, 2006). Old flowering shoots should be removed after harvesting and after the harvest is complete. These branches should be thinned out to increase light penetration to the inner canopy. Selective pruning is also effective for equipment movement and other management operations. Trees may also be mechanically topped at about 4-5m and hedged at a 5-10^{o} angle from the vertical (Haq, 2006).

Fruit thinning is also recommended to prevent damage to branches as heavy fruit load break branches and can result in death or stunting of the tree. Limiting the number of fruits per limb may also improve the quality of the fruits besides increasing their size (Crane *et.al.*, 2003).

Nutrition and INM

For quick growth of trees, manures should be applied twice a year, before and after monsoon. It is advisable to apply 20-30 kg of farmyard manure per tree per year. The manures should be spread in the basin and thoroughly mixed with soil by spading. The manure should be applied in an area up to the leaf drop around each tree leaving a portion around the trunk. The recommended dosage of NPK for mature jackfruit tree varied in different states. It varies with soil and climate prevailing in a particular agro-ecological region. In red and lateritic soils, jackfruit showed typical potassium deficiency symptoms (Naidu *et.al.*, 1996). The recommended dose of NPK (g/plant/year) is 750:400:500 in Tamil Nadu, 800:480:1050 in Madhya Pradesh, 600:300:240 in Karnataka and 210:160:1000 in Assam (Hore, 2011). As a general schedule of recommendation, stage wise fertilizer requirement may be given as in the table-1. Application of boron at 15 g/tree significantly corrected the flower and fruit characters and reduced the deformity of fruits (Farid *et. al.*, 2007).

Table 2. General schedule of NPK recommendation by crop growth stage

Nutrient (g/tree)	1-3 years	4-7 years	7 and above
N	200	400	600
Urea	435	870	1304
P	120	240	300
S/P	750	1500	1875
K	60	120	240
MOP	100	200	400

(Chithirachelvan *et.al.,* 2012)

Cropping systems

The jackfruit requires a long time to occupy fully the land provided during planting for future mature trees. It is desirable that the inter space should not be left unutilized. Root distribution studies of the wild jackfruit tree revealed that most of the physiologically active roots were concentrated within the radius of 75 cm and 30 cm depth. Although tap root might reach even deeper, the tree roots seldom extend beyond 2.25 m laterally from the stem, hence the effect of overlapping root zones and the associated competitive effects may not be serious problem for intercropping during the first few years (< 10 years after planting) of tree growth (Jamaludheen *et.al.*, 1996).

Jackfruit based multi-storey cropping system is much suited under rain fed farming conditions (Das *et.al,*. 2006). In Bangladesh, existing jackfruit-pineapple agroforesty system is found to be profitable and has a great contribution to meet nutritional demand (Hasan *et.al*., 2008). Intercropping with vegetables like beans, brinjal, chilli, gram and other crops can be taken if moisture is not a limiting factor. Suitable crops should be grown every year till the trees reach bearing stage. When the trees come into bearing, pulses like gram and kalai can be grown as intercrops. These crops will also improve the nitrogen status in the soil. Jackfruit varieties like Khajva, Swarna poorti and Swarna manohar are suitable as main crops in jackfruit based cropping systems (Dhakhar *et. al.,* 2013). Jackfruit can be intercropped with other tree crops. In the Philippines, jackfruit has been used as an intercrop with coconuts. Other intercrops include durian, mango, and citrus (Elevitch and Manner, 2006).

Jackfruit is a major tree crop used in agro-forestry production systems. It grows best as alley crop in between hedge rows of nitrogen fixing crops like *Calliandra calothyrsus* and *Acacia anguistissima* (Elevitch et.al., 1999). It can be best utilised for silvi-pastural system. Young trees would not survive exposure to grazing animals. However, livestock can be pastured among mature trees. Fallen fruit are readily eaten by livestock and make an excellent contribution to their diet. Jackfruit has been used a support for pepper vine and yam (Elevitch and Manner, 2006)

Irrigation

The jackfruit is not normally irrigated in homesteads. But, for commercial cultivation of jackfruit, irrigation is essential during the dry periods of the year. In irrigation trial conducted at Gazipur, Bangladesh, Akanda *et.al.* (2006) found that the highest annual return/tree was obtained from the tree irrigated at 15 days interval. The number of fruits and unit fruit weight were also found to be higher in irrigated trees than those of the control during all the years. The critical stage for irrigation to jackfruit was found from bloom through fruit development. Gosh and Bera (2006) also could observe that irrigation at 15 days interval from November to April, along with mulching give significant increase in fruit yield in Bengal condition.

In order to economise use of water, ring system may be adopted for irrigation. Alternatively drip irrigation may be followed for effective water use. For young orchards, hand watering is necessary during first 2 to 3 years till the root system has penetrated deep enough. The frequency of irrigation will depend on the soil moisture condition. Protective irrigations are necessary initially at 12-15 days intervals depending on soil and climate conditions (APAARI, 2012). The species is intolerant to poor drainage also (Soepadmo, 1992), and roots fail to grow under flooded conditions.

Weed Management

Weed is not a serious problem for jackfruit. Even, Perdomo and Magalhães (2007) reported allelopathic effect exhibited by jackfruit tree. But for the proper utilization of nutrient and light the field should be free from weeds. Manual weeding with khurpi or mechanical weeding by hoe is the best way to keep the field free from weed population. Interspace may also be kept clean to avoid the harbouring of insect pests and disease.

Pest Management

As many as 38 species of insects are known to attack jackfruit in India. Survey for pest incidence across the country revealed the incidence of bud borer, fruit borer and leaf caterpillar complex has emerged as the major pest problem in jackfruit (Patil *et. al.,* 2014) (Table-2). Three different species of lepidopterans namely, *Glyphodes* (*Diaphanea*) *caesalis*, *Glyphodes canthusalis* and *Glyphodes sibillalis,* emerged as the fruit borer complex. These are pests of the fruit, and occur at the beginning of the season on early-bearing varieties as serious pests, but gradually become unimportant as the number of fruits increases. Population dynamics of fruit and shoot borer in jackfruit indicated thatthemean percentage of damaged shoots was significantly higher in the first fortnight of January, whereas it was the least in the second fortnight of June (Patil *et. al*., 2014). At Periyakulam, webber incidence were found to be negatively correlated with rainfall and RH, and positively correlated with maximum and minimum temperatures. Cultural practices like collection and destruction of affected shoots and fallen fruits and fruit covering with alakathene bags helps to prevent pest attack. It can also controlled by spray of profenofos (1ml/l). Infestation may be checked naturally if the trees are regularly pruned of dead and diseased twigs and small shoots within the canopy, to allow sufficient light and air to pass through. Pruning may be done soon after harvest or at the end of rainy season to reduce the pest attack (SCUS, 2006; Chithirachelvan *et. al.,* 2012).

The bud borer (*Ochyromera artocarpi)*grubs bore into tender flower buds and fruits and induce premature drop (SCUS, 2006). It can be controlled by cultural methods or by spraying carbaryl (3g/l). Fruit fly attack is also becoming serious in various parts of the country. They attack maturing fruit. Jackfruit seedlings were reported to be affected by Sucking pests like aphids (*Aphis craccivora and Toxoptera aurantii)and* leaf-eating caterpillars, jelly worms and *Cispia* sp. affecting the jackfruit seedlings in some areas of Kerala and West Bengal (Patil *et.al.,* 2014).

Table 3. Pest infestation on jackfruit during 2012–13 at different AICRP Fruits centres

Centre	Fruit borer (%)	Mealy bug (%)	Leaf webber (%)	Fruit fly (%)
Kovvur (Andhra Pradesh)	3-30	0-100	1-4	2-6
Periyakulam (Tamil Nadu	0-15	-	3-4	Trace
Kannara (Kerala)	2-18	-	1-2	2-6
Jorhat (Assam)	-	-	Trace	1-4
Mohanpur (West Bengal)	0.6-2.5			

(Patil *et.al.,* 2014)

Disease Management

The most significant diseases reported from major jackfruit growing regions across the world includes leaf spots, dieback, fruit rots and pink disease. Many of the diseases are more severe during wet seasons, under high relative humidity and temperature, or in orchards with poor air circulation and drainage (Borines *et.al.,* 2013).

Roving and fixed plot surveys were conducted in different jackfruit growing regions of the country, to identify disease incidence and intensity under the AICRP Fruits project. The study revealed that fruit rot is a common disease found across the jackfruit growing areas of the country (Patil *et.al.* 2014). Jackfruit orchard in Kovvur (AP) recorded the disease incidence as high as even 50%, followed by Jorhat (Assam) (20%). Fruit and blossom rots caused by the fungi *Rhizopus artocarpi*. The male inflorescences and young fruits are attacked and only a small proportion of them survives and matures. The infected fruit rot slowly, mummify and fall from the tree (McMillan 1974; Roy 1983). Spray of Bordeaux mixture (0.5%) or copper-oxychloride (0.2%) can control fruit rot disease (Chithirachelvan *et.al.,* 2012).

Leaf spot complex were also another major disease across the centres (Table-3). Leaf spots are commonly caused *by Colletotrichum species, Corynespora cassiicola, Phyllosticta artocarpina* and *Septoria artocarpi* (Borines *et.al.,* 2013). Against leaf spot disease, Sprays of carbendazim (0.1%), thiophanate methyl (0.1%) or chlorothalonil (0.2%) is recommended (Chithirachelva *et.al.,* 2012).

Wilt and the stem canker diseases, die-back and post-harvest rot were also observed to be serious diseases in some parts of the country. Dieback in jackfruit is caused by the fungal pathogen *Botryodiplodia theobromae*, which affects growing shoots, causing discolouration of the bark as it spreads downwards, ultimately killing the tree (Haq, 2006). Another type of die back caused by a bacterium (*Erwinia carotovora*) also resulting in leaf yellowing and gummy exudates from the stems and branches in jackfruit (Ton *et al.,* 1990). Pruning of infected twigs followed by spraying of carbendazim (0.1%) or thiophanate-methyl (0.1%) is recommended to control die back disease (Chithirachelvan *et.al*., 2012).

Incidences of algal rust, as well as the pink disease, were reported in Kerala (Patil *et.al.* 2014). Pink disease is caused by the fungus *Erythricium salmonicolor*, results in wilting and defoliation of infected trunks, branches and twigs. The disease is found to be more severe in the rainy season, and in trees with a dense canopy. In order to control pink disease, prune affected trees and paste cut ends with copper fungicides (copper oxychloride at 0.2%).*Phytophthoral* decline is observed to be a devastating disease affecting jackfruit orchards in South-East Asia. Symptoms included trunk cankers, wilting and dieback of the canopy and, in many cases, tree death. Fifty two percent of farms surveyed had a disease incidence greater than 50 %. On some farms 100 % of trees were affected in Philippines. Results of the survey clearly indicated that the decline has a significant impact on yields and the long term viability of plantations, and consequently, farmer incomes (Borines *et.al.,* 2013). Incidence of this disease is not severe in Indian conditions. The wilt and stem canker symptoms were observed in Kovvur (AP).

Table 4. Incidence of diseases of jackfruit at different AICRP Fruits centres

Diseases	Disease incidence (%)s				
	Jorhat	Kannara	Kovvur	Mohanpur	Periyakulam
Fruit rot [1]	12-20	+	2-50	-	0.0-5.46
Fruit rot [2]	-	+	-	-	-
Young fruit rot[3]	-	-	-	3.23-15.67	-
Leaf spot [4]	-	+	1.0-9.0	15.34-25.33	-
Leaf spot [5]	-	-	-	8.59- 21.2	-
Leaf spot [6]	-	-	-	-	0-15.25

Algal rust*		+	-	-	-
Pink Disease*	-	+	-	-	-
Wilt	-	-	< 1.0	-	-
Stem Canker*	-	-	0-2.0	-	-
Die back[7]	-	-	-	0.83-2.6	-
Post-harvest rot[7]	-	-	-	15.6	-

[1]*Rhizopus* sp. [2]*Colletotrichum gleosporides, Botrydiplodiatheobromae*

[3]*Rhizopus atrocarpi*, *Aspergillusniger*[4]*Colletotrichum gleosporides*

[5] *Phyllosticta* sp.[6]*Rhizopus* sp.

[7]*Botrydiplodia* sp.[+] Mentioned presence of disease * C.O .not mentioned

(Patil *et.al.*, 2014)

Fruiting and Harvesting

Grafted trees bear fruits within 4-5 years after planting, while trees grown from seeds will start bearing fruits only after 6-8 years from planting. Varieties of jackfruit trees differ widely in their bearing age. Early varieties such as Singapore Jack bear in 2-3 years in India and Sri Lanka. Other vegetatively propagated trees also bear in 4-5 years (Chithirachelvan et.al., 2012). To achieve the maximum productivity, the trees should be 12 years or even older. Because jackfruit is an underutilized species, there are no reliable statistical data on its production from producing countries. Hence, systematic documentation is warranted.The yield of fruits per tree differs greatly on the basis of plant age, cultivars, season and localities, but most varieties yield 100-200 fruits/tree depending upon proper cultural management practices (SCUC, 2006). In south India, trees mature in 6-7 years but in the cool weather of north India, fruiting is delayed. Fruit bearing is delayed and fruit quality is affected if the trees are grown at a higher elevation also (Medagoda and Tennkoon, 2001).

In order to produce the best marketable fruits, the fruits must be allowed to develop on the tree to full maturity, until they are ready for marketing. If harvesting is done a few days earlier than its maturity date, the fruit will not ripen to its best quality. Fruits require 3-8 months to develop from flower emergence to full maturity, depending on the individual tree, growing conditions, season of the year, temperature, rainfall, etc. This indicates that the time from flowering alone is not a good indicator of maturity (Elevitch and Manner, 2006). In Malaysia, individual fruits are covered for better development and uniformity in its colours, which helps in quality produce.

Tender jackfruit is harvested for use as vegetable during early spring and summer until the seeds harden. The fruit matures towards the end of summer in June (Haq, 2006). Period of fruit development is February to June. The optimum stage of harvest maturing of jackfruit has been reported to be 90-110 days after the appearance of the spike, depending on the individual tree, growing conditions, and weather; therefore, time from flowering alone is not a good indicator of maturity (Mitra *et.al.* 2010). It takes some experience to gauge maturity like change in skin colour from light green to yellowish or brownish green, turning of last leaf on the stalk to yellow, widening apart of spines, slight yielding of fruit skin to pressure and production a dull, hollow sound when tapped. Usually two or more of these indicators are used to evaluate the maturity of fruit (APAARI, 2012). For harvesting at other stages of maturity such as those intended for use as vegetable, one can use similar criterion such as when the spines start to grow further apart, but not yet fully flattened and the skin colour should be still green. Since individual trees will have fruits of different maturity levels, it is necessary to harvest the fruits at least weekly.The fruits are harvested at different stages of maturity depending on the intended use and market demand. Based on the maturity, the following grading criteria can be applied (APAARI, 2012)

Stage I	:	Very immature fruits are generally used for making pickles and cooked as vegetables. No fruitlets (arils or bulbs) or seeds are formed. The preparations taste like chicken if proper spices are added.
Stage II	:	Fruitlets and seeds are just starting to develop; good for cooking into vegetable.
Stage III	:	Fruitlets and seeds are fully developed, but they are still very immature. Testa of the seed is not yet formed, hence there is no need of special cleaning of the seeds.
Stage IV	:	Seeds and fruitlets are fully developed. This stage is ideal for making chips and for use in different food preparations like curries.
Stage V	:	Fully mature fruits are utilized for making chips and used for preparing different
Stage VI	:	Ripe fruits are used in various food preparations as well as eaten fresh as dessert.

Optimum harvesting for long distance transport is done when the fruit changes its color from green to yellowish green and when a portion of the stalk attached to the fruit is already large enough to be used for handling (Kader, 2009). Once the fruit is harvested, it is not possible to differentiate between soft fleshed and firm fleshed types, so they should be kept separately during harvesting. The other grading system for jackfruit is based on the size of the fruit. Uniform fruits are selected for special markets while extra large and small fruits are sold locally. In the case of ripe fruits, orange coloured fruitlets are preferred as they command the highest price. If the fruitlets are big and very juicy, they command special prices. So the fruits are graded according to quality. While ripening, some varieties turn black giving the impression that the fruit is infected with fungus, so light coloured skin is preferred by the customers. The emission of a sweet and strong aroma indicates that a fruit is fully ripe (Acedo, 1992).Jackfruit has a storage life of 3 to 10 days. However, at 11–12°C and 85–90% relative humidity, fruits can be stored for 20–30 days (Mitra *et. al.*, 2010).

Conclusion

Although the importance of jackfruit has been well recognized, very little research work has been done on this important fruit species. Hence the crop still remains underutilized. Standardized technologies for propagation, production, post-harvest handling, processing of products and their marketing are still lacking for this crop. Systematic experimentation is needed to develop optimum agronomic packages for jackfruit in different agro-ecological areas. The potential of the crop in different cropping systems has not yet been adequately investigated. Thus, the future research has to focus on the following areas-

- Suitable cultivars/varieties need to be developed to meet the specific needs for fruit and timber production as well as for multipurpose use.
- Information on the mode of inheritance of important characters need to be generated and identification of gene(s) for seedlessness, dwarfness, resistance against fruit fly, fruit-rot and soil salinity need to be initiated on priority.
- There is a great need for developing of optimum and standard vegetative methods of propagation for the use by small farmers who can develop small businesses through the establishment of nurseries.
- Greater thrust needs to be given for developing reproducible in vitro methods of propagation to multiply promising planting materials.
- Systematic studies on the wild species need to be conducted to assess grafting compatibility to identify vigorous and genetically stable rootstocks.
- The production technologies including organic production techniques need to be standardized for better crop management and input use efficiency.
- Suitable strategies need to be developed for integrated pest and disease management (IPDM) using botanicals and biological control agents (BCA).
- Efforts need to be made to established appropriate mechanism for transfer of information and technology to the farmers
- There is a need to study the impact of climate change on the performance of jackfruit

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Recent advances in production technology of garcinia species

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Garcinia is a rich genus having more than 200 listed species. Of the 30 species available in India, important ones are *G. indica* (Kokum), *G. Gummigutta (*Malabar tamarind*), G. Mangostana (*Mangosteen*)*, *G. tinctoria (G. xanthochymus)(*Anavaya*), G. Morella, G. cowa and G. Hombroniana (Assam aur aur)*. Few important species reported, their distribution and uses are furnished in the Table 1 (Nadkarni *et al.* 2001).

Table 1. Important *Garcinia* species their distribution and economic value

Name of species	Distribution	Economic value
G. anomala	Khasi hills	Tree yields gum and resin of inferior quality
G. atrovidis	Assam	Unripe fruits used in curries, used as fixative with alum in dyeing of silk. Ripe fruit is edible
G. cambogia	Western ghats, Nilgiri hills	Fruits edible, seeds have an edible fat, dried rind used in curries and yellow gum, resin from bark used in paintings and water colour
G. cowa	Assam, Bengal, Bihar, Orissa and Andaman Islands	Fruit edible, used for preserve and jam making, yellow resin obtained from bark used as varnish, leaves used as vegetables, yellow dye obtained from the bark
G. gummigutta	Western ghats, Nilgiri hills	Rind used in curries, seed gives edible fat, tree gives yellow resin used as varnish. Fruit rind is anti-rheumatic, vermifuge.
G. hombroniana	Nicobar Islands	Fruit is edible, wood used for construction and carts
G. indica	Western ghats, Coorg, Wynad, coastal Maharashtra, Goa (Konkan)	Anthelmintic, antiscorbutic, astringent, demulcent and anticeptic. Fruit rind used for making syrups, juice and culinary purposes. An edible fat kokum butter of commerce obtained from seed kernals – used in soap, candle manufacture, suitable for ointments. Also a source of anthocyanins, which can be used as a natural food colour.
G. mangostana	South India, Lower Nilgiri hills	Fruit edible, has medicinal value. Rind astringent, used in chronic diarrhea and dysentery, effective against skin infections, bark and young leaves used as gargle for sour mouth

G. morella	Assam, Khasi hills, Western ghats	Gamboges, yellow resin from stem used for preparing water colours and varnishes for metals, for dying silk fabrics, rind used as tan, seeds yields fat which is used in cooking, confectionary, candle making and in medicines
G. pinctoria	Western ghats	Exudate from tree yields excellent pigment, seeds yield oil
G. spicata	Western ghats	Dye obtained from bark, wood used as strong timber
G. succifolia	South India	Wood used as timber, bark yields inferior gamboges
G. travancoria	Western ghats	Yields gum resin
G. waghttii	South Indian forest	Gamboges yields good pigments which are very soluble
G. xanthochymus syn. *G. tinctoria*	Eastern Himalayas, Western ghats, Andaman Islands	Fruits edible, preserves and jams prepared from fruits. The exudates fromo bark and fruits used as dye. Seedlings are good rootstock for Mangosteen.

Among all these species only Kokum, malabar tamarind and mangosteen are cultivated.

Area and Production

Kokum (*Garciniaindica* Choisy) is one of the native underexploited tree spice. It is mostly found in Konkan region of Maharashtra, Goa, Coastal Karnataka, Kerala, forests of Assam, Khasi Jayanti hills, West Bengal and Surat district of Gujarat. In spite of its incredible medicinal and nutritive properties, kokum is generally not cultivated systematically on orchard scale like that of mango, cashewnut etc. It is mostly found as a kitchen garden plant or mixed crop in plantations of coconut, arecanut, road side plants or in forest.Malabar tamarind is widely seen in the homesteads of Kerala. The tree is found commonly in the ever green forest of Western Ghats of India from Konkan southwards to Travancore and Shola forests of Nilgiris up to an altitude of 2000 m. The tree is rep[orted to be native of India (George *et al.,* 2002) It is also seen in Malaysia, Assam and Sri Lanka (Seidemann, 2005).

Mangosteen is considered by many to be the most delicious fruit of the tropics with a universal appeal. According to some it is the queen of fruits. In India, it is successfully grown only in selected places on slopes of Nilgiris, Malabar and Kanyakumari.

The precise statistics regarding area production and productivity is missing for all Garcinia species as they are not planted in an organize pattern as that of mango, cashew, Arecanut or coconut. As per a base line survey (2010) in 1000 ha area is occupied by kokum in Konkan region with production of 4500 MT fruits. According to survey conducted earlier by Chief Conservator of Forest out of the total 46600 Kokum trees in the state of Maharashtra; 43000 trees existed in Ratnagiri and Sindhudurg Districts alone. It was also reported that in South Konkan 1674 MT of Kokum fruits were used for dried Kokum rind, 757 MT for preparation of Kokum syrup and 40MT for Kokum butter.

Varietal Improvement

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

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

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, at various research stations have conserved more than 300 types of kokum. Uptil now two improved kokum varieties namely Konkan Amruta and Konkan Hatis have been released by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli. The important morphophysiological characters of these varieties are as under

Characters	**Konkan Amruta**	**Konkan Hatis**
Yield (7 years) kg	138	250
No. of fruit/kg	29	11
Length of fruits (cm)	3.74	4.22
Circumference of fruit (cm)	13.15	20.10
Wt. of fruit (g)	34.45	91.50
Wt. of rind (g)	17.55	48.34
No. of seed/fruit	6.40	5.60
Shape of fruit	Apple shape	Apple shape
Shelf life (days)	15	18
Volume of fruit (ml)	35.50	112.8
Diameter of fruit (cm)	3.95	4.20
Thickness of rind (cm)	4.45	5.58
Chemical parameters		
T.S.S. (^{0} B)	9.08	9.20
Reducing sugar (%)	2.41	2.40
Total sugar (%)	4.52	4.10
Acidity (%)	5.12	5.10
pH	1.81	1.80
Flowering behaviour		
Flower bud appearance	1st week of October	2nd week of November
Initiation of flowering	2nd week of November	2nd week of December
Harvesting period	March-April	April-May

Very title research on varietal improvement is done in Malabar tamarind. Variability was observed in terms of vegetative, floral, fruiting and biochemical characters of fruit. Dome shaped trees are found high yielding.lite mangosteen varieties are unknown, though it has been cultivated for centuries. A general grouping of cultivated mangosteen in to two types is possible, one with large leaves and fruits of variable size and other with small leaves and small fruits. In Phillipines, a variety called 'Jolo' produces fruits that are larger with big seeds but more delicious pulp.

Climate and soil

Kokum flourishes very well up to an elevation of about 800 m from MSL. It requires warm and humid tropical climate. It thrives well in coastal areas receiving over 250 cm of rainfall. It comes up well in lateritic, alluvial soils having depth of 1.2 m and pH of 6.7. Kokum prefers valley situations. The locations where coconut and arecanut can be cultivated are suitable for kokum. Though kokum can be cultivated as a rainfed crop, it can not be cultivated on hill tops like that of mango or cashewnut. It can be grown as a monocrop or as a mixed crop in established coconut and arecanut plantation.

The Malabar tamarind prefers a warm humid tropical climate. It is seen in the coastal areas, evergreen forests and up to 1800 MSL in Nilgiris in India. Alluvial soils are the best for its cultivation (Sara *et al.*, 2000). Dry areas are not suitable for its cultivation (Mathew *et al*., 2008).

Mangosteeen is the fruit of humid tropics and comes well in the south India up to an altitude of 400 – 900 m. an areas receiving 180- 250 cm rainfall. Very high humid or arid conditions over along spell are not suitable for mangosteen. Such conditions lead to disorder gamboges. Deep well drained soil with high content of organic matter are suitable for its cultivation. It comes up well close to water bodies.

Plant propagation

Kokum, Malabar tamarind and mangosteen are traditionally propagated by sexual means however recently it is also propagated by the vegetative method like softwood grafting.

Sexual Propagation

Kokum fruit generally contains 4 – 8 seeds. For propagation seeds are collected from fully ripe fruits of early and high yielding kokum tree, having good quality. Seeds are extracted and spread on floor under shade. The seeds are allowed to soak in rains for germination. Pre sowing treatment of seed with wet packing or drying with coal ash is recommended for good germination. The seeds can be sown on raised bed or in polybag. Seed germination is not a hurdle in kokum. The seeds germinate without any treatment. 90 to 100 per cent seed germination is reported in kokum. However, the seed treatments such as soaking in water, cycocel 500 ppm have shown promise. After germination the seedlings are transplanted in polythene bags of 10 X 15 cm size containing potting mixture of soil and FYM in the ratio of 3:1. The initial growth of kokum seedling is very slow. For planting in the field, 12 – 14 month old seedlings are preferred. The experience of farmers suggests that bigger size seedlings suffer less mortality in the field. In Malabar tamarind, the fruits ripe in June – July, which is the monsoon season. The seeds are collected, washed and spread on a floor under a roof for 20 days and sown afterwards in bags or beds. The seeds remain dormant for about 8 to 9 months and takes 10 months for germination if sown with seed coat. Removal of seedcoat without injury to cotyledon helps for germination in 20 to 25 days. Mangosteen seeds are azygotic and produce tree resembling mother. Freshly extracted large seeds are planted in humus rich medium with good drainage. As seedlings attends two leaf stage, they should be transplanted in polybags.The initial seedling growth in all *Garcinia* species is slow.

Vegetative propagation

Kokum is a dioecious plant. Female plants are productive whereas male plants supply pollen grains for proper fruit set but do not produce fruits. Furthermore wide variability for economical characters is found in kokum. The probability of occurring male plants is 50 per cent in sexual propagation. Softwood grafting is presently used commercially for vegetative propagation of kokum.

Softwood grafting

The scionsticks should be selected from high yielding female trees having all desirable characters. The rootstock should be healthy and vigorous. Kokum seedlings of 10 – 12 cm height, 0.25 cm thickness at collar region with green apical softwood are selected. The scion shoots should be prepared like a wedge giving about 4 cm slanting cut from both the sides at the lower end. This wedge should be inserted in cleft of rootstock and the joint should be tied tightly with the help of polythene sheet of 250 gauge and 1.5 cm width. October to November and March to August was found to be the best season for softwood grafting in kokum under Konkan conditions. the vegetative propagation in kokum is significantly influenced by tropism. When orthotropic shoots are used for grafting the resulting graft take the typical architecture that of a mother tree. When plagiotropic shoot is used as a scion the resulting graft remain short and bushy. In Malabar tamarind June to October is the best period for graft success. Three to four month old scion of fifteen cm length and green colour is the best. Twelve month old seedlings are idle for rootstock (Sara *et al*., 2002).The trials conducted at Regional Fruit Research Station, Vengurla indicated promising success in softwood grafting of mangosteen

Planting

Kokum can be planted as a monocrop or as a mixed crop in coconut and arecanut plantation and can also be planted in a kitchen garden. Considering the growth habit and conical canopy of kokum Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli has recommended a spacing of 6 X 6 m for sole plantation of kokum. In an established coconut plantation planted at 7.5 to 8 m spacing, Kokum can be planted in the centre of 2 coconut palms. 300 kokum plants can be accommodated per hectare as a mixed crop in coconut plantation planting of kokum as mixed crop has proved to increase the coconut yield by 34 per cent. In an arecanut plantation planted at 2.7 X 2.7 m, kokum can be planted at the alternate centre of arecanut palm. When grafts are used for planting the spacing can be reduced to 5 m. While planting in kitchen garden, kokum should be planted at least 4 to 5 m away from other tall plants. A pit of 60 cm^3 is prepared before monsoon and filled with a mixture of top soil, 10 kg FYM and 1 kg Single Super Phosphate. Planting is done at the onset of monsoon. When grafts are planted, periodical removal of suckers below graft joint is essential. In Malabar tamarind a spacing of 7m for seedlings and 4m for grafts are recommended with a pit size of 75 cm ^{3} to 50 cm ^{3}(KAU, 2003). Like kokum it can be planted in back yards or intercropped in coconut or arecanut plantations. It comes up well under moderate shade.Mangosteen is planted at 8 to 10 m spacing depending upon soil fertility. It can develop normally when no shade is provided.

Irrigation and Manuring

Irrigation helps for better establishment of garcinia plant. Initially 15 L of water per week in winter and twice a week in summer is advised in Konkan region of Maharashtra. Mulching helps to retain soil moisture. The weed near plant should be removed and used for mulching.For Kokum in Konkan region of Maharashtra application of 2 kg FYM, 50 g N, 25 g P_2O_5 and 25 g K_2O is recommended for 1 year old kokum plant. This dose is increased in same proportion every year upto 10 years and there onwards 20 kg FYM, 500 g N, 250 g P_2O_5 and 250 g K_2O is recommended. The fertilizers are applied in the month of August after the heavy rains by ring method. Farmers in the Konkan region do not apply inorganic fertilizers to kokum. FYM or available organic manures are used. Most of the kokum plantation can said to be an organic. However, since the plantation is scattered and very small, the certification becomes difficult. In case of Malabar tamarind 10 kg FYM, 20 g N, 18 g P_2O_5 and 50 g K_2O is given in the first year and progressively increased every year and after 15 years a constant dose of 50 kg FYM, 500 g N, 250 g P_2O_5 and 1000 g K_2O is applied (KAU, 2003). For mangosteen, after 15 years 1.4 kg NPK with 60 kg FYM is applied.

Training and pruning

Kokum is an evergreen plant with attractive conical shaped canopy. When seedlings are planted, the central stem is allowed to grow without pinching to develop the canopy. The plant attains a height of about 10 m when it is fully grown. It is often experienced that as the height increases the lower portion of plant comes under shade and becomes less productive. Furthermore it is also noticed that the fruits at the top of tall tree remain small in size and becomes unmarketable. The harvesting from tall plants of kokum is an important constraint. Maintaining the height of kokum tree at about 4 – 5 m by decapitating the apex have preliminary shown promise at Dapoli.

When the grafts are planted it is observed that only one branch grow in certain direction. This growth should be prevented by regular pinching. Growth in all directions should be tried to induce on a graft. The suckers from rootstock below graft union should be removed regularly. Height restriction up to 4 m is recommended Malabar tamarind. In mangosteen, old diseased and damaged branches are removed. Severe pruning is avoided.

Plant protection

Major diseases and pests are not noticed in garcinia. Some times pink disease is noticed on branches. It is advised to remove the diseased portion of a branch and smearing of Bordeaux paste on the wound in kokum. Leaf blight and leaf spot due to fungi are reported (Sara *et al.,* 2000). Sooty mould, seedling blight and thread blight are also reported (KAU, 2003)

Flowering and yield

In kokum, the seedlings start flowering 7 to 8 years of planting whereas flowering in grafts is noticed after 3 to 4 years. Generally kokum plant flowers during December to January. Flowers are borne singly or as fascicular cymes on leaf axils and are tetramerous. Pollination is through wind. The fruits are harvested after about 120 days of fruit set. Kokum fruits are ready for harvesting from the month of April to May. Most of the fruits are harvested in the month of May and June which is the start of rainy season. Generally 6 – 8 pluckings are required in high yielding plants. Post flowering foliar spray of Potassium Nitrate and Monopotassium Phosphate helps to prepone harvesting by about 10 to 34 days. In a seedling population 30 – 50 kg yield per plant is obtained. In a well managed plantation 100 kg yield per plant is obtained. When kokum is planted as mixed crop in coconut plantation 15 kg yield per plant is obtained. The harvested fruits are exclusively used for processing. The Malabar tamarind seedlings normally flower by 7 or 8 th year or even 12 th year. The grafts yield fruits by third year and full bearing is reached by 12 to 15 yrs. The flowers are born in the axils of leaves or on tip of branches either solitary or in groups. Fruit is a berry, ovoid or spherical in shape with 7 to 13 grooves, yellow or red when ripe. After flowering, it takes three weeks for fruit set and fruit takes 12 – 135 to ripe (Parrota, 2000, Sara *et al*., 2002 and Mathew *et al*. 2008). The yield ranges from 50 to 600 kg (Muthulakshmi, *et al*., 2001) and yield stabilizes by 15 year (KAU, 2003).In mangosteen, well attended trees begin to fruit at 7th year. Usually a single crop is produced annually but at Nilgiri hills two crops are reported. The main season of harvest is August to October. The yield ranges from 500 to 1500 fruits per tree.

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Recent advances in cultivation of passion fruit in India

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Passionfruit (*Passiflora edulis* Sims.) belonging to the family Passifloraceae is native to Brazil and grown mostly in tropical and sub-tropical parts of the world. In India, it was introduced during early twentieth century to the Nilgiris, Kodagu and Malabar regions of Kerala. Passion fruit is a perennial, vigorous, climbing, woody vine that produces round or ovoid fruits, which have a tough, smooth, waxy dark purple or yellow coloured rind with faint, fine, white specks. Fruit contains orange coloured pulpy juice with numerous small, hard, dark brown to black pitted seeds. It possesses unique flavour and aroma with a good proportion of reducing and non-reducing sugars and acids and has high nutritional and medicinal properties. Fruits are rich in Vitamin A (1300-2500 IU/100 g pulp), Vitamin C (30 –50 mg/100 g pulp) and minerals such as sodium, magnesium, sulphur and chlorides. It finds use as a mild diuretic against urinary infections, digestive stimulant, heart tonic and for treating asthma, whooping cough, bronchitis, coughs, gastric cancer etc. The fruit generally is not used for table purpose, but processed in to juice and concentrate. The juice is delicious and is used for blending with other fruit juices.

Passion fruit is a popular crop of South America, with Brazil and Ecuador as the largest producing countries. In India, its cultivation is limited to a few districts of Karnataka, Kerala and Tamil Nadu, but has spread since last decade to some parts of north India, especially North East states, where its cultivation is rapidly intensifying in Mizoram, Nagaland, Manipur and Sikkim. In South India, passion fruit is cultivated in Munnar and Wayanad regions of Kerala, the Nilgiris and Kodaikanal area in Tamil Nadu and in Kodagu, Sakleshpur and Chickmagalur region of Karnataka. The estimated area and production of passion fruit in India is 18,020 ha and 1,00,510 tonnes respectively, of which 70 per cent is contributed by Manipur and Nagaland. The average productivity of passion fruit in India is around 5.57 tonnes/ha, much lower than countries like Brazil, Australia, Columbia etc where it is 30-35 tonnes/ha.

Soil and climatic requirements

Passion fruit prefers tropical and sub-tropical climate with moderate annual rainfall ranging from 100 to 250 cm. Yellow passion fruit grows under low land tropical conditions, whilst the purple type prefers subtropical areas or higher altitudes of 800 -1500m above sea level in the tropics. In purple passion fruit, cool temperatures (18-23^{O}C) are favourable for flower initiation and fruit set, while relatively high temperatures seem necessary for promoting juice production and fruit quality. Very low temperature affects fruiting and causes cold injury to the aerial parts.

Passion fruit is shallow rooted and grown on many soil types, but light to heavy sandy loams with a pH of 6.5 to 7.5, rich in organic matter and low in salts are most suitable. If the soil is too acid, lime must be applied. Good drainage is essential to minimize the incidence of collar rot. Water logging and poorly drained soils should be avoided.

Varieties

Two distinct forms of Passion fruit, the yellow (*Passiflora edulis f. flavicarpa* Deg.) and the purple (*Passiflora edulis* Sims), differing in acidity and sugar content are of commercial importance. The yellow are more acidic while the purple are less acidic and has relatively higher sugar content. The vines of purple passion fruit are moderately vigorous and more productive at higher elevation. Generally fruits are smaller than yellow passion fruit, about 4 to 5 cm in diameter and deep purple in colour when ripe. The average fruit weight ranges between 37-50 g. The juice content of the fruit varies from 35-38% and has a better flavour and aroma as fresh, canned and frozen juice or pulp than the yellow. The seeds are black in colour. The Commercial cultivars of the purple type are Ouropretano, Muico, Peroba, Pintado etc. in South America. In India there is no standard cultivar and local line such as Purple is cultivated by the growers. The yellow type is more vigorous in nature and is suitable for plane regions with lower elevation and is less productive at higher elevation due to its sensitivity to low temperature. The fruit is generally larger (weighs about 60 g.) than the purple variety, round in shape with yellow mottled spots and turns to golden yellow when ripe. Juice is more acidic and its recovery is comparatively less than the purple variety. Seeds are brown. This form is inferior to the purple one with regard to juice content (25-30%) and flavor but has got bright golden yellow juice. The Commercial cultivars of the yellow are Mirim or Redondo and Guassu or Grande in South America and Golden Star in USA. There is no standard cultivar In India, but local yellow lines are cultivated. Several hybrids of purple and yellow form have also been developed for cultivation in Brazil, Australia, South Africa, etc. In India, one such hybrid named 'Kaveri' was developed in 1986 at Central Horticultural Experiment Station, Chettalli, which is very popular among the farmers. It is tolerant to *Alternaria* leaf spot, *Fusarium* collar rot and nematodes, yielding 40-60 fruits per plant per annum. Fruits are ovoid to round and purple dotted with 25-30% juice having 11.5-12% sugars and 3.0-3.5 mg citric acid / 100 ml.

Propagation

Passion fruit can be propagated through seed, stem cutting, grafting as well as serpentine-layering. Seedlings and grafted plants are more vigorous than the plants raised by cuttings while vines raised from cutting or grafting start fruiting much earlier (7-6 months) than those from seeds (10-12 months). Seed propagation is not preferred for commercial multiplication due to genetic variation in the progeny, but may be employed for raising rootstocks. For seed propagation, fruits are collected from vines known for their performance in term of yield and quality. The pulp is fermented for 72 hours by heaping up the harvested fruits and seeds are extracted and dried in shade. Sowing is done preferably during March - April or October, depending on seed availability, in well-prepared seedbed, pot or polybags. The seeds start sprouting in about 12-15 days after sowing and germination is completed in about a month. In some cases germination extends even up to 50-60 days. When the seedlings attain four to six leaves in pots or beds, they are transplanted to 10 cm x 22 cm polythene bags filled with a mixture of soil, compost and sand in 2:1:1 proportion. The seedlings or grafts are ready for transplanting in the field or grafting in about three months. Grafting is mainly employed to multiply hybrid varieties on disease resistant rootstocks. The yellow passion fruit is found to be a good rootstock for hybrids. Scion from healthy young vines is preferred to that from mature plants. Generally both stock and scion should be of pencil thickness. Cleft graft, whip graft or side wedge graft methods can be used.

Stem cuttings is the most popular method of multiplication though passion fruit is not an easy to root plant. Rooting is satisfactory under favourable conditions with 30-35 cm long cutting having 3 to 4 nodes from mature portion of the vines. Rooting may be hastened by treatment of cuttings with NAA at 200 ppm for very short period of 3-5 second or at 80 ppm for 12 hours. It should be raised in a suitable media such as mixture of sand, soil and farmyard manure in equal parts. Rooting takes place within a month and can be transplanted to the field in about three months. For serpentine layering, the lateral shoots emerging from the main branches are given partial slanting cut below the nodes and allowed to root in rooting medium consisting of soil, sand and compost (1:2:1) with regular irrigation in February. The roots emerge profusely within 45 days and the young plants should be separated during April-May. The method gives 90-95% success after 75 days of layering.

Spacing and planting

Spacing of 3 m between rows and 2m between plants is suitable. The land should be well prepared by deep ploughing, levelling and incorporation of manures. Pits of 45 x 45 x 45 cm size are dug and filled with a mixture containing three parts of top soil and one part of compost. Planting is done preferably on cloudy days during June-July after the onset of monsoon so that the plants are well established by the end of the monsoon.

Training and pruning

Passion fruit is a woody vine needing support for good growth and fruiting. For commercial cultivation, the vines are trained on a frame of wires and poles, 1.5 to 2 meter above the soil surface. Among the different types of trellising, Kniffin (four arm) system is the most economical wherein 2½m long poles are erected 6m apart and a wire is fixed on the top. The wires should always run across the slope or in the North-South direction for maximum and even exposure of vines to sunlight. In order to withstand the weight of the vines and to support a heavy crop, it is necessary to use eight or ten gauge wire, turning buckles and also strong stone pillars or cement or wooden poles. Weak and faulty construction of trellis may result in sagging and loss of vines. If wooden pole is used it has to be treated with tar up to the portion that is buried in the soil to prevent deterioration and termite attack.

The vines are supported with hardwood stake or gunny twine, which may be stretched vertically from the bottom of the plant to the top of the wire. Plants start growing very fast just after establishment and several branches arise from the base of the plants. All the shoots leaving only two vigorous shoots are removed as and when they appear. The main shoots are bound on stake or twine and all the lateral growth in these shoots are removed till they reach the wire. Once the main vines reach the wire, the tips are pinched so as to encourage leader formation. Two leaders are directed on either side of the wire, and are tied with loops around the wire until the leader of the adjoining plants meet, when the tips of the leaders are cut. This forces the leaders to produce laterals that are trained downwards hanging from the wire and all the tendrils obstructing downward growth of the laterals are to be removed as and when they arise. The laterals which are touching the ground should be pruned and the laterals coming in contact with the soils should be discouraged.

Passion fruit vines bear fruits only on current season's growth. Systematic pruning of vine encourages new growth resulting in regular and higher fruit yield. The lateral branches are initially allowed to grow and fruit. Once the laterals have produced the fruits, they are cut back to 4-6 buds to induce regular bearing. Pruning is generally done twice a year, first in March-April and again in October-November depending on the harvest. Pruning is confined to the cutting back of those laterals that have fruited. In the case of old laterals, cutting back is limited to the nearest active bud as otherwise with increasing age of the lateral, the basal buds become dormant or sterile. Indiscriminate and drastic pruning of inactive or dormant vine may lead to a setback in growth and reduction in yield and longevity of the vines.

Nutrition and Integrated Nutrient Management

The nutrient removal pattern by whole plant (including fruits) revealed that from an hectare land area accommodating 1666 plants and averaging 37 tons fruit yield, the different nutrients removed were 202.5 kg N, 17.4 kg P, 184.2 kg K, 151.6 kg Ca, 14.4 kg Mg, 25 kg S, 770.4 g Fe, 2810.2 g Mn, 198.7 g Cu, 316.9 g Zn and 295.8 g B. This indicates the nutritional requirements of passion fruit for optimum fruit yield and longevity of vines, but optimum dose of fertilizer may vary according to the fertility status of the soil. The fertilizer recommended for south Indian states is more than that for North-eastern states. A dose of 110 g N, 60 g P_2O_5 and 100 g K_2O per vine per annum is recommended for the established orchards in South India, while 80 g N, 40 g P_2O_5 and 50 g K_2O per vine per annum is recommended for the 4 year old orchards of North Eastern States. Fertilizers should be evenly spread in a circle of 45-50 cm radius around the stem when there is sufficient moisture in soil. Nitrogen should be applied in 3 split dozes in February-March, July-August and October-November along with farmyard manure, while potash should be given in the two split doses. Additionally, 2-3 sprays of 0.5% Urea can be given during summer months. The foliar application of micronutrients is also recommended if any deficiency symptoms are noticed.

Irrigation

Prolonged dry spell during January-March may reduce main summer crop and may also adversely affect the development of flowering laterals. Flowering and fruiting stages are considered to be critical for irrigation. If there is no rainfall during the dry months, supplementary irrigation may be given at fortnightly intervals. Drip irrigation is very useful. On an average, passion fruit requires irrigation of 12-15 litre/vine/day in summer and 6-8 litre/vine/day in winter. Passion fruit vine responds significantly to fertigation also, especially to K fertigation for commercial fruit production.

Inter-cultivation

Passion fruit being shallow rooted with most of the feeder roots within 15 cm depth of the soil surface, require light digging. Deep digging is avoided and weed growth is checked by surface weeding or by scraping and scuffling. Mulching with dried leaves or grass is done to conserve moisture during summer months. Cultivation of intercrops in passion fruit is to be discouraged.

Integrated Pest and Disease Management

A) Diseases

Collarrot (Haematonectriahaematococca (anamorph:Fusarium solani)):

Symptoms

First above ground symptom is the mild die back of the plant followed by changing of leaf colour to pale green. Wilting, defoliation and finally plant death occurs resulting from the complete necrotic girdling of the plant collar. Necrosis generally reaches 2 to 10 cm above ground and may migrate to roots. Tumescence and fissures in the affected collar bark show purple lesion borders, where reddish structures appear under high relative humidity. The disease generally affects plants one to two years after planting, although it may occur earlier in replanting areas where the pathogen has previously appeared.

Disease management

Cultural: Areas previously infected with the disease should be avoided for new plantings and nurseries. Badly drained soils have to be avoided and careful irrigation has to be conducted in order to avoid excess water, water stress as well as injuries to plant collar and roots.

Chemical: Biweekly drenching of copper oxychloride reduces the number of plants developing collar disease. Under favorable conditions use of fungicides is ineffective. The use of a resistant root stock is an effective way to deal with the problem in the contaminated areas.

Fusariumwilt (*Fusariumoxyporumf*.sp.*Passiflorae* Nelson) :

Symptoms:

The glossy green leaves of young passion fruit plants show a pale green colour and mild die back. Drop of lower leaves, general plant wilting and sudden death take place as the disease progresses. In adult plants, the disease causes yellowing of young leaves, followed by plant wilt and death. Symptom development may be unilateral or encompasses the entire plant. The vascular system becomes darkened at the root, collar, stem and twig areas. The disease typically affects the xylem vascular system, leading to the impermeability of vascular walls and preventing the translocation of water to other plant parts.

Under high relative humidity conditions, lesions and fissures can be found in the plant collar and stems.

Disease management

Cultural: Planting areas previously affected may be avoided. Use of healthy seedlings and careful control of weeds to avoid root injury can check the spread of disease.

Chemical: Carbendazim +Ridomil MZ as well as *Trichoderma harzianum* and *T.asperellum* can be integrated in the management of Fusarium wilt. Another control measure that can be implemented is usage of resistant root stocks or resistant hybrids from crosses between purple and yellow passion fruits. However,no considerable progress has been made in this aspect in our country.

Phytophthora rootandCrown rot (*Phytophthora cinnamomi,* Simmonds *P.nicotianae*):

Symptoms

Phytophthora root and crown rot disease affects both adult as well as nursery plants. Mild cholorosis is followed by wilting, defoliation and death. Cortical tissues of the plants are exposed.

Plant intumescences and bark fissures are found in the collar. Injured leaf shows a burned appearance. Occurrence of foliar blight followed by drop of flowers is observed. There is a change in leaf color from colourless to pale green, with leaves reaching a light copper colour. The affected plant shows burned –like black twig tips and flowers which eventually die. Large grayish- green aqueous spots can be viewed in fruits, which easily fall down.

Management

Cultural

Chlamydospores and zoospores are resistant spores capable of surviving in soil and plant tissues for several months. Under favorable environmental conditions and in the presence of a host, chlamydospores and oospores can germinate and produce a great number of zoospores. Cardinal temperature for growth is 37° C. Avoid water logging for effective control of the disease by providing suitable and good drainage.

Chemical: The elimination of diseased tissues during the initial stages of the disease and use of Bordeaux mixture can check the spread of disease.

Integrated strategies

Applications of fungicides effective against oomycetous organisms directly applied on the plant collar soon after the beginning of the rainy season may control the disease. Pulverizations with copper oxychloride at an interval of every seven to ten days can control foliar blight.

Anthracnose (*C. gloeopsporiodes* syn. *Glomerella cingulata*)

Symptoms

Spots, initially 2–3 mm in diameter and oily in appearance, are produced on the leaf. They become dark brown, round or irregularly shaped and 1 cm in diameter. The centers of spots become brittle and may break apart. Lesions also develop on petioles. As foliar lesions coalesce, large areas of the leaf die, resulting, eventually, in abscission. Dark brown spots, 4 – 6 mm in diameter, are produced on the branches and tendrils, eventually turning into cankers. Severe lesions can cause the death of shoots and a partial blighting of the plant.

Affected flowers abort, and immature fruit abscise. Lesions on fruit initially are superficial and light brown, and later become sunken and grayish to dark brown. They may be larger than 1 cm in diameter and may reach interior portions of the fruit. As fruit mature, the spots enlarge and become oily or light tan.

The fruit skin becomes papery and acervuli are formed on lesions here and on leaves. Under high humidity, masses of red and orange spores form in acervuli. Dieback, characterized by reduced elongation of shoots, shortened internodes and an eventual wilting and death of these structures are the symptoms normally associated with anthracnose.

Management

Cultural: Use of disease free seedlings, pruning to eliminate affected areas, improved aeration and light conditions in the canopy help control of the disease. Fruit should not be harvested during wet conditions, unduly exposed to sun light or kept for long in the absence of refrigeration. Pruning should be done when plants are dry and should be followed with applications of fungicides.

Chemical: Fungicides mentioned as efficient against anthracnose are benzimidazole, cupricdithio carbamate, chlorothalonil and tebuconazole. The fungicides prochloraz and imazalil show the best results for the control of post harvest rots.

Integrated strategies

Trichoderma spp can control the disease in field or post harvest conditions. Thermal treatment of *Passiflora edulis* fruits at 42.5 – 45 ^{o}C for eight minutes significantly reduces the disease incidence in fruits.

Septoriablotch(spot) (*Septoria passiflorae, Septoriafructigena*) :

Symptoms

Leaves are the most affected organs, showing light brown slightly round necrotic spots normally encircled by a chlorotic halo. A single lesion per leaf is sufficient to cause abscission, and even leaves without visible symptoms may fall prematurely. When the disease reaches 15-20% of leaves in the same plant, partial or even complete leaf abscission is observed. In young twigs, lesions may promote girdling leading to wilt and twig tips death.

Lesions on flowers are similar to those on leaves. The primary infection in the calyx may reach the stalk, causing the early drop of flowers. The infection may occur at any stage of the development of the fruits, affecting maturation or development. Leaf and fruit abscission, twig wilt and plant death may occur under disease favoring conditions.

Disease management

Cultural

Control measures used for the above ground diseases such as the use of carbamate and benzimidazole fungicides are generally enough to avoid damages caused by septoriosis in nurseries and field plants.

Chemical: Thiabendazole or thiophanate-methyl + chlorothalonil applied at 15 days interval is effective against this disease. Benomyl in a mixture or alternated with fungicides of different modes of action can be effective.

Scab (*Cladosporium oxysporum, C.herbarum, Cladosporium spp*.)

Symptoms

Plants infected with the Cladosporium show small round spots on the leaves. Spots are initially translucent, later become necrotic showing greenish-grey centers which correspond to fungal fructification.

Lesions can perforate leaves, occur on veins and cause them to be deformed leading to abscission. Similar spots may appear on bud sepals or open flowers. High numbers of lesions on flower buds or on peduncles can greatly reduce the number of flower buds.

Twigs and twig tips initially show lesions similar to the ones on leaves, which later turn into cankers of elongated and sunken aspect that become greenish – grey, where the pathogen fructification takes place. As scar tissue forms, branches become weakened and break in the wind.

On small fruits, symptoms are slightly sunken with small dark circular spots. On bigger fruits lesions on fruit skin grow and become corklike, prominent and brownish. Lesions do not reach the inner fruit and consequently do not affect juice quality. Several lesions may form on the same fruit causing it to be deformed and stunted.

The disease mainly affects young tissues of leaves, branches, tendrils, flower buds and fruits, when not controlled cause significant damages. In field conditions it causes death of the twigs,

Management

Cultural: High densities of seedlings and excessive irrigation are to be avoided in nurseries. Fungicide applications have to be periodically carried out. Adult plants should be provided with adequate ventilation. Pruning and cleaning of plants should be followed by incineration of infected tissues.

Chemical: Fungicide applications have to be carried out especially during periods of intense growth and flowering. Effective fungicides are tebuconazole, strobilurin, copper oxychloride, mancozeb, captan and chlorotalonil + copper oxychloride.

Virus Diseases

Commonly Cucumber woodiness virus, leaf mottle, mosaic and vein clearing disease are found. These diseases can be effectively managed by using disease free planting material and strict quarantine measures along with efficient plant protection measures.

B)InsectPests

1. **Fruitfly (Bactroceraspp.):** The insect punctures the tender fruits that turn woody around the punctured area and in several cases, they are deformed and the pulp is reduced.This can be controlled by as pray of malathion (0.05%) or Delta methrin 1ml/ litre. Since fruiting and flowering occurs often simultaneously, praying may bed one only in the afternoon to minimise the harm to insects pollinating the flowers. Fruit fly traps can be erected as mentioned under custard apple.
2. **Thrips (Selenothripssp.):** This feeds on buds and developing fruits.Affected fruits are deformed and fruit weight and juice contents are reduced.in the main summer crop only and it can be effectively controlled by spraying malathion (0.05%).
3. **Mites (Tetranychussp.):** Mitesfeedon sap of leaf and tender fruits.Defoliation and undersized fruits are formed and can be controlled by a spray of dicofol (0.05%)

Harvesting and yield

Passion fruit flowers and fruits throughout the year under favourable conditions, yet there are two main periods of fruiting: the first harvest extends from August to December and the second one from March to May. The first fruits are obtained from the ninth month and full bearing is reached in 16-18 months. About 80-85 days are required from fruit set to the harvest of fruit. The fruit when ripe falls down from the vine. Generally such fallen fruits are collected at regular intervals and sent for processing after thorough washing. Harvesting is done along with the stalk when fruit turns slight colour change. On an average, yield of 15-20 tonnes per hectare per year can be obtained. However, in well maintained irrigated orchards, yields upto 40t/ha can be expected. The vines are perennial and can produce yield for 5 to 10 years but maximum production can be obtained up to 3-4 years after which the yield declines. Fruits harvested should be disposed off quickly to prevent the loss in weight and appearance. About 10-20% loss in weight results from storage, and fruits wrinkle and give a bad appearance. To avoid this they can be stored in polythene bags and for transport to distant markets polythene-lined crates may be used.

Strategies for improvement of Passionfruit cultivation in India

Although passionfruit cultivation has great potential in view of its greater adaptability under tropical humid and sub tropical regions, it has failed to emerge as a major commercial fruit among the farmers. The following points have been suggested for expansion of passionfruit cultivation in our country.

1. Creating awareness among the farmers about the potential of passionfruit both in the domestic and export markets.
2. Introduction of superior hybrids / varieties from countries like Ecuador, Columbia Brazil and Australia
3. Increasing the availability of quality planting material in large quantity through vegetative and micro propagation
4. Initiating research on rootstocks for resistance to *Fusarium* wilt complex
5. Research on cost effective training system for maximizing yield
6. Creating small scale processing units and organized marketing system
7. Providing institutional support and incentives for passionfruit cultivation

Improved cultivation techniques in Avocado

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Avocado (*Persea Americana* Mill) is an important minor fruit crops grown in many parts of the world including India and belongs to the family Lauraceae. It is the highest and richest source of fat 26. 4g. containing fruit under cultivation. The pulp has a buttery consistency, looks very much like cow's butter and blend in taste with a nutty flavour. It is also known as Butter fruit because of high fat content. A taste for this fruit could be developed by adding country sugar to the pulp before consuming it. The pulp is used as and winch filling or spread, and in ice-creams and milk shakes. The pulp may be used as a substitute for vegetable oil in wheat flour for making chapatti. As the sugar content is low it could be recommended as a high energy food for diabetics. Avocado oil, similar in composition to olive oil, is widely used for the preparation of cosmetics. Avocado juices also provide coolerant in body, rectifying eye problems and stones.

Avocado is a native of Central America from where it reached different parts of the world during the sixteenth century. In India, it might have been introduce of India about 50 to 75 years ago from Ceylon. The crop is widely cultivated in Karnataka (Coorg), Kerala, Tamil Nadu, Assam, and Himachal Pradesh. In lower pulleys' of Kodaikanal (Tamil Nadu), over 10 lakhs trees are under in cultivation as shade crop, and as a fence crop.

Climate

Avocado thrives best in tropical and sub-tropical conditions. The average temperature required for a good crop is ranged from 18 to 33^{0}c and the precipitation is between 700 and 1500 mm. time to flowering was accelerated but number of flowers was reduced if the day length was shortened from 15 to 9 hours per day. Avocado can thrive and produce well in climatic conditions ranging from true tropical to warmer parts of the temperate zone.

In avocado, though the following three ecological races have been recognized, it is the natural inter-racial hybrids of these races that are of horticultural and commercial importance now.

1. Mexican race. The fruits are small weighing less than 250 gm and ripening 6 to 8 months after flowering of bud is thin with smooth surface large seed fitting loosely in the central cavity and its oil content is up to 30 per cent, the highest of all the three races. It is the most resistant race for cold temperature.
2. Guatemalan race. This is native of the highlands of Central America. Fruits are fairly large, weighing up to 600 gm and borne on long stalks. The fruits ripen 9 to 12 months after flowering. Their skin is thick and brittle and often warty. The seeds, held tightly in the cavity of the fruit are small. The oil content is around 15 per cent.

3. West Indian race: This group with medium size fruit is native to the lowlands of Central America. Their skin is smooth but leathery and glossy. Fruits are borne on long stalks and require up to 9 months for ripening from the date of flowering. The seeds are large, fitting loosely in the cavity. The oil content of the fruit is low, ranging from 3 to 10 per cent. This race is the least resistant to cold temperature.

Varieties

There are four traditional varieties of avocado which are widely grown in India. They are

1. Fuerte: This is the most popular variety of avocado. Fruits are pyriform, weighing between 225 and 450gm, with 18 to 26 per cent fat. It is fairly suited to subtropical conditions.
2. Lula: fruits are pyriform with an average weight of around 400 to 700 gm. The fat content is around 15 per cent. This variety is suited for tropical climate.
3. Hass: fruits are medium sized, roundish and turn purple on ripening. This variety is suited for sub-tropical conditions.
4. Pollock: Fruits are large sized that weight up to 1 kg or more but the fat content is less, ranged from 3 to 5 per cent. It is suited to tropical conditions.

From Horticultural Research Station, Thadiyankudisai, Tamil Nadu Agricultural University is released first Asian variety as TKD-1during 1997. The features of this variety are a selection from germplasm pool. The fruits are dark green colored, round shaped and medium sized. Trees are semi spreading, suitable for high density planting. Fruits mature earlier in the harvesting season. The tree yields 264 kg of fruits per tree per year (26.4t/ha). This is recommended for Lower Pulneys, Shevroys and other hills of Tamil Nadu under irrigated and rainfed conditions. There is seedless type also found in Lower Pulneys area with small size fruits weighing about 90-100g and over 10,000 numbers in a tree. Apart, yellow colour fruits, dark red colour fruit trees also available.

Propagation

Avocado trees are propagated mainly through seeds. The viability period of avocado seed is 2 to 3 weeks, which could be improved by storing the seeds in dry peat or sand at $5^{0}C$. The seed could be split lengthwise with embryo into to two or four or even more parts of multiplication. Avocado seedlings would also behave like asexually propagated since it is highly poly embryonic fruit crop. It is also commercially propagated by stone grafting and inarching methods of asexual means.

Planting

The tree is having cross pollination nature of diurnally synchronized dichogamy. For betterment of fruit set, fruit retention; go for planting of multiple varieties instead of single variety.Planting can be done found the year. However, to obtain better per cent survival, planting should be undertaken during the months of July to November.The normal distance for avocado is 8 to 10 M depending on vigour of the variety, soil types, and slope of the land, growth habits and method of cultivation. The transplants are planted with a ball of earth around the roots for good establishment and survival.

Irrigation

Immediately after planting irrigation has to be done. After third day of planting life irrigation should be given for keeping roots to more alive and thereby better establishment. The frequency of irrigation depends upon weather conditions and soil types. Usually during summer months the crop should be irrigated at 10 days intervals and provide organic mulches. Staking should be provided during first year.

Weeding and Inter-cropping

The weeds may be controlled by resorting to hand weeding around the basin and spreading the mulch with dried leaves. Inter-cropping with legumes or shallow rooted annual crops may be done in young orchards for conservation of soil moisture and limit the run off during the heavy precipitation period. Avocado can be grown as shade crop in coffee plantation along with other hill crops *viz.,* mandarin, hill banana etc.

Nutrition

Avocado being a voracious feeder requires heavy manuring of the major nutrients. Nitrogen application was found to be most essential for quick growth of the crop. In general, young avocado seedlings should get N, P_2O_2 and K_2O in the proportion of 1:1:1 and older trees in the proportion of 2:1:2

Crop protection

Pest: In general,fruit fly affected the crop as serious pest. By keeping trap, this could be reduced. However, in nursery the sacking pests cause damage to leaves. It can be effectively controlled by spraying of systemic insecticides like dimethoate at the rate of 1 ml per litre of water.

Diseases

Avocado fruits are found to be seriously infested with a fruit spot disease caused by *Colletotrichumgloeosporiodes*. The infection of the disease results in shedding of young fruits. The remaining unshed fruits do not attain normal size and become deformed. Fruit rot can be controlled by spraying mancozeb 0.2 per cent thrice starting from flowering at 15 days interval.

The most serious disease of avocado is root-rot caused by *Phytopthoracinnamomi*. It can be controlled by drenching of phytolan (Cropper oxy chloride) or carbendazim in the soil before planting.Die back also severe in poorly managed orchards. For which, trees should be properly managed with regular nutrition.

Harvesting and yield

The In world, avocado in India alone to flowers twice and yielding twice.The flowering seasons are April to June and followed by fruiting and second season from October to February.During flowering period, the tree look like flower mass and produce lakhs of flowers in a tree and from that 0.01 to 0.10% fruit set. Flowering to harvest will take 90-120 days. Fruits are classified into Climacteric type of ripening. Fruits are not ripening in the tree itself. The ripening will start after harvest and this is the advantage for prolonging keeping period in the tree and market need based fruits can be harvested. Mature fruits can be stored on the tree for several months. The fruits remain hard as long as they stay on the tree. The maturity index of Avocado fruits is that the seed within the fruit changes from yellowish white is about 100-500 fruits per tree. However, good maintenance of orchards has been found to give a yield of 6,000 to 12,000 fruits per acre per annum. Currently the farm price of avocado fruit is about Rs.80/kg.

Production technology of annona species

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In India, Annona fruits somehow closely linked to the great Epic- Ramayana and different species are ascribed to legends involved in it. Though originated in South American continent, *Annona* species are closed to Indian's heart. One of the distinct features of this genus is that more than one speciesyield edible fruits, unlike other fruits genera. A. squamosal: sweet sop/Sugar Apple, popularly called *Sitaphal*inIndia.,*A. reticulata*: Custard apple, locally described as *Ramphal,A. atemoya*: LakshmanPhal, *A. muricata* : Sour Sop, revered as *Hanuman Phal*and*A. cherimola*, though not popular in India, yields edible fruits of high market value. Each species has its own merits and scope for improvement, the common problem encountered could be yield/unit area, edible quality, highly perishable nature of the fruit and seediness. Hence, there are no serous production constraints rather quality enhancement, distant marketability and shelf life.

Just like any other fruit crop where yield/unit area is the prime object of improvement,*Annona* is not an exception. Conventional means to achieve this is by hybridization and evolving newgenotypes. In the process, as the scope for source of variability within a species is very narrow, inter specific hybridization is the only way out. Interestingly, this model results in mitigation but, further inherits problems will crop up. *A. atemoya*, a natural hybrid between *A. cherimoya* x *A. squamosa* though subsequently increased fruit weight,pulp quality and fewer seeds/fruit brought in undesirable traitslike crooked fruit shape and highly shy bearing nature into this hybrid. Highly perishable nature continued in the process. Improving fruit set by natural way of pollination has no scope. Being a genera in Magnoliales, in the primitive level of plant kingdom, species are still in the process of evolution and A. squamosal is most evolved species among the edible ones.This is apparently expressed by lack of petal colour, scant scent,lack ofnectar and anemophily nature of pollination. Adaptation to arid climate made the genus to have thick cytoplasm, deciduous nature of growth habit, emergence of new vegetative growth and flowering. Dichogamy isthe mode adopted to avoid selfing and very few insects like Nitidulidae beetles visit flowers only to forage on pollen after desiccation.

Another hurdle in fruit set is the pollen release after dehiscence. Pollen grains remain intact in pollen mother sac even after tetrad formation and they dangle in air. Most of the pollen did not reach receptive stigma due to distinct protogyny. All these factors culminate in un productivity and shy bearing nature in interspecific hybrids. In an ideotype variety/hybrid is developed fulfilling all the prerequisites like fewer seeds/fruit, higher edible portion with maximum number of flakes with out seed, longer shelf life etc., assisted pollination becomes inevitable. This is in fact essential as *Annona* is aggregate fruit requiring large amount of pollen to maintain required fruit shape that make it fit for marketing.

The method of assisted pollination is also simple and does not require emasculation. The ploidy level is same among most of the species except in *A. glabra* a tetraploid, and this specieshowever, yield no edible fruits. There are no functional barriers in the stigma and stylar canal to hinder pollen tube growth, if it is viable. From the studies it is found that the male parent has pseudo xeniceffect that reflects in the odd fruit shape. So it is apparent that selection of pollen parent very specific and important. In *Annona* spp. Assisted pollination procedure was standardized. Anthesis takes place between 6-9 am. Collect the pollen into a small paper /plasticcup and smearing the pollen with a small (zero size) brush on dipping bristles. While doing so one or two petals may be removed or need not be if they gape open, exposing receptive stigma. Hard strokes of brush should be avoided that could smash delicate stigma.

New shootsstarts emerge with the onset of spring season. Vegetative and flower flushes go concurrently and there will be two to three floral flushes. Most of the flowers emerge in the first flush wither off. The second flush normally coincide with the onset of monsoon tend to set and retains till maturity. Most of the third flush flowers though initially set, tend to be mummified.To mitigate the problem of assisted pollination component of pruning is one way out. This agro technique gives relief from non synchronization of flowering between female and pollen parents. Another cultural practice is to create a humid micro climate in the orchard by providing micro sprinklers or surface irrigation from flowering to fruit set stage. But this is a costly affair and defeats the concept of arid horticultural practices. An estimated 15 man days are necessary to effect assisted pollination in an extent of one acre. In areas where there is non synchronization of flowering, pruning fruiting cane at appropriate length and time are to be standardized.

Tree vigor control: Root stock found to have profound effect on the scion of inter specific hybrids like ArkaSahan. Experimental results on these aspect showed increased canopy vigorfor ArkaSahan(*A. atemoya* x *A. squamosa*) grafted on *A. reticulate*and the scion on *A.squamosa*root stock found to be dwarf. However, uniformity of root stock raised through seed is a debatable issue. Regular spacing of 5 x 5m is necessary for scions on *A. reticulata*where as close spacing of 3.5 x 3.5m may be adapted in *A. squamosa* root stock.

Nutrient management: Expected yield levels in inter specific hybrids is about 17-18t/ha which demands additional inputs unlike traditional /local varieties.

Applying manures and fertilizers to custard apple is not common but the plants respond very well to fertilizers by increasing vigour,yield and fruit quality.General recommendation for major nutrients and organic manures are given below:

Nutrient	**Plant age (years)**			**Deficiency symptoms**
	1-2	**3-5**	**>5**	
N (g)	75	150	250	Restricted growth and pale-yellowish leaves
P(g)	50	100	125	Reduced growth, necrotic bands at leaf tip & margins
K(g)	50	100	125	Marginal scorching of leaves
Organic manure as FYM (kg)	25	25-50	50	
Green manures	Grow green gram and sun hemp in corporate at flowering			

Fertilizers application should coincide with emergence of new growth after the dormancy. Along with new vegetative growth, flowering also appear on old as well as new shoots. Hence it is advisable to apply nutrients in the peak vegetative growth. Training of plants should also facilitate working space below the canopy by clearing the stem up to a height of 1-1.5 feet above the ground level. Supplementary irrigation should be provided during the flowering period to facilitate good fruit set.

Arka Sahan cultivation involves additional costs of cultivation, like fruit fly traps as the hybrid is highly susceptible to fruit fly owing to very sweet pulp. Fruit fly traps @ 6-8/acre could reduce the infestation. Spraying 1.5ml of Rogor (Dimethoate) and Jaggary 5g/l twice when the fruits attain maximum size, but before fully mature.

Physiological disorders

Annona trees are deciduous in nature. Once the fruiting is over in winter season, leaves start turn yellowing and wither off. With the onset of spring, new vegetative grqoth starts along with flowering. If there is acute drought, most of the first flush flowers turns to black and become very without further growth. Such fruits are referred as stone fruits or mummified fruits.Thismummificationoffruitsappearstobeanatural thinning mechanism,especiallyduringperiodsofdrought.Anthracnose is a common disease in custard apple which requires one or two sprays of fungicides like Topsin M (Thiophanate Methyl).

Integrated nutrient and water management of litchi in Southern climatic conditions of India

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Litchi (*Litchi chinensis* Sonn) is an important subtropical fruit crop of the region after the mango. It is known as queen of the fruit due to its attractive deep pink/ red colours and fragrant aril. It has high nutritive value and suitable for geotropic weak person. It originated in the area, near Southern province of China and Northern Vietnam. It was introduced into India during the 18th century in the North East region (Tripura) from where it came to eastern states and percolated in the northern states. It is now one of the important commercial fruit crop in India due to its domestic demand and export potentiality. Cultivation of litchi is widely spread in eastern states of India which provides livelihood opportunities to millions of people in the region. In India about 83340 ha area are under this crop and more than 20 cultivars are cultivated among them Shahi, China, Bedana, Rose Scented, Bombai, Purbi, Saharanpur, Muzaffarpur, Kasba are commercial cultivars. Bihar is the premier state in litchi production and marketing. Litchi is being cultivated in large area in Bihar (31000 ha) with an annual production of about 2,54,600 MT of fruits having productivity of around 8.0 tonnes/ha. The harvesting of litchi fruits starts from last week of April in Tripura to end of July in Himachal and foot hills of Uttrakhand. In Bihar, the harvesting period lies between 2nd week of May to 3rd week of June for different cultivars like Early Bedana, Shahi, Mandraji, China, Purbi, Rose Scented, Longia, etc.

The latest global review of area and production shows that India is the second largest producer of litchi only next to China with the highest productivity in the world contributing about 25% of total world production. It occupies 1% area with 1.5% production of total fruits grown in India. There has been slow increase in the area and production of litchi in the country because of its specificity to the climatic requirements. It is restricted to northern parts particularly in the foot hills of Himalayas from Tripura to Jammu and Gangetic plains. Frost free, cool, dry winters and humid summers free from hot and dry winds, hails and storms characterize as favorable growing zone for litchi. One of the major factors limiting fruit production in litchi is lack of a suitable nutrition programme. Yields may be low because of excessive vegetative growth in winter following late or heavy N fertilization. Deficiencies of N and K, and to a lesser extent of B, Zn and Cu, may limit yield by restricting the set and subsequent development of fruit. Among the several factors associated with production of litchi, balanced nutrition is considered to be the most important which determines productivity and quality. Researchers have shown that very high rates of nitrogen depress yield, presumably because of excessive vegetative flushing in autumn. Highest yield are associated with a leaf nitrogen level of 1.47%, and lower yields with 1.42 or 1.52% N. This is close to the suggested range in Australia. There is strong interest in restricting N applications between panicle emergence and fruit set so to reduce excessive flushing prior to flowering in winter. Only slight responses to fertilizer phosphorus and potassium have been recorded.India has unique advantage as litchis start ripening from 15th April in Tripura and harvesting season lasts in other states up to end of June, thus giving enough time to export litchi in different countries.

Nutrient management

Litchi require good amount of mineral nutrients to sustain good yield and quality produce in commercial plantations. These can be supplied either by growing the crop in very fertile soils or by supplementing moderate soil fertility with applied fertilizers. Sooner or later even the most fertile soils become depleted and require additional fertilization. However, of the total acreage of litchi, only a small portion is intensively fertilized. The remaining is grown with few applied nutrients, apart from some organic matter and house hold refuse. This undoubtedly contributes to the gradual depletion of soil fertility and the phenomenon of yield decline, which is so prevalent in traditional plantations.

Litchi crop have precise requirement of nitrogen, phosphorus, potassium and other micro nutrients. The early stages of vegetative growth are critical for later quality production of fruits. Thus nutrients must be available to the plants from establishment to the stabilized fruiting stage of plants. Large quantity of nutrients removed by the litchi plants and these must be effectively replaced to sustain the yield and quality of fruits. One of the major factors limiting fruit production in litchi is lack of a judicious nutrient programme. Excessive application of nitrogenous fertilizer before flowering should be avoided. Phosphorus application at the time of flower bud differentiation improves flowering and fruiting. Application of cakes and manure is generally practiced to get better quality fruits. In general, litchi orchards, maintained with higher doses of organic manure, have better yield and quality as compared to orchards maintained with chemical fertilizers. Nutrition management is supported by leaf analysis annually together with soil analysis every two to three years for each block of trees. Leaves are sampled from behind the fruiting cluster about six to eight weeks after fruit set. Tentative leaf standards have been developed from limited trial work.

Methods for determining nutrients need

For determining the type of fertilizer elements and its quantity, litchi growers are suggested to go for soil or leaf analysis method to know the deficiency precisely. Recommended soil and leaf nutrient concentrations are given in Table 1 & 2.

Table 1. Recommended soil nutrient concentrations for litchi

Parameter	Value	Parameter	Value
pH	5.5 to 6.0	Magnesium	2.0 to 4.0 meq100g^{-1}
Organic carbon	1.0 to 3.0%	Zinc	2 to 15 mg kg^{-1}
Electrical conductivity	<0.20 dS m^{-1}	Manganese	10 to 50 mg kg^{-1}
Nitrogen	10 mg kg^{-1}	Boron	1.0 to 2.0 mg kg^{-1}
Phosphorus	100 to 300 mg kg^{-1}	Copper	1.0 to 3.0 mg kg^{-1}
Potassium	0.5 to 1.0 meq100g^{-1}	Chlorine	<250 mg kg^{-1}
Calcium	3.0 to 5.0 meq100g^{-1}	Sodium	<1.0 meq 100 g^{-1}

Table 2. Leaf nutrient standards in litchi

Nutrient	Value	Nutrient	Value
N (%)	1.50-1.80	Zn (μg/g)	15-30
P (%)	0.14-0.22	Cu (μg/g)	10-29
K (%)	0.70-1.10	B (μg/g)	25-60
Ca (%)	0.60-1.00	Na (μg/g)	<500
Mg (%)	0.30-0.50	Cl (%)	<0.25
Fe (μg/g)	50-100	Mn (μg/g)	100-250

Leaf nutrient standards are available for China, Australia, Thailand and India. Tentative standard leaf nutrient levels for Australian litchi orchards after panicle emergence during May to August are: 1.5-1.80 percent for N, 0.14 – 0.22 percent for P, 0.70 – 1.10 percent for K 0.66 -1.00 percent for Ca, 0.30 – 0.50 percent for Mg. The suitable leaf nutrient levels for Guangdong province of China are suggested as 0.93 – 2.10 percent for N, 0.08 – 0.21 percent for P and 0.12 -0.33 percent for K. In India, optimum nutrient content of leaf N, P and K are in range of 1.5-1.8, 0.15 -0.30 and 0.70 – 1.10 percent of dry matter. Ca content in the leaves varies from 0.60 – 3.0 percent of the dry matter basis (Hundal and Arora , 1995). It has been stated that a yield of 100 kg fruits removes about 90-250g N, 35-50g P, 240-320g K 20-60g Ca, 2.0- 2.50 g Cl, 1.40g Na (Singh, 1952, Beyers *et al.,* 1979 and Menzal *et al.*,1987).

Besides soil and leaf nutrient standards of determining the deficiency symptoms, visual deficiency symptoms can be a very powerful diagnostic tool for evaluating the nutrient status of plants.

Fertilizer application rate

Total and relative amounts of each nutrient or fertilizer vary greatly in different litchi orchards. Since soil and climate of different places are highly diverse, there is wide variation in the response (i.e. yield) *vis-à-vis* the rate of fertilizer application in India. Experiments conducted at different locations with different cultivars have clearly demonstrated the effect of a graded dose of NPK on growth, yield and quality of fruits. Application of 600-800 g N, 200-300 g P_2O_5 and 400-600 g K_2O per plant is recommended for 12-15 year old trees.

The common dose of fertilizer is presented in Table 3. The fertilizer rates given in the table are a guide only and should be supported by the results of leaf and soil analysis. Depending on cropping patterns and soil, they can easily be modified to suit other environments. In many parts of litchi belt, most of the nutrients are supplied from organic fertilizers. The suggested applications of the different nutrients can be amended as necessary. The major nutrients are best applied to the soil. Responses to foliar applications have been reported in some countries, but tend to be short-lived. For nitrogen, don't apply fertilizer if leaf concentrations are above 1.8 per cent and the trees are vigorous and have not set a crop. If the range is 1.5 to 1.8 per cent, apply the recommended amount. If the range is 1.2 to 1.5%, apply 25% more, if it is 1.1 to 1.2%, apply 50% more, and if it is less than 1.0%, apply double dose of nitrogen. For phosphorus, interpret the results in conjunction with soil analysis, and don't apply if the leaf test is more than 0.22% or if the soil test is above 300 ppm. For potassium, trees carrying a heavy crop, with less than 0.50% K in the leaf test, will require twice the amount of fertilizer listed for their size or age. If the leaf test is 0.5 to 0.6%, use another 50% more than the recommendation. If the leaf potassium is 0.70 to 1.10%, use the recommendation, but if it is above 1.10%, add nothing.

Table 3. Recommended dose of manures and fertilizers

Year	Quantity/annum/tree						
	FYM (kg)	Cake (kg)	Nitrogen (g)	Phosphorus (g)	Potash (g)	Zinc (g)	Boron (g)
1	10	1.0	50	25	25	25	-
2	15	1.50	100	50	50	50	-
3	20	2.00	150	125	75	75	-
4	25	2.50	200	150	100	100	-
5	30	3.00	250	200	125	125	125
6	35	3.50	300	250	150	150	150
7	40	4.00	350	300	175	175	175
8	45	4.50	400	350	200	200	200
9	50	5.00	500	400	250	225	225
>9 Year	60	5.00	600	600	250	250	250

Table 4. NPK recommendations for litchi in India

Reference	Variety /Age	Quantity (g/plant/year)		
		N	P	K
Nijjar (1981)	Grown up litchi tree	1470	680	540
Ray *et al.*(1985)	Grown up litchi tree	600	250	750
Sharma *et al.* (1990)	Dehradun (8 years)	100	50	25
Kanawarand Shrivastava (1989)	Rose Scented (9 years)	75	50	60
Hasan And Chattopadhyay (1990)	Bombai	600	200	200
Ghosh and Mitra (1990)	Bombai (7 years)	600	-	200

In China the recommended annual dosage is 0.6 kg urea, 1.2 kg super-phosphate and 0.6 kg of potassium chloride on a five-year-old tree basis, with the N:P:K ratio of 1:0.96:1.3. Fertilizers are generally used separately in three stages, i.e. inflorescence emergence (early to mid-January), rapid fruit growth (early to mid-May) and the time to stimulate autumn flushing (late June to July). However, in most orchards fertilizers are applied frequently and in small doses each time (in many cases over 10 applications of both soil and foliage sprays).

Time of application

The fertilizer programme for young trees begins when the plants begin to flush (Menzel and Simpson , 1987). The rate of nutrients is increased each year. Fertilizer application is usually followed by irrigation unless rain falls within a day of application. On poor soils, application of organic manures can be used to great advantage in the first few years (Cull and Paxton, 1983). The newly planted trees are are not likely to need feeding in the very first year. The fertilization programme may start from the second year. In case of fully developed bearing trees, nutrition management is directed first to give maximum vegetative growth immediately after harvesting. The second requirement is to maintain the tree in state of dormancy for 3-4 months before flowering. The third requirement is to maintain nutrition at a high rate once fruit have set (Menzel and Simpson,1986). To achieve this, nutrients are applied twice in the year. The first application is made just after harvest to encourage growth flush and second application is to be done at 2-3 weeks after fruit set to encourage fruit growth and development. Application in early spring can promote growth flushing which may compete with the flowers and reduce shedding (Menzel and Simpson 1986).

Method of fertilizer application

Considering the roots of newly planted saplings which are very shallow special care must be taken not to apply these compounds very close to the plant during its first six months in the field. To increase fertilizer use efficiency, fertilizers should be applied in 25 cm wide and 20-25 cm deep trenches dug around the tree about 1 m inside from outer canopy. Fertilizer application should be followed by light and controlled irrigation.

In recent years, considerable progress has been achieved in spraying of nutrients on the trees or dripping them in the root zone with irrigation water. High levels of N can be applied to get better results but with caution as this may delay the entering of trees into bearing. If the spraying is done on foliage, it is necessary that strong solutions are not used as they cause injury to the plants. Urea can be sprayed safely on trees. Its concentration varies between 2 and 4%. Three kilograms of urea in 500 litres of water has been found good for litchi trees. Foliar sprays of micronutrients to supplement their soil applications have been found effective to obtain quick response and to correct deficiencies in litchi. For micronutrients, if the range is within the optimum values, use the recommended rate (Table 5), but if it is below the optimum, apply a second application. If the leaf test is above the standard value, apply nothing.

Micronutrients are generally applied through foliar sprays at the time of their deficiencies. Frequency and time of spray depend on severity of the deficiency. Usually B and Zn sprays are applied yearly (i.e. once in a year). Deficiencies of Zn, B and Cu can also be overcome by single soil application during summer every 2-3 years. It is possible that water stress may interfere with the response to these nutrients. There have been many attempts to increase fruit set and fruit size with foliar applications of zinc, copper and boron. However, most of these sprays did not result in consistent increases in yield. Responses to foliar applications would only be expected if leaf nutrient concentrations are below critical values.

Water management in litchi

Water is vital for plant growth and production. In case of evergreen perennial litchi plants, apart from metabolic and physiological activity, water is essential for annual growth, optimum flowering, fruit setting and fruit growth. Limited availability of irrigation water coupled with the growing concern for ground water depletion warrants for its most efficient utilization. Efficient water use means high production of quality fruits per unit of water applied to the plant ideally, the maximum proportion of applied water should be utilized in transpiration by the tree with minimum losses due to surface evaporation, deep drainage and runoff. This can be achieved by applying optimum quantity of water as precisely as possible and adoption of the available litchi production techniques. Sufficient retention of moisture in the soils and high relative humidity in the atmosphere, particularly during fruiting period is considered most favourable for economical fruit production. In scanty rainfall areas, however, maintenance of proper soil moisture by regular irrigation is essential.The young plants of litchi are prone to water stress. Therefore, weekly irrigation is required for better establishment and growth. Regular irrigation should be given atinitial stage in young plant whereas in bearing orchards, the critical period for irrigation is from fruit set to maturity. At fruit set stage, irrigation should be given at three weeks interval which can be progressively reduced to fortnightly interval during April and at 10 days interval in May-June. It is advised that watering should not be done four months prior to panicle initiation. Absorbing roots of litchi occur mostly in the top 20 to 30 cm soil layer therefore the soil moisture should be maintained above 50 per cent during fruit development.The water requirement of a litchi orchard can be calculated on the basis of water deficit, root zone depth and soil type. Litchi has deep root system however effective root zone extends to about 1.5 m depth. Root moisture extraction pattern in fruits trees indicate the maximum soil moisture is extracted from the top 40 to 60 cm profile.

Irrigation and fruit cracking

High soil moisture and atmospheric humidity have been found essential for successful litchi cultivation. Increasing frequency of irrigation helps in maintaining proper soil moisture and balance inside the plant tissues, especially in the developing and maturing fruits which also reduce the extent of cracking.The dry hot winds during fruit growth and development are harmful and cause severe fruit cracking which results in substantial low fruit yield and poor quality.Frequent irrigation helps in reducing the fruit cracking by altering the micro-climate of the orchard. It is observed that loss of soil moisture and low frequency of irrigations during fruiting resulted insevere cracking of litchi fruits. Reduction in fruit cracking by regular irrigation is probably due to availability of optimum range of humidity, soil moisture and reduced air temperature. Experiments conducted at CHES, Ranchi indicated that irrigation of litchi through drip system from first week of April was highly beneficial in checking fruit cracking. Litchi trees initiate flowers when early flush development coincides with low temperatures. Consequently, flowering only occurs if new flushes develop during cool weather. Olesen and his co-workers (2000) from Australia suggested four possible ways to alter flushing and induce flowering in litchi. Trees can be hedged to induce one or two vegetative flushes over summer and autumn, and a second or third in winter or create moisture stress in autumn to prevent more than one or two leaf flushes after the preceding harvest. They can also be pruned going into winter to induce flowering directly below the pruning cut. There is also the possibility of using ethephon (1 to 3 litre of ethrel and 5 kg of urea per 1,000 litre of water) to selectively remove the young red flushes in winter.

Production technology of tree spices

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Tree spices refer to spices originating from tree crops. Seventeen tree spices are grown in India. The commercially important ones are nutmeg, clove, cinnamon, cassia, allspice, cambogia, kokam, tamarind, curry leaf and pomegranate. This paper deals with the prospects and problems of cultivation of three major tree spices namely nutmeg, cinnamon and clove. The commercial products of these crops are whole spice, ground spice, spice oil, oleoresin etc and find applications in flavouring food, pharmaceutical, perfumery and cosmetic industries. The area under these crops are very meager and hence, there is a lot of scope for expanding the area under traditional and non traditional areas thereby increasing the production. Area and production of cinnamon, nutmeg and clove is given in the Table 1.

Table 1. Area, production and productivity of nutmeg, cinnamon and clove

Spice	Area ('000ha)	Production ('000 tonnes)	Productivity (kg/ha)
Nutmeg	7.00	1.78	254
Cinnamon	0.79	0.42	532
Clove	3.43	3.27	953

Nutmeg

Nutmeg (*Myristicafragrans* Houtt.) (Family: Myristicaceae) produces two separate spices, namely nutmeg and mace. Nutmeg is the dried kernel of the seed and mace is the dried aril surrounding it. Nutmeg is indigenous to Moluccas Islands (Indonesia). Over 50% of the world's export of nutmeg and mace originate from Indonesia. Grenada is the second largest exporter of nutmeg and mace in the world. In India, nutmeg is mainly cultivated in Thrissur, Eranakulam and Kottayam districts of Kerala and parts of Kanyakumari and Tirunelveli districts in Tamil Nadu.

Climate and Soil

Nutmeg thrives well in warm humid conditions in locations with an annual rainfall of 150 cm and more. It grows well from sea level up to about 1300 m above MSL. Areas with clay loam, sandy loam and red laterite soils are ideal for its growth. Both dry climate and water logged conditions are not good for nutmeg.

Varieties and planting material

As nutmeg is an obligatory cross-pollinated crop, the variation observed in the crop is considerable. The plants differ not only for all aspects of growth and vigour, but also for sex expression, size and shape of nutmeg, quantity and quality of mace. A good tree yields about 2000 fruits annually on an average, but the yield may vary from a few hundreds to about 10,000 fruits. IISR has released a variety namely IISR Viswashree with a very high yield potential. This clonal selection yields 100 fruits at 5th year after planting, 600 fruits (6$^{th\ year}$), 800 fruits (7th year) and 1000 fruits (8th year). At 8th year after planting @ 360 plants/ha, an average yield of approximately 3122 kg dry nut (with shell) and 480 kg dry mace per hectare could be obtained. A9/4 gives 70% dry recovery in nut and 35% dry recovery in mace, while the nut has 7.1% essential oil, 2.5% oleoresin and 30.9% butter, the mace has 7.1% essential oil and 13.8% oleoresin.

Varieties

Genetic variability in nutmeg population is low in the country as the present population evolved from a few mother tree introduced by Britishers. Crop improvement programme in nutmeg aims at selecting and breeding high yielding trees. Since nutmeg and mace are of economic importance, while breeding/ selecting, emphasis is laid on both the products. High yielding elite trees have been identified from various nutmeg growing areas and their progenies are being evaluated for yield. Recently few varieties have been released for commercial cultivation. These varieties areKonkan Sugandha, Konkan Swad,Konkan Shrimanti andIISR Viswashree. A new nutmeg variety IISR Keralashree was approved for release in 2013. This is the first nutmeg variety developed by farmer participatory breeding programme.

Nursery

An important problem in nutmeg cultivation is the segregation of seedlings into male and female plants resulting in about 50% of unproductive male trees. Though, there have been several claims that sex could be determined at seedling stage on the basis of leaf form and venation, colour of young sprouts, vigour of seedlings and shape of calcium oxalate crystals on leaf epidermis, none of them is sufficiently reliable. The only alternative at present is to adopt vegetative propagation either to top-work male plants or to use budded or grafted plants. Nutmeg is commercially propagated through grafts. For raising rootstocks, naturally split healthy fruits are harvested during June-July. The seeds are extracted from the pericarp and sown immediately in sand beds of convenient length,1 to 11/2 m width and 15 cm height. Regular watering is necessary for good germination. Germination may commence from about the 30th day and last up to 90 days after sowing. About 20 day old sprouts are transplanted to polythene bags containing a mixture of good soil, sand and cow dung (3:3:1).

Epicotyl grafting

The selected rootstock at the first leaf stage should have a thick stem (diameter of 0.5 cm or more) with sufficient length to give a cut of 3 cm long. Scions with 2-3 leaves, collected from high yielding trees can be used for grafting. The stock and scion should have approximately the same diameter. A 'V' shaped cut is made in the stock and a tapered scion is fitted carefully into the cut. Bandaging at the grafted region may be done with polythene strips. The completed grafts are to be planted in polythene bags of 25 cm x 15 cm size containing potting mixture. The scion is covered with a polythene bag and kept in a cool shaded place protected from direct sunlight. After 1 month, the bags can be opened and those grafts showing sprouting of scions may be transplanted into polythene bags, containing a mixture of soil, sand and cow dung (3:3:1) and kept in shade for development. The polythene bandage covering the grafted portion can be removed after 3 months.During grafting, precautions should be taken to prevent wilting of scions and to complete the grafting as soon as possible. The grafts can be planted in the field after 12 months.

Preparation of land and planting

Planting in the main field is done at the beginning of the rainy season. Pits of 0.75 m x 0.75 m x 0.75 m size are dug at a spacing of 9 m x 9 m and filled with organic manure and soil about 15 days earlier to planting. For planting plagiotropic grafts, a spacing of 5 m x 5 m has to be adopted. A male graft has to be planted for every 20 female grafts in the field.The plants should be shaded to protect them from sun scorch during early stages. Permanent shade trees are to be planted when the site is on hilly slopes and when nutmeg is grown as a monocrop. Nutmeg can best be grown as an intercrop in coconut gardens more than 15 years old where shade conditions are ideal. Coconut gardens along river beds and adjoining areas are best suited for nutmeg cultivation. Irrrigation is essential during summer months.

Manuring

Manures are applied in shallow trenches or pits dug around the plants. The Kerala Agriculture Department recommends 20 g N (40 g urea), 18 g P_2O_5 (110 g superphosphate) and 50 g K_2O (80 g muriate of potash) during the initial year and progressively increasing the dose to 500 g N (1090 g urea), 250 g P_2O_5 (1560 g superphosphate) and 1000 g K_2O (1670 g muriate of potash) per year in subsequent years for a fully grown tree of 15 years or more. FYM is to be applied @ of 25 kg for 7-8 year old trees and 50 kg for fully grown up tree of 15 years.

Diseases

Die back

The disease is characterised by drying up of mature and immature branches from the tip downwards. *Diplodia* sp. and a few other fungi have been isolated from such trees. The infected branches should be cut and removed and the cut branches pasted with Bordeaux mixture 1%.

Thread blight

Two types of blights are noticed in nutmeg. The first is a white thread blight wherein fine whitish hyphae aggregate to form fungal threads and traverse along the stem underneath the leaves in a fan shaped or irregular manner causing blighting of affected portions. The dried up leaves with mycelium form a major source of inoculum for the spread of the disease. The disease is caused by the fungus *Marasmius pulcherima*.The second type of blight is called horse hair blight. Fine black silky threads of the fungus form an irregular, loose network on the stems and leaves. These strands cause blighting of the leaves and stems. However, these threads hold up the detached, dried leaves on the tree, giving the appearance of a birds nest, when viewed from a distance. This disease is caused by *Corticium equicrinus*. Both the diseases are severe under heavy shade. These diseases can be managed by adopting phytosanitation and shade regulation. In severely affected garden, Bordeaux mixture (1%) spraying may be undertaken in addition to cultural practices.

Fruit rot

Immature fruit split, fruit rot and fruit drop are highly prevalent in a majority of nutmeg gardens in Kerala. Immature fruit split and shedding are noticed in some trees without any apparent infection. In the case of fruit rot, the infection starts from the pedicel as dark lesions and gradually spreads to the fruit, causing brownish discolouration of the rind resulting in rotting. In advanced stages, the mace also rots emitting a foul smell. *Phytophthora* sp. and *Diplodianatalensis* have been isolated from affected fruits. However, the reasons for fruit rot could be both pathological and physiological. Bordeaux mixture 1% may be sprayed when the fruits are half mature to reduce the incidence of the disease.In addition to these, occasional dark sunken lesions, dark scabbing, mostly restricted to the outer layers of the pericarp without affecting the mace, have also been noticed. The causative organisms, have not yet been isolated.

Shot hole

The disease is caused by the fungus *Colletotrichum gloeosporioides*. Necrotic spots develop on the lamina which is restricted by chlorotic halo. In advanced stages the necrotic spots become brittle and fall off resulting in shot holes. A prophylactic spray with Bordeaux mixture 1% is effective against the disease.

Insect pests

Black scale

The black scale (*Saissetia nigra*) infests tender stems and leaves especially in the nursery and sometimes young plants in the field. The scales are seen clustered together and are black, oval and dome shaped. They feed on plant sap and severe infestations cause the shoots to wilt and dry.

White scale

The white scale (*Pseudaulacaspis cockerelli*) is greyish white, flat and shaped like a fish scale and occurs clustered together on the lower surface of leaves especially in nursery seedlings. The pest infestation results in yellow streaks and spots on affected leaves and in severe infestations the leaves wilt and dry.

Shield scale

The shield scale (*Protopulvinaria mangiferae*) is creamy brown and oval and occurs on tender leaves and stems especially in nursery seedlings. The pest infestation results in wilting of leaves and shoots.

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

Harvesting

The female nutmeg tree starts fruiting from the sixth year, though the peak harvesting period is reached after 20 years. The fruits are ready for harvest in about 9 months after flowering. Flowering and harvesting continue throughout the year, but June-August is the peak period.The fruits are ripe and ready for harvesting when the pericarp splits open. After harvest the outer fleshy portion is removed, and the mace is manually separated from the nut. The nut and mace are then dried separately either in the sun or by passing hot air. The scarlet coloured mace gradually becomes yellowish brown and brittle when drying is completed. The fleshy pericarp can be used for making pickles, jams and jellies.

Cinnamon

Cinnamon (*Cinnamomum verum*) (Family: Lauraceae) is one of the earliest known spice and the dried inner bark of the tree is used as spice. Cinnamon is a native of Sri Lanka and is cultivated in the lower elevations of Western Ghats in Kerala and Tamil Nadu.

Soil and climate

Cinnamon is a hardy plant and tolerates a wide range of soil and climatic conditions. In the West Coast of India, the tree is grown on laterite and sandy patches with poor nutrient status. It comes up well from sea level up to an elevation of about 1,000 m. Since it is mostly raised as a rainfed crop, an annual rainfall of 200-250 cm is ideal.

Varieties

Two high yielding, high quality cinnamon varieties released from IISR are suitable for cultivation in various regions of India. The varieties Navashree and Nithyashree have an yield potential of 56 and 54 kg dry quills/ha/year respectively in the initial years, when one seedling/cutting is planted in hill.

Navashree yields 2.7% bark oil, 73% cinnamaldehyde in bark, 8% bark oleoresin, 2.8% leaf oil and 62% leaf eugenol. Nithyashree yields 2.7% bark oil, 58% cinnamaldehyde in bark, 10% bark oleoresin, 3% leaf oil and 78% leaf eugenol.

Propagation

Seed

Cinnamon can be propagated through seeds. In such cases variability is observed among the seedlings. Under West Coast conditions, cinnamon flowers in January and the fruits ripen during June-August. The fully ripened fruits are either picked up from the tree or the fallen ones are collected from the ground. The seeds are removed from the fruits, washed free of pulp, and sown without much delay as the seeds have a low viability. The seeds are sown in sand beds or polythene bags containing a mixture of sand, well rotten cattle manure and soil (3:3:1). The seeds start to germinate within 15-20 days. Frequent irrigation is required for maintaining adequate moisture. The seedlings require artificial shading till they are about 6 months old.

Cuttings

For raising cinnamon from cuttings; semi hardwood cuttings of about 10 cm length with 2 leaves are taken and dipped in IBA 2000 ppm or in a rooting hormone (Keradix - B) and planted either in polythene bags filled with sand or a mixture of sand and coirdust in the ratio 1:1 or in sand beds raised in a shaded place. The cuttings in polythene bags must also be kept in a shaded place or in a nursery. The cuttings are to be watered regularly 2-3 times a day to maintain adequate moisture and to prevent wilting. The cuttings root in 45-60 days. The well rooted cuttings can be transplanted to polythene bags filled with potting mixture and maintained in a shaded place and watered regularly.

Air layering

Air layering of cinnamon is done on semi hardwood shoots. A ring of bark is removed from the semi hardwood portion of the shoot and a rooting hormone (IBA 2000 ppm or IAA 2000 ppm) is applied on the portion where the bark has been removed. Moist coir dust or coir husk is placed around the region where the hormone has been applied and is secured in position by wrapping with a polythene sheet of 20 cm length. This would also avoid moisture loss. Rooting takes place in 40-60 days. The well rooted air layers are separated from the mother plant and bagged in polythene bags filled with potting mixture and kept in a shaded place or nursery by watering the plants twice daily. The rooted cuttings and layers can be planted in the main field with the onset of rains.

Preparation of land and planting

The area for planting cinnamon is cleared and 50 cm x 50 cm x 50 cm size pits are dug at a spacing of 3 m x 3 m. They are then filled with compost and top soil before planting. Cinnamon is planted during

June-July to take advantage of the monsoon for the establishment of seedlings. For transplanting, 10-12 month old seedlings or well rooted cuttings or airlayers are used. In each pit 3-4 seedlings or rooted cuttings or airlayers can be planted. In some cases, the seeds are directly dibbled in the pits that are filled with compost and soil. Partial shade in the initial years is advantageous for healthy, rapid growth of plants.

Manure and cultural practices

Two weedings in an year during June-July and October-November, and one digging of the soil around the bushes during August-September is recommended. A fertilizer dose of 20 g N, 18 g P_2O_5 and 25 g K_2O per seedling is recommended in the first year. The dose of fertilizers is increased gradually to 200 g N, 180 g P_2O_5 and 200 g K_2O for grown up plants of 10 years and above. The fertilizers are to be applied in two equal split doses, in May-June and September-October. Mulching with green leaves (25 kg) during summer and application of FYM (25 kg) during May-June is also recommended.

Diseases

Leaf spot and die back

Leaf spot and die back disease is caused by the fungus *Colletotrichum gloeosporioides.* Small deep brown specks appear on the leaf lamina, which later coalesce to form irregular patches. In some cases the affected portions shed leaving shot holes on the leaves. Later the entire lamina is affected and the infection spreads to the stem causing die back. Pruning the affected branches and spraying Bordeaux mixture 1% are recommended to control thie disease.

Seedling blight

Seedling blight caused by the fungus *Diplodia* sp. Occurs on seedlings in the nursery. The fungus causes light brown patches which girdle the stem resulting in mortality of seedlings. The disease can be controlled by spraying Bordeaux mixture 1%.

Grey blight

Grey blight is caused by the fungus *Pestalotia palmarum*and is characterized by small brown spots which later turn grey with a brown border. The disease can be controlled by spraying Bordeaux mixture 1%.

Insect pests

Cinnamon butterfly

The cinnamon butterfly (*Chilasa clytie*) is the most serious pest of cinnamon especially in younger plantations and in the nursery and is generally seen during the post monsoon period. The larvae feed on tender and slightly mature leaves; in severe cases of infestation, the entire plant is defoliated and only midribs of leaves with portions of veins are left behind. The adults are large sized butterflies and occur in two forms. One of the forms has blackish brown wings with white spots on outer margins; the other form has black wings with bluish white markings. Fully-grown larvae are pale yellow with dark stripes on the sides and measure about 2.5 cm in length. The pest can be controlled by spraying quinalphos 0.05% on tender and partly mature leaves.

Leaf miner

Infestation by the leaf miner *Conopomorpha civica*) is more common during the monsoon period and generally nursery seedlings are seriously affected. The adult is a minute silvery grey moth. The larvae are pale grey initially and later become pink measuring about 10 mm in length. They feed on the tissues between the upper and lower epidermis of tender leaves resulting in linear mines that end in 'blister' like patches. The infested leaves become crinkled and the mined areas dry up leading to the formation of large holes on the leaves. Spraying quinalphos 0.05% during emergence of new flushes is effective in preventing the pest infestation.Many other leaf feeding caterpillars and beetles also occur sporadically on cinnamon feeding on tender flushes. Application of quinalphos 0.05% would keep them under check.

Harvesting and processing

The cinnamon tree may attain a height of 10-15 m, but in cultivation, it is generally coppiced or cut back periodically. When the plants are 2 years old, they are coppiced during June-July to a height of about 12 cm from the ground. The stump is then covered by earthing up. This operation encourages the development of side shoots from the stump. This is repeated for every side shoot, developing from the main stem during the succeeding season, so that the plant will assume the shape of a low bush of about 2 m height and a bunch of canes suitable for peeling would develop in a period of about 4 years. Coppicing can be commenced from the fourth or the fifth year of planting.The shoots are harvested from September to November, under Kerala conditions. Coppicing is done in alternate years and shoots having 1.5-2.0 cm thickness and uniform brown colour are ideal for bark extraction. A 'test cut' can be made on the stem with a sharp knife to judge the suitability of the time of peeling. If the bark separates readily, coppicing can be commenced immediately. The stems are cut close to the ground when they are about 2 years old, as straight as possible, 1.00 to 1.25 m, length. Such shoots are bundled after removing the leaves and terminal shoots. Cutting is followed by scraping and peeling operations. Peeling is a specialized operation, requiring skill and experience. It is done by using a specially made knife, which has a small round end with a projection on one side to facilitate ripping of the bark. The rough outer bark is first scrapped off. Then the scrapped portion is polished with a brass or an aluminium rod to facilitate easy peeling.

A longitudinal slit is made from one end to the other. The bark can be easily removed by working the knife between the bark and the wood. The shoots cut in the morning are peeled on the same day. The peels are gathered and kept overnight under shade. They are dried first in shade for a day and then in sunlight for four days. During drying, the bark contracts and assumes the shape of a quill. The smaller quills are inserted into larger ones to form compound quills.The quills are graded from '00000', being the finest quality, to '0' the coarsest quality. The small pieces of the bark, left after preparing the quills are graded as 'quillings'. The very thin inner pieces of bark are dried as 'featherings'. From the coarser canes, the bark is scraped off, instead of peeling, and this grade is known as 'scraped chips'. The bark is also scraped off without removing the outer bark and is known as 'unscraped chips'. The different grades of bark are powdered to get 'cinnamon powder'.

Leaf and bark oil

Leaf and bark oils of cinnamon could be obtained by distilling dried cinnamon leaves and bark, respectively. The dried cinnamon leaves are steam distilled in special distiller. About 4 kg of bark oil could be obtained from a hectare of cinnamon plantation.Leaf oil and bark oil are used in the manufacture of perfumes, soaps, tooth pastes, hair oils and face creams and also as an agent for flavouring liquor and in dentifrices. The cost of extraction of bark oil is expensive compared to the returns available from it.

Clove

The clove of commerce is the aromatic, dry, fully grown, but unopened flower buds of the clove tree (*Syzygium aromaticum*) (Family: Myrtaceae). The islands of Zanzibar and Pemba (now part of Tanzania) and Indonesia are the major producers of clove in the world. In India, clove is mostly grown in the hilly tracts of Tamil Nadu, Kerala and Karnataka.

Climate and soil

Clove grows well in rich loamy soils of the humid tropics and can be grown successfully in the red soils of the midlands of Kerala as well as in the hilly terrain of Western Ghats at higher elevations in Tamil Nadu and Karnataka. A cooler climate with well distributed rainfall is ideal for flowering.The site selected for cultivation of clove needs good drainage since the crop cannot withstand water logged conditions. It thrives well in areas receiving an annual rainfall of 150-300 cm. In India, clove grows from sea level up to 1500 m above sea level. It can be successfully grown as inter-crop in coconut and arecanut plantations. In higher elevations it can be mix-cropped with black pepper or coffee.

Varieties and planting material

Clove plantations in India are reported to have originated from a few seedlings obtained originally from Mauritius. The germplasm collections made from within the country have not yielded any appreciable variability mainly due to this and the self fertilizing nature of the plant.Horticultural Research Station, Pechiparai (Tamil Nadu), has released a clove variety PPI(CL-1), suitable for Kanyakumari, district. It has high yield (5.2 kg dry/tree), high oil (6%) and high oleoresin (7.13%) contents.To raise seedlings, the seeds should be collected from fully ripe fruits. Fruits for seed collection, known popularly as 'mother of clove' are allowed to ripe on the tree itself and drop down naturally. Such fruits are collected from the ground and sown directly in the nursery or soaked in water overnight and the pericarp removed before sowing. The second method gives quicker and higher percentage of germination. Only fully developed and uniform sized seeds which show signs of germination by the presence of pink radical, are used for sowing. Though the ripe fruits can be stored for a few days by spreading them in a cool shaded place, it is advisable to sow the seeds immediately after harvest. Heaping the fruits or keeping them tied up in airtight bags hastens the death of seeds.

Nursery practices

Beds for sowing seeds are to be prepared of 15-20 cm height, 1 m width and convenient length. The beds should be made of loose soil-sand mixture over which a layer of sand may be spread (about 5-8 cm thick). Seeds can also be sown in sand beds but care should be taken to prevent leaching of the beds in rain. Seeds are sown at 2-3 cm spacing and depth of about 2 cm. The seed beds have to be protected from direct sunlight. If only small quantities of seeds are available for sowing, they can be sown directly in polybags filled with soil-sand-cowdung mixture and should be kept in a shady cool place. The germination commences in about 10 to 15 days and may last for about 40 days. The germinated seedlings are transplanted in polythene bags (25 cm x 15 cm) containing a mixture of soil, sand and well decomposed cowdung (3:3:1). Sometimes, the seedlings are again transplanted after 1 year to large polythene bags containing the same soil mixture. The seedlings are ready for transplanting in the field when they are 18-24 months old. Transplanting time can be reduced to 1 year by planting clove seedlings in a mixture consisting of soil and vermicompost in 1:1 proportion. The nurseries are usually shaded and irrigated daily. To avoid damage by crickets, chloropyriphos 0.05% may be drenched in the nursery.

Preparation of land and planting

The area selected for raising clove plantations is cleared of wild growth before monsoon and pits of 75 cm x 75 cm x 75 cm size are dug at a spacing of 6-7 m. If planted as an intercrop, the spacing is to be adjusted based on the spacing of the major crop. The pits are partially filled with compost, green leaf or cattle manure and covered with top soil. The seedlings are transplanted in the main field during the beginning of rainy season, in June-July, and in low lying areas, towards the end of the monsoon, in September-October. Clove prefers partial shade and comes up well at higher elevations, having well distributed rainfall. Under Indian conditions it is best suitable for mixed cropping in older coconut or arecanut plantations or in coffee estates. In order to give a cool humid microclimate, intercropping with banana is ideal.

Manuring and after cultivation

Cattle manure or compost @ 50 kg and bone meal or fish meal @ 2-5 kg per bearing tree per year can be applied. Organic manures can be applied as a single dose at the beginning of the rainy season in trenches dug around the trees. The Kerala Agriculture Department recommends the application of inorganic fertilizers also @ 20 g N (40 g urea), 18 g P_2O_5 (110 g super phosphate) and 50 g K_2O (80 g muriate of potash) in the initial stage. The dosage is progressively increased to 300 g N (600 g urea) 250 g P_2O_5 (1560 g super phosphate) and 750 g K_2O (1250 g of muriate of potash) per year for a grown up tree of 15 years or more. The fertilizers must be applied in two equal split doses in May-June and in September-October in shallow trenches dug around the plant normally about 1-1½ m away from the base.

Diseases

Seedling wilt

Seedling wilt is a serious problem in majority of the nurseries and causes 5-40 % death of seedlings. The leaves of affected seedlings loose natural lustre, tend to droop and ultimately die. The root system and collar region of the seedling show varying degrees of discoloration and decay. *Cylindrocladium* sp., *Fusarium* sp. and *Rhizoctonia* sp., are the commonly associated organisms with the disease.Since the infected plants promote further spread of the disease, they are to be removed and the remaining seedlings should be treated with carbendazim 0.1% both as spray and soil drench. Alternatively the foliage may be sprayed with Bordeaux mixture 1% and the soil drenched with copper oxychloride 0.2%.

Leaf rot

Leaf rot is caused by *Cylindrocladium quinqueseptatum* and is noticed in mature trees and seedlings. The infection starts as dark diffuse patches at the leaf tip or margin and later the whole leaf rot, resulting in severe defoliation. The foliage of affected trees should be sprayed with carbendazim 0.1%. Prophylatic sprays with Bordeaux mixture 1% also prevents the disease.

Leaf spots and bud shedding

The disease is characterized by the appearance of dark brown spots with a yellow halo on leaves and is caused by *Colletotrichum gleosporioides*. Such spots also appear on the buds resulting in their shedding. *C. crassipes* causes reddish brown spots on the leaves.Prophylatic spraying with Bordeaux mixture 1% prevents both the diseases.

Insect pests

Stem borer

The stem borer (*Sahyadrassus malabaricus*) infests the main stem of young trees at the basal region. The larva of the pest girdles the stem and bores downward into it. The girdled portion and bore-hole are covered with a mat- like frass material. The infested trees wilt and succumb to the pest attack subsequently.Inspect base of clove trees regularly for symptoms of pest attack. Spray quinalphos 0.1% around the bore-hole and inject the same into the bore-hole after removing the frass. Swab the basal region of the main stem with carbaryl and keep the basins free of weeds.

Scale insects

Many species of scale insects infest clove seedlings in the nursery and sometimes young plants in the field. The scale insects generally seen on clove include wax scale (*Ceroplastes floridensis*), shield scale (*Pulvinaria psidii*), nasked scale (*Mycetaspispersonata*) and soft scale (*Kilifia accuminata*). The scales are generally seen clustered together on tender stems and lower surface of leaves. Scale insects feed on plant sap and cause yellow spots on leaves and wilting of shoots and the plants present a sickly appearance. Spraying monocrotophos (0.05%) is effective for the management of scale insects.

Harvesting and processing

Clove trees start flowering from the 4th year of planting under good soil and management conditions. But the full bearing stage is reached only by about the 15th year. The flowering season varies from September-October in the plains to December-January at high altitudes. The unopened buds are harvested when they are plump and rounded before they turn to pink. At this stage, they are less than 2 cm long. The opened flowers are not valued as a spice. Harvesting has to be done without damaging the branches, as it would adversely affect the succeeding growth of the trees. It is a common practice among growers not to leave the trees to bear fruits (mother of clove), as they believe that it has an adverse effect on subsequent flowering.The harvested flower buds are separated from the clusters by hand and spread in the drying yard for drying. The correct stage of drying is reached when the stem of the bud is dark brown and the rest of the bud lighter brown in colour. Well dried cloves will be only about one-third the weight of fresh cloves. About 11,000 to 15,000 dried cloves make 1 kg.

Allspice

Allspice, *Pimentadioica* (L.)Merr. (syn: *P. officinalis* Lindl., *Myrtus pimenta* L. , *M. dioica* L. and *Eugenia pimenta* DC (Merrill 1947) is a polygamodioecious evergreen tree, the dried unripe fruits of which provide the culinary spice, pimento, of commerce. Leaves are aromatic and are used in the distillation. The berries are used for the preparation of essential oil and oleoresin. It belongs to the family Myrtaceae and is known in English as allspice or pimento. The family Myrtaceae consists of about 3000 woody species, most of which is grown in the tropics. The genus *Pimenta* Lindl.consists of about 18 species of aromatic shrubs and trees native to tropical America. The genus is closely related to *Myrtus* L. and *Eugenia* L. The commercially important *Pimenta* spp. are*Pimenta dioica* (L.) Merr.providing the spice pimento (allspice) and *P. racemosa* (Mill) Moore, bay or bay rum tree providing oil of bay. Allspice was introduced into West Indian Islands (Grenada, Barbados, Trinidad and Puerto Rico) from its place of origin. Attempts to introduce it into countries in tropical regions namely, India, Sri Lanka, Fiji, Malaysia, Singapore and Indonesia (Java, Sumatra) have not succeeded fully due to various reasons. In India, a few trees are available in Maharashtra, Tamil Nadu, Karnataka and Kerala. In India, the plant is reported to be grown in some gardens, especially in Bengal, Bihar and Orissa. There are a few allspice trees available in Nagarcoil, Kallar, Burliar and Horticultural Research Station, Ambalavayal.

Improving productivity, profitability and sustainability through agro forestry intervention in fruit orchards

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Agro forestry is an age old practice used by our ancestors but it was not in planned way. As the agricultural research advanced and scientists engaged in agro forestry research, they came out with the conclusion that by incorporating agro forestry in planned way farmers/ planters can improve productivity, profitability and sustainability from their existing agriculture/ orchards and could be a best solution to solve the problems of food, fuel, fodder, timber, unemployment, malnutrition, GHG's, environment pollution, soil health and so on. There are number of agroforestry systems based on agricultural components used in the orchard and almost all the systems are being used in one or other part of the country. These systems not only provide fruits but also help in fulfilling the requirement of timber, food, fuel, fodder, employment generation and provide economic stability. In Jhansi, an experiment conducted in aonla with pasture for over 10 years and result concluded that the system produced 9.08 t/ha fruit, 3.38 t/ha dry fodder with B:C ratio of 1.85 (pure pasture), 3.70 (aonla + pasture) and 3.62 (aonla pure), generated employment 27.6 man days (pure pasture), 47.6 man days (pure aonla) and 64.9 man days (aonla + pasture)/ha/year including improving in soil fertility. In the similar way the Coorg region (Western Ghat) where coffee is the main source of livelihood and needs shade through silver oak and other suitable plants of the region for its growth, can be easily diversified with other agroforestry components such as fruit trees particularly underutilized fruits, plantation crops, timber trees, field crops, vegetables, grasses etc and can contribute in the Indian economy by reducing the gap between the demand and supply of food, fodder, fuel, timber etc.

Varieties and quality planting material production of important underutilized fruits

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Fruits are vital for a wholesome natural diet. They are rich sources of vitamins, minerals, proteins, carbohydrates and antioxidants that are essential for human nourishment. Being naturally low in calories, fat, sodium and cholesterol, fruits lower the risk of illness and disease. Fruits and their juices are good sources of water too. Thus, they hydrate the body, regulate body temperature, keep the joints moist, and remove the waste products from the body. Cultivation and processing of fruits generate a substantial income to the rural and peri-urban population, and their distribution channels create job opportunities for many. Southern India's diverse climatic conditions allow the production of a wide range of underutilized fruit crops having national importance in view of their potential for export. Some of them are rambutan, pulasan, mangosteen, jackfruit anddurian. Farmers in many parts of keralaand Karnataka have seriously taken the cultivation of these crops to cater to the demand for the fruits from traders in Tamil Nadu and Karnataka. There is an ever growing demand for these fruits in the metros and production has not grown to support even a fraction of the current demand. The demand for these fruits is so great that it is sold like hot cakes in Bangalore, Mumbai and Chennai markets. In view of the ever-increasing demand for these fine fruits, Homegrown Nursery and Farms ventured into the business of producing high quality planting materials in large quantities. Homegrown Nursery and Farms is one of the leading fruit crop nurseries in South India, established in 1999 with the primary objective to reposition the state of Kerala as the food and fruit basket of the country. It is an innovative business concern driven by professional expertise, high fidelity and state-of-the art technology. What makes us unique is the way we exhibit Kerala's own traditional fruits along with world's finest tropical fruits such as rambutan, pulasan, mangosteen and durian. We hope this move would throw some light to open the challenge to restore Kerala's once lost glory as a food grower. Availability of high quality planting materials is essential for commercial fruit production. We have short-listed twenty exotic as well as indigenous fruit crops for commercial production. Quality planting materials of many of these fruit crops are being distributed to farmers who take up commercial/homestead cultivation.

III-3

Production technology of passion fruit (*Passiflora edulis*)

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The passion fruit is a shallow-rooted, woody, perennial vine and climbs by means of tendrils. It is the native of Brazil. In India, passionfruit cultivation is confined to Kerala, Tamil Nadu (Nilgiri hills and Kodaikanal), Karnataka (Coorg) and northeastern states (Mizoram, Nagaland, Manipur and Sikkim). *Passifloraedulis* exists in two distinct types known as *P. edulisedulis,* the purple passion fruit and *P. edulisflavicarpa*, the yellow passion fruit. The purple passion fruit, *P. edulis* bears a dark-purple or nearly black rounded or egg-shaped fruit about 5 cm long, weighing 30-45 g. Fruit of the yellow passion fruit is deep yellow and similar in shape but slightly longer than the purple passion fruit. Its length is about 6 cm and it weighs about 60-90 g. Inside the thick protective rind there are numerous small seeds covered by a juicy aromatic, sweet-acidic pulp. The purple form has black seeds and the yellow form has brown seeds. The yellow variety is used for juice processing, while the Purple variety is sold in fresh fruit markets. The seeds are consumed with the pulp. The fruit is also made into juice and often blended with other juices such as orange. The yellow form has a more vigorous vine and generally larger fruit than the purple.The purple passionfruit is subtropical grows at an altitude of 650-1,300 m in India, while yellow passionfruit is tropical produces at an elevation of 600 m.Passion fruit vines require full sunlight for proper growth. Passion fruit is propagated by seeds, layers, cuttings or approach grafting. Recommended spacing are 2.0-4.0 m between rows and 2.5-5.0 m between plants in the rows (500-1300 vines/ha). The best time for planting in during the monsoon.Skillful trellising is quite important in regulating yield as it has to support a considerable weight for 5 years. Two arm kniffinsystem is ideal. The trellis should always run across the slope or in north-south direction to facilitate even exposure to the sunlight. Once the vines reach the wire, the tips are pinched to facilitate leader formation. Pruning should be done after harvesting the crop in April and November - December. It is done by cutting back of laterals to the nearest active bud as otherwise with increase in age of the lateral the basal buds become dormant or sterile. The fruits are obtained from the 10^{th} month and full bearing reaches by 16-19 months. Although its plants flower and provide fruits throughout the year, these are 2 main periods of fruiting from August to December and March to May. About 80-85 days are required from fruit set to harvest. Yield being 12-20 tonnes/ha.

III-4

Testing seed viability in passion fruit

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Passion fruit seeds are recalcitrant in nature and lose viability very fast. Germination decreases with increased period of storage. Stored seeds have a lower and slower rate of germination. To know the viability of seeds a study was carried out with seven treatments consisting of different days of extraction and sowing in different environments. The experiment was conducted with 3 replication in factorial CRD design. Observations on germination characters, germination percentage, vigor index and morphological observations were recorded. Irrespective of the environmental conditions seeds sown after 10 days of extraction recorded significantly higher germination percentage(54%) followed by 20 days extracted seeds(50.2%). There was drastic reduction in germination percentage from 54 per cent to 21.5 per cent with storage of seeds. Seeds sown after 20 days of sowing significantly took lesser days to germinate and lesser days to attain 50 per cent germination (19.50 and 27 days respectively). Among two environments, seeds sown under shade net resulted in more germination percentage (40.00%) compared to laboratory conditions ((34.49%).Sowing of seeds after 10 days of extraction increased the germination and recorded maximum germination index (1.89). Minimum germination and vigor index was recorded with seeds sown after 60 days of extraction.

III-5

Soft wood grafting in passion fruit

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Study on success of softwood grafting with yellow passion fruit as rootstock was studied. The rootstocks were raised with seeds which were subjected to pre germination treatments like GA_3, Vermivash, thiourea, cowdung, cow urine and water soaking. The design adopted was CRD with eight treatments and three replications. The age of the rootstock was 90 days. Soft wood grafting was done and kept under shade net. Observations on graft success and growth parameters were recorded. The maximum grafting success (100%) was recorded with stocks pre treated with cow urine followed by GA_3 500 ppm(86.66%) and vermiwash(86.66%) which are on par with each other. Graft height was recorded maximum (28.88 cm) after 90 days of grafting in cow urine treatment and number of leaves was maximum in cow dung slurry treatment. The results showed that soft wood grafting is highly successful and commercially adopted for large scale multiplication.

Avocado and jackfruit trees for multipurpose use in coffee eco systems

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The coffee plant originated in the forests of Ethiopia as an understory tree species. Coffee farmers have for centuries grown coffee under shade and intercropped with various fruit tree species for shade, food and income. Nearly 50 different types of shade trees are found in coffee plantations. Shade trees prevent soil erosion besides enriching the soil by recycling nutrients and create conducive microclimate and protect coffee plants from seasonal fluctuations of climate, pest and diseases. The impact of some underutilized fruit crops like Avocado and Jack fruit on health of coffee plants is little known. The Jackfruit and Avocado considered as underutilized fruit crops as their uses limited to certain regions of the country and at present gaining importance in India through value added products. To understand shade pattern and soil nutrient enrichment by Avocado and Jackfruit trees in coffee ecosystem a study was carried out at Coffee Research Sub Station (CRSS), Chettalli, N-Kodagu. The results indicated that the growth of Avocado and Jack fruit is comparable with other prominent shade trees like Ficus and other Sps. The net photosynthesis (Pn) was higher under multiple shades of Jack, Ficus, Avocado and Erythrina trees in both S.795 (66.02%) and Cauvery (45.23%) coffee cultivars which was associated with reduced transpiration rate (E), vapour pressure deficit (VPD), leaf temperature (Tleaf), photosynthetic active radiation(PAR) and higher relative humidity (RH%). The cultivars under Silver oak mono shade exhibited lower Pn higher E, VPD, leaf temperature, higher PAR and less RH% indicating adverse influence of mono shade on coffee plants. The observations on instantaneous water use efficiency (IWUE) and carboxylation efficiency indicated significantly higher IWUE (122.7% and 123.3%) and CE (106.5% and 94.05%) respectively in both the cultivars under multiple shades of Jack, Avocado, Ficus and Erythrina trees compared to mono shade implying usefulness of Jack and Avocado trees as shade canopy to improve crop production of coffee. The mid day light intensity of these trees is more suitable as they provide 50 to 60% daylight (55,000 to 60,000 lux) to the coffee plants with around 50% relative humidity. The soil organic carbon (% OC) found to be 3.64%, 2.64% and 2.66% under Avocado, Jack and Ficus trees respectively where as 1.84% and 1.92% under Silveroak and control indicating their contribution to soil health. Both eco-physiological and soil factors improved even a way from the tree. Hence, the study indicated that coffee can be intercropped with Avocado and Jack fruit as shade trees, which can gives additional income to the grower.

III-7

Standardization of method of propagation in karonda (*Carissa caranda*)

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Karonda (*Carissa caranda*) is a hardy shrub with green foliage and thorns. The sweet ripe as well as unripe acidic fruits are of economic importance, which are a good source of vitamin "c", iron and phosphorus. Asexual methods of propagation of karonda are best for maintaining purity of promising types. Plants raised through vegetative propagation are exactly like the parent plant. To reduce the juvenile phase, the propagation studies were undertaken at RFRS, Vengurle. From pooled data, it is clearly seen that the air layering method was significantly superior over softwood grafting. In air layering survival percentage was 75.95%, which was significantly superior over softwood grafting method (62.54%). From ancillary data, it is clear that the number of leaves, height and overall quality is superior in air layering method as compared to softwood grafting.From pooled data, it can be concluded that for Karonda mass multiplication air layering method of propagation is superior over softwood grafting. Air layering method of softwood grafting is superior in terms of survival percentage, number of leaves, height of layer and in economics. In soft wood grafting water suckers are less as compared to air layering. The grafts prepared by soft wood grafting are more stout and hardy in nature. When the mother plantation is limited for mass scale production of Karonda planting material in that case softwood grafting is second better option for propagation of Karond.a

III-8

Morphological and biochemical changes during fruit development in kokum (*Garcinia indica Choisy* (Thouars))

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Fruit development studies were conducted in Kokum var Konkan Amrutaat ICAR RC for Goa during 2012-13. The flowers were tagged on the day of anthesis. Samples were periodically drawn once in 15 days during the fruit development. Observations like fruit weight, fruit volume, fruit length and diameter, rind weight and thickness and formation of seeds and seed weight were recorded. Quality (or) biochemical parameters like total acids and total soluble solids, total and reducing sugars were also estimated during the fruit developmental stages. It took 135 days from anthesis to fruit harvest. The fruit weight (5.0 to

61.79 g) and volume (5.25 to 59.84 cc) followed a sigmoid pattern of growth. There was a gradual increase from anthesis to 45 days after anthesis. Later on, there was a sharp increase by two fold, followed by a second phase of gradual increase. Similarly, fruit length (1.90 to 4.30 cm), fruit diameter (2.15 to 5.75 cm) and rind weight (4.32 to 40.47 cm) showed a sigmoid pattern of growth, whereas, increase in seed weight (0.69 to 21.32 g) showed a double sigmoid growth pattern. The rind thickness reached 0.5 cm after 30 days of anthesis and remained constant up to harvest stage. Unlike in other fruits, total solids (6.4 to 13.2 %),total sugars (3.42 to 10.02%), reducing sugars (0.7 to 5.81%) and also total acids (6.4 to 9.4%)), kept increasing during the development of fruit.

III-9

Jackfruit in tamil culture

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Archeological findings in India have revealed jackfruit was cultivated in India 3000 to 6000 years ago. The jackfruit is one of the three auspicious fruits of Tamil Nadu, along with the mango and banana, known as the *mukkani*. In Tamil, the riddle mean the jack fruit goes like this "*Appan Soriyan Aathaal Sadaichi Pullai Sakkaraikutti*" meaning the father is a man with itches, the mother is a woman with a lot of hair, but the kid is as sweet as sugar. The presence of jackfruit trees, each with a bunch of jackfruits, in a country indicates the country's fertility in those good old days. The ones that grow in the roots are called as *Vaer Palaa*. *Vaer* means root, so *Vaer palaa* means the one fruit grows in the root. The taste of jackfruit soaked in honey, ghee and jaggery from cow's milk showed excellent taste in ancient times. The tender fruits and seeds were used to prepare several delicious dishes. The timbers, leaves and latex were used for various purposes in ancient days. The jackfruit is one of the three auspicious fruits of Tamil Nadu, along with the mango and banana, known as the *mukkani*. These are referred to as *ma-pala-vaazhai* (mango-jack-banana). The onset of summer indicates the arrival of the Mukkani. The jackfruit forms part in auspicious festivals, especially the Tamil New Year. These three fruits (*mukkani*) are also related to the three arts of Tamil (*mu-Tamizh*). With this background, this paper deals about the description, ecology, eco-types, value addition and byproducts of jackfruit in Tamil culture.The ancient Tamil poem *Purananooru* stanza 374 said "Under the jack fruit tree the wandering mistrel, *Panan* (Muscian) bears his drum. The bear which is nearby turns its ears to catch the music on the mountains of Arthivan that is full of *karum kurinji* (one kind of flowering plant, which flowers once in twelve years).The famous *Sangham* Tamil poem *Akanaanuru* stanza 348 said "The ripe, sweet, aromatic mangoes of summer from the stout trees in the yards and the glowing inner segments of green skinned jackfruit, mixed with honey, age in long bottles, section of swaying bamboo, and brew into a liquor as powerful, as quick as viper. The hills men offer it first to the mountain sky peak and living god; soon get drunk on it, served by their women in leaf skirts, and forget to guard the millet fields on the slopes which elephants attack and ravage". The jackfruit grown on Kolli hills in Namakkal district (ruled by one of the seven great philanthropists of ancient Tamil Nadu, Valvil Ori around 200 AD), known for its taste and fragrance and is often soaked in wild honey that is also harvested from these mountains.Even in many *pasurams* (worship songs) by Thirumangai Azhwar in *Naalayira Dhivya Prabandham*, he mentions about jackfruit soaked in honey. In Tamil Nadu, seeds of jackfruit can be used in many culinary preparations as boiled or roasted item and sometimes even the outer skin is used in the cuisine. The seeds are cooked, roasted and used in combination with *Pulikkulambu* (Tamarind Gravy), *Karuvaadu* preparations (Dried Fish) and of course other spicy varieties like *Sundal* etc.Jack timber is valuable for making furniture as it is rarely attacked by white ants. It is also used to make the body of the Indian string instrument *veena* and the drums *mridangam* and *kanjira*; the golden yellow coloured timber with good grains is used for building furniture and house construction in India. The ornate wooden plank called *avani palaka* made of the wood of jackfruit tree is used as the priest's seat during Hindu ceremonies in Kerala. The leaves and skin of fruits are a good source of cattle feed. The leaves are used as a wrapping for steamed *idlis*. The latex from the bark contains resins, and it is used to plug holes in earthen vats and buckets.

III-10

Effect of coloured shade nets on softwood graft success in jackfruit

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An experiment was carried out to know the effect of coloured shade net on softwood grafting at K.R.C.College of Horticulture Arabhavi. Four colour nets i.e. Black, Red, Blue and Green colour shade nets were compared for graft success and growth. Thirty days old rootstocks were soft wood grafted and kept under coloured shade net. The design adopted is CRD with five replications. Observations on grafting success, per cent survival and growth parameters were recorded. Significantly the highest per cent graft success (34.68%) and graft survival(79.91%) was recorded in red colour shade nets and lowest graft success and survival was recorded in green coloured shade nets(30.09% and 621.91% respectively). Higher graft height, number of sprouts and number of leaves were recorded in grafts kept under red shade nets compared to green shade net.

III-11

Effect of invigorated shoots on grafting success in jackfruit

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The success of jackfruit by grafting is very less compared to other fruit crops especially under dry areas. Under dry conditions higher success could be achieved by juvenile grafting or epicotyl grafting. However it cannot be practiced throughout the year due to non availability of young seedlings. Under such conditions the old rootstock can be head back and invigorated shoot may utilize for better success. Study was carried out to know the effect of age of invigorated shoot on grafting. Different aged rootstock ie. 5,10,15,20 and 25days old invigorated shoots were grafted with four replication following CRD design. Observations on grafting success, survival percentage and growth parameters were recorded. The results showed that significantly highest grafting success and survival (22.25% and 76.75% respectively) was found in 10 days old invigorated shoot and the lowest per cent graft success and survival was found in 25 days old invigorated shoot (11.00% and 60.50% respectively).Regarding growth parameters 15 days old invigorated shoots recorded maximum number of sprouts, leaves and sprout height compared other shoots. The results showed that 10-15 days old invigorated shoot could be used to get higher graft success and survival in jackfruit.

III-12

Effect of seed treatments on germination of marking nut (*Semecarpus anacardium)* seeds

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Marking nut is a moderate sized deciduous tree belonging to family anacardiaceae. The stem yields an acrid juice from which a varnish is prepared. The nut yields a powerful and bitter substance used as a substitute for marking ink. The fruits are also used as a dye. They are also largely employed in Indian medicine (allergic, poisonous bites, cough, asthma etc.). An experiment was conducted on marking nut seeds to study the effect of different treatments on germination at K. R. C. College of Horticulture, Arabhavi. Marking nut seeds were sown in poly bags of 5”x8” size filled with soil and FYM (1:1 ratio) .The design of experiment was completely randomized block design with 16 treatments replicated 3 times. Observations were recorded on germination percentage, number of days taken for initiation and completion of germination. The results showed that seeds treated with 1 % KNO_3 solution for 12

hrs and water for 24 hrs showed maximum per cent of germination (61.67 %) which was on par with seeds treated with cow urine for 48 hrs (58.33 %) compared to control (43.33 %). Minimum per cent of germination (23.33 %) was recorded in seeds treated with conc. H_2SO_4 for 3min. Seeds treated with conc. H_2SO_4 for 3min and 5 min, 1 % thiourea for 12 hrs, GA_3- 100 ppm for overnight, cow urine for 24 hrs and 48 hrs took minimum number of days (33) to complete 100 per cent germination while seeds treated with hot water treatment at 65^0 for 10 min took maximum days (50) to attain 100 per cent germination.

III-13

Effect of different seed treatments on germination of charoli (*Buchanania lonzan*) seeds

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Charoli is an important minor indigenous fruit of India belonging to the family anacardiaceae. **It** has potential commercial value as important arid zone horticulture crop because of its hardy nature and high yielding potential. The fruits are good source of fat, protein, minerals, sugars, starch and tannins. The kernels are used in sweet preparation and vinegar. The kernels form a substitute for almonds.An experiment was carried out to study the effect of different seed treatments on germination at K. R. C. College of Horticulture, Arabhavi. Charoli seeds were sown in poly bags of 5”x8” filled with soil and FYM (1:1 ratio). The design of the experiment was completely randomized block design with 13 treatments replicated 3 times. Observations were recorded on germination percentage, number of days taken for initiation and completion of germination. The results showed that for complete germination seeds treated with conc. H_2SO_4 for 3min took minimum number of days (25) where as seeds treated with 1 % KNO_3 solution for 12 hrs took more number of days (40). The seeds treated with water for 24 hrs showed maximum per cent of germination (65 %) compared to control (48.33 %). Minimum germination per cent (8.33 %) was recorded in seeds treated with conc. H_2SO_4 for 3min.

PKM 1 Manila tamarind – a boon for farmers of vertisols and alfisols both under rainfed and irrigated conditions

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Manila Tamarind is an important economic crop especially in Southern Districts of Tamil Nadu. It is a drought tolerant tree suitable for semi arid and arid zone condition. It is highly tolerant to fire and regenerates rapidly by basal or aerial shoots. It is grown as border crop, fence crop and inter crop with other forest tree species. Recently farmers have started to cultivate this crop as pure crop, using grafts as propagation material. The crop is economically grown in the districts of Ramanathapuram, Sivagangai, Virudhunagar, Theni, Madurai, Thoothukudi and Thirunelveli in Tamil Nadu. The crop is also cultivated in Tiruchirapalli district especially in the blocks of Edhumalai, Thathaiyangarpettai, saline and alkaline soil areas of Manapparai. In Thanjavur district, the crop is grown in the blocks of Thiruvarur, Narimanam, Sikkal and Swampy areas of Vedaranyam both for edible fruit as well as live fence and wind break. In North India, the crop is cultivated as arid zone crop in Gujarat and Rajasthan states. In Hindi, it is known as jungle jilebi. In several countries, it is cultivated (African Island, Northern Mariana Island (USA), Alamagan Island (USA), Pagan Island (USA), Sarigan Island (USA), Vanna Reru Island (USA), Guam Island and Hawaii regions. PKM 1 Manila tamarind is a selection from high yielding trees screened from Soolakkarai and surrounding villages near Virudhunagar in Virudhunagar district where plantations are available. The age of the parent tree (seedling) is around 45 years. The mother tree located at Soolakkarai of Virudhunagar district in Tamil Nadu was vegetatively propagated and was evaluated for growth and yield parameters at Horticultural College and Research Institute, Periyakulam and released as PKM 1 Manila tamarind. Tamil Nadu Agricultural University is the first university which would release economically important minor fruit in India. The clone is distinguished from other varieties owing to its high yield, bold sweet arils without acridity even at tender stage. In the regular season the harvest commences from 1st week of March and extends upto 1st week of May. Peak harvest is taken up between March last week and April 2nd week. Early maturity is observed. In addition, off season fruits are harvested during September – October. No disease incidence was observed under field conditions. The bird and bat damages were observed during fruiting season. The fruits are spirally twisted with prominent constrictions. The arils are bold and sweet and no acridity even at tender stage. Exhibits higher level of tolerance to drought and sewage water inundation. Vegetative propagation by grafting (either soft wood grafting or inarching) is recommended for multiplication. The salient features of PKM 1 manila tamarind are clonal selection from open pollinated seedling with compact drooping canopy amenable for high density planting (tolerate severe pruning of branches). It bears regularly in clusters (2 – 3 / cluster) and has spirally twisted fruits with clear constrictions, pale yellow pods, white aril and black seeds. It possesses total soluble solids of 18° Brix and suitable for the preparation of sweet candies. It is a high yielder (79 kg / tree / year : 11.85 t / ha) and tolerates brackish water, waste water. water / sewage water stagnation, sandy, saline and alkaline soils. The fruits contain moisture content (80.4%), total carbohydrate (14.25%), reducing sugars (1.3%), total free amino acids (1.76%), total protein (2.28%), titrable acidity (0.35%), fat (0.5%), total phenols (140 mg/100g edible portion) and ascorbic acid (134 mg/100g edible portion).

III-15

Standardization of propogation technique in mangosteen (*Garcinia mangosteena*)

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Mangosteen (*Garcina mangostena*) native to South East Asia, but it comes well under konkan conditions. Mangosteen is usually propogated by seed. The seed lose viability quickly, and must be planted fresh. Mangosteen planted by seedling takes 8 to 9 years for fruiting, but sometimes it takes more than 10 or even 20 years. Hence, for shortening the juvenile period there is urgent need to standardize propogation technique in mangosteen, with this view the studies were undertaken at Regional Fruit Research Station, Vengurle. Various age of seedlings, length of scion stick and season of grafting there parameters were taken for studies.It was observed that the twelve months age old seedling used for grafting was significantly superior over rest of the treatments. A twelve month old seedling recorded 74.38% sprouting with 49.83% graft survival after one year. Length of scion sticks influenced the sprouting and survival percentage. Scion sticks of 15 cm length used for grafting recorded 72.61% sprouting which was significantly superior over rest of the treatments. Grafting in September was significantly superior over rest of the months. From pooled data, it can be concluded that twelve months age old seedling with 15 cm length scion stick used for soft wood grafting during September month recorded success up to 70-72% for mangosteen.

Effect of different pruning levels on growth, yield and quality parameters in tamarind (*Tamarindus indica* L.)

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Tamarind is a productive tree spice crop and one of the most popular trees found throughout India as stray plantation or avenue. The fruits are used for various culinary purposes all over the country. The wood is used in cartwheels, rice pounders, oil mills, etc. The bark is used in tanning; the tender leaves and flowers are eaten as vegetable. The decoction of bark is useful in diarrhoea. The seeds are rich in pectin. Though it is a deciduous crop and has the tendency of alternate bearing, crop load regulation has not yet been taken up. Pruning is necessary to have regular crop load every year. With this background, an experiment was conducted with four levels of pruning in 15 years old tamarind cv. PKM 1 trees at Horticultural College and Research Institute, Periyakulam to study the effect on growth, fruit yield and quality. The pruning treatments consisted of T_1 - Control (unpruned), T_2 - Light pruning, T_3 - Medium pruning and T_4 - Severe pruning. Light pruning was done by leaving 5th branching shoot on the tree and removing only terminal branches. Medium pruning was carried out by leaving 4th branching shoot on the tree and removal of remaining branches. Severe pruning consisted of leaving 3rd branching shoot on the tree and removal of remaining portion. The pruning operations were carried out after the harvest of fruits (i.e.) during April. The observations namely tree height, plant spread, fruit length, fruit breadth, fruit yield, pulp recovery and tartaric acid were recorded and the data were subjected to statistical scrutiny. Studies conducted in tamarind cv. PKM 1 with three different levels of pruning revealed that the lightly pruned trees (T_2) recorded the highest plant height (7.94 m), plant spread (EW – 9.74 m and NS – 9.67 m), fruit length (8.45 cm), fruit breadth (3.05 cm) and pod yield (244.25 kg/tree), pulp recovery (43.75%) and tartaric acid (10.50%). The light pruning (T_2) i.e. pruning done by leaving 5th branching shoot on the tree and removal of remaining terminal branches during April resulted in more flowers and fruit set, which could favorably leads to higher yield than the unpruned trees.

III-17

Nutrient requirement of aonla

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Aonla or Indian gooseberry *(Emblica officinalis* Gaertn*)* has immense potential to utilize and conserve rained area for betterment of poor farmers. Aonla provides higher economic returns with little investment in plantation, establishment and its management.For maintenance of tree health and to obtain regular yield, the application of manures and fertilizers are required. So for nutrient requirement of Aonla under this region was not studied. Hence, the study was undertaken with combination of chemical and organic fertilizers at Regional Fruit Research Station, Vengurle. Seven various levels of fertilizers were tried.Growth parameter like tree height, Spread (N-S & E-W) of Aonla trees increased with age. The maximum height as well as fruit yield was recorded in treatment F_5 {(250: 250: 250 g NPK/plant/year) + (10kg FYM/plant/year)}. From pooled data, it is concluded that the treatment F_5 {(250: 250 : 250g NPK/plant/year) + (10 kg FYM per plant per year)} recorded highest yield (6.33 MT/ha) with better physico chemical properties. The nutrient balance status shows that the treatment F_3 (750: 750: 750 g NPK/plant/year) recorded highest values for N(33.117 kg/ha); P (59.24 kg/ha) and for K (321:87 kg/ha). Among the seven treatments tried, F_5 {(250: 250 : 250 g NPK/plant/year) + (10kg FYM/plant/year)} was significantly superior and recorded highest B:C ratio 1:2.39.

III-18

Seed germination studies in *Baccaurea courtellensis*- Muell Arg. A threatened under-utilized fruit species of Western ghat region

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Baccaurea courtrallensis, Muell Arg. a member of Euphorbiaceae family popularly known as *Burmee's grape* or *Khattaphal*, is endemic to Western Ghats of India. Fruits of this plant are eaten and used in folk medicines and making pickles by village folk of Western Ghats of India. The IUCN has listed this species as a threatened species in its red data book. A study was taken up to understand seed germination and storage behavior as this plant is propagated mainly through seeds. Fruits and seeds collected from Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Palode, Trivandrum were used in this study. Germination was maximum (96.7%) when seeds were sown immediately after extraction with moisture content of around 50%. Reduction in moisture from initial 50 % to 34

% showed little decrease in germination but further drying resulted in drastic reduction. Dried seeds took more time to germinate than fresh ones. Seeds with m.c. 21% recorded about 60% germination whereas seeds with m.c. 10.2% and 8% failed to germinate indicating recalcitrant nature of the seed. Temperature in the range of 25 to 30 ^{0}C was found optimum as the seeds subjected for this temperature range showed higher and rapid germination compared to alternate temperature of 20-30 ^{0}C and constant 35 ^{0}C. The seeds exposed to room temperature of 24-28 ^{0}C and constant 30 ^{0}C took only 20 days to attain germination of 84-85% whereas at other two temperature regimes the germination was only 51-59% after 20 days. However, the final germination count after 43 days of sowing was almost same across the temperature regimes. Out of two media tried to raise seedlings, cocopeat medium was found to be ideal as it supported faster growth of seedlings. The root and shoot length was considerably longer in cocopeat than in soil mix medium so also the survival rate of the seedlings. Establishment of seedlings was poor when planted out of its habitat.

III-19

Effect of growth regulators on seed germination of ker (*Capparis decidua*)

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Ker (*Capparis decidua*) belongs to family Capparidaceae is one the important underutilized fruit/ medicinal plant which is mainly distributed in arid regions and other parts of the country. The xerophytic plant generally found in desert area and highly drought resistant. Fruits are used as vegetable, preparation of pickle and food additives. The investigation was carried out at CIAH, Bikaner by using growth regulators and chemicals like giberellic acid, KNO_3, Salicylic acid at different concentrations along with hydration and control. The significant differences were found among the different treatments for germination characters. The early initiation of germination and 50 per cent of germination was observed in the seeds which were treated with GA_3 300 ppm (7.2 and 7.8 days) which were at par with GA_3 200 ppm (7.4 and 8.0 days) and GA_3 100 ppm (7.6 and 8.4 days) and delayed germination was in control (11.80 and 14.2 days). The maximum germination percentage was noticed in the seeds treated with GA_3 300 ppm (97.33 %) which was at par with GA_3 200 (94.66 %) and GA_3 100 ppm (91.99 %) and minimum was in control (64.0 %). There is no much problem in germination but the major problem is survivability of seedlings which varies from 22 to 30 per cent and the growth of seedlings is also very slow. Hence there is lot of scope to work on growth and survivability of seedlings.

III-20

Myristica prainii King seeds - An alternate source of myristic acid

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Myristica prainii King, a member of the family Myristicaceae, is an evergreen tree used in tribal medicine. Its fruits are red, ovoid, edible and resinuous in flavor. Fresh fruits were collected and pericarp, mace and nut were separated and dried. The results indicated that the butter from *M. prainii* seeds can be a substitute for *M. fragrans*. In Indonesia bark is used to treat sprue. Its pharmacological properties are unexplored. The nuts were extracted with petroleum ether and the extract was concentrated and fatty acid profile was determined by GC- MS. Lauric acid is reported first time in *Myristic afragrans*. *M.fragrans* contains more saturated fatty acids compared to *M.prainii*.Myristolenic acid , the second most abundant compound in *M.prainii*, is absent in *M fragrans* . Dried seeds yielded about 35% oleoresin. The fatty acid profile of nuts was determined by GC-MS. It contained 78-83% myristic acid, 7.7-8.2% myristoleic acid and 5.8-7.4% palmitic acid. The fatty acid profile was compared with that of *M. fragrans*. The medicinal uses of its constituents are discussed.

III-21

Enhancing the germination of nutmeg (*Myristica fragrans*) seeds

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The Nutmeg (*Myristica fragrans*), being a dioecious crop the seedling progenies segregates into male and female, which resulted in the probable production of more number of unproductive male plants. The viability of nutmeg seeds decreases with loss of moisture and the seeds loose total viability within a short period of storage and thus the seeds are classified under recalcitrant group. The seeds loose their viability when 20 percent of their moisture content is lost and under tropical conditions, it occurs within seven days of storage. The seeds possess a hard brittle seed coat, which prevents or delays the germination. They study conducted to enhance the germination revealed that the germination percentage is increased to 90 percent by decoating the seeds, while it was 37.5 percent in seed coat intact seeds. The decoating is done very carefully without any damage to the embryo. The decoated seeds take 7 to 10 days for germination, while intact seeds look 30 to 60 days.

III-22

Production potential of clove (*Eugenia caryophyllata)* in off-season

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Extended availability and off-season production of clove can help India to play a major role in the international market. In the Southern Peninsular India, the cloves are produced when it is off-season to other parts. Besides the normal crop (December to February) in certain pockets of Kanyakumari, it gives off-season crop (July to August). The off-season bearing though a genetic phenomenon was induced by favourable seasonal and climatic conditions. This has been attributed to the influence of fairly well distributed rainfall, ambient temperature, fairly high nutrient rich soil and high RH of this tract. The studies conducted during the years 2007-2009 revealed that, 25 percent of the population in the clove orchards have produced off-season crop. The yield ranges from 0.5 – 3 kg dry bud / tree, the 100 bud weight ranges between 6.60 to 7.12 g. The flower clusters per square meter area of canopy ranges from 10-33, and the buds per square meter canopy area ranges from 40 – 128.

III-23

Standardization of propagation time of cashew nut by soft wood grafting under eastern vidarbha zone of Maharashtra

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Although cashew nut is one of the major cash crop of India, its commercial potential is yet to be exploited in the eastern Vidarbha zone of Maharashtra. It is sparsely grown in this zone and most of the existing plantations are of seedling origin which usually are genetically heterogynous and hence varies in quality and quantity. Although the climatic condition prevailing in this region has found to be suitable for its commercial cultivation, it is very difficult to fulfil the need of true to type planting material due to less grafting success. Seasonal influence on grafting success is one of the important factor governing success percentage. Hence, the present study was undertaken at Taluka Fruit Nursery, Wakadi, DistGadchiroli, Maharashtra state during 2011-13 to find out the appropriate time for soft wood grafting in cashew. Soft wood grafting was carried out on one year old healthy rootstock at monthly interval from first week of July to first week of November. The experiment was laid out in Randomized Block design and replicated four times. Observations were recorded for number of days required for sprouting, sprouting percentage, length of sprouted shoot and survival percentage of grafts. Results revealed that grafting performed in the first week of July gave earliest sprouting in 17.55 days with maximum sprouting (73.33%), shoot length (1.17 cm) and survival percentage (67.5%) of cashew grafts.

III-24

Micropropagation studies of pomegranate (*Punica granatum* L.) Var. Bhagawa

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In the present investigation, the Bhagawa variety of pomegranate was undertaken for micropropagation in which total five sub experiments were carried out. In this experiment CRD was applied for laboratory experiment and RBD for field experiment to find out best explants, surface sterilents, shooting media, rooting media and hardening mixtures. Regarding the suitability of explants, shoot tip was best for culture establishment. The study on surface sterilization revealed that explants treated with 0.1 per cent mercuric chloride for 10 minutes showed the maximum survival percentage and less contamination percentage. Shoot differentiation study showed that maximum number of shoots per shoot tip explant was recorded in treatment containing MS + BAP 2.0 mg/l, maximum shoot length was observed on medium containing MS + BAP 2.5 mg/l and maximum number of leaves was recorded on medium containing MS+BAP 2.5mg/l. Among the auxins used in the rooting experiment, the maximum number of roots per shoot tip explant was recorded in treatment containing ½ MS + NAA 6 mg/l. Maximum root length was found on medium containing ½ MS + IBA mg/l, while hardening in different hardening media, it was observed that maximum survival of plantlets from shoot tip explants were found on medium containing soil + sand (1:1v/v).

III-25

Effect of ethrel on the physiological changes during ripening of off-season fruits of mango (*Mangi feraindica* L.)

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In the present investigation matured detached fruit (off-season) *Mangi feraindica* L. var. Neelum was used to study the ripening process. The control fruits were kept in the laboratory naturally while the experimental fruits were treated with different concentrations of ethrel (100,200 and 300ppm).In control fruits, partial ripening led to incomplete metabolic changes, which did not alter the presence of sourness in the fruits. Hence,they were not fit to be eaten on the other hand, the fruit treated with different concentration (100,200 and 300ppm) of ethrel ripened on 13^{th} day, 11^{th} day and 9^{th} day respectively after

treatments. The colour changed from green greenish to yellow and fruits were palatable in nature. All the experiments were carried out using the peel and the pulp of fruits tissues individually and the following results were obtained during the process of ripening. The chlorophyll content decreased during ripening both in the control and treated fruitson the other hand, respiration and ethylene production increased. Among the different 100,200 and 300 ppm ethrel treatments, the 200ppm alone had the optimum effect on the ripening of off-season fruits of*Mangiferaindica* L. varNeelum.

III-26

Technology adopted to save the fruit crops most particularly orchards of sweet orange during drought hit condition of Marathwada

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Area under fruit crops in Marathwada is more than 85000 ha out of which sweet orange occupies a major share of 52500 ha followed by Mango (19300 ha) pomegranate 4500 ha besides Guava Sapota, Banna, Grape,Custard Apple and Anola with constitutes nearly 8500 ha collectively. Sweet Orange orchards are mostly concentrated in Aurangbad in jalna districts and are severely affected fur to drought like saturation and majority of them are facing extinction. Average annual rainfall of Aurangbad division which comprises Aurangabad Jalna and Beed districts is 680 mm but his year the total rainfall is just 378 mm (nearly 56 %). in view of this fact water availability of this division is just sufficient to meet during water requirement of human and cattle wealth. However availability of water for irrigating crops in general and orchards crops in particular is almost negligible.

III-27

Rejuvenation of old avocado trees

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The present investigation to rejuvenate the old avocado trees were conducted at Horticultural Research station, Tamil Nadu Agricultural University, Thadiyankudisai during the year 2014. Rejuvenation of old and unproductive avocado trees have to be improved through 'top working' method. Top working is the process of changing fruit varieties on mature trees. Top working was done involving 40 years old unproductive avocado trees. This method of grafting will maximize the yield without much investment and uprooting of the old trees. Under the technique, unwanted branches of the old trees should be pruned at a height of 1 to 2 metres above the ground level during the month of August. The exposed surface of the trees would be treated with fungicide to protect it from infection. After four months of pruning, shoots would emerge from the branches. At this stage, selective and regular thinning would facilitate for the development of canopy. Except five to six healthy shoots, others have to be clipped off for the development of the canopy. After rejuvenation, the desired variety of avocado (TKD-1) can be grafted on the newly emerged four to five selected shoots through cleft grafting method during the month of November. After grafting, the union has been wrapped with a plastic strip of desired length. The plastic strip has to be removed after the proper success of graftage. Unwanted shoots from the stem should also be removed or clipped during this period. Grafted trees require intensive and timely care to get optimum production for the forthcoming season.

III-28

Standardization of propagation methods of litchi

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The present investigation was carried out at Horticultural Research station, Tamil Nadu Agricultural University, Thadiyankudisai, India during the year 2014 with the objective of mass multiplication of litchi plants through semi hardwood cuttings. Litchi is one of the subtropical evergreen fruit crop and having juice of excellent quality. To avoid the high variability and long juvenile period, asexual propagation method is recommended for commercial cultivation. The treatments were imposed on semi hard wood cuttings with 20 cm length in the litchi cultivars namely, Shahi, Mclean, Bombay and Culcuttia. The cuttings were treated with 10000 ppm of Indole -3 Butyric Acid (IBA) solution. Forty cuttings were used for each cultivar along with untreated control were planted at nursery. Observations on germination percentage and seedling growth characters like number of shoots, shoot length, root length and number of leaves were also recorded during the study. The results indicated that germination percentage and plant growth characters were positively increased in the cultivar Culcuttia followed by Shahi, Mclean and Bombay.

Production and marketing practices of manila tamarind in Virudhunagar district of Tamil Nadu – A case study

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The Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam has released a variety in Manila Tamarind in the name of PKM (MT) – 1 which is capable of yielding 30 per cent higher yield than the traditional variety. It is a selection of Choolakkarai of Virudhunagar District suitable for sandy, alkaline and saline soils. Its yield under normal conditions could be around 80 kgs per tree per annum. However, the progressive and innovative farmers numbering around one thousand in number in Virudhunagar District of Tamil Nadu are cultivating Manila Tamarind in a big way. Some of the farmers were permitting the natural growth of Manila Tamarind and are regulating for space, nutrients and yield. Some of them are planting the selected best yielding saplings and are regulating for higher yield after following intensive silvicultural practices. One such progressive farmer is Mr. Periandavar, Choolakkarai Village of Virudhunagar District is interviewed following the case study approach with regard to Production and Marketing Practices which are prevalent in Manila Tamarind. In this district, around one thousand farmers were involved in cultivating Manila Tamarind. Yearly once the Manila Tamarind could yield and the normal harvest could be realized. But in this belt, because of intensive management practices, they could harvest the yield of Manila Tamarind twice in a year. The age gradations of the Manila Tamarind trees were ranging from 3 year to 50th year old in the case farm. During the fruiting season, the menace of bats could be alleviated by adopting the Indigenous Practices with the farm. With regard to marketing practices, there were commission agents spread over in Virudhunagar District and they command the entire output produced in the district and the same are dispatched to different consuming centers in Tamil Nadu and other parts of India. Amidst these, there were some peculiar constraints which are manned by the progressive farmers and are gaining higher dividend from the Manila Tamarind Plantations.

III-30

Effect of different mulches on growth, yield and quality of fig

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The common fig (Ficuscarica) is a species of flowering plant in the genus Ficus,from the family Moraceae, known as the common figgrown commercially. Figs are high in natural sugars, minerals and soluble fibre. Figs are rich in minerals including potassium, calcium, magnesium, iron and copper and are a good source of antioxidant vitamins A, E and K that contribute to health and wellness. The study was conducted on the effect of different mulches on growth, yield and quality of fig in which for experimental analysis RBD had been used with seven treatment of Black, Silver, Bicolour polythene, Dry grass, Wheat straw, and control. The investigation result indicates that among the different mulching treatments maximum shoot length, Number of new shoots, leaf area, fruit diameter, weight and volume of fruit, TSS, Acidity, Ascorbic acid, Reducing non reducing total sugar, soil moisture, soil temperature found significant result in Black polythene followed by dry grass much than other treatments. Organic coarbon was higher in dry grass followed by leaf littre and wheat straw even the dry matter production is higher in these treatments. The benefit cost ratio was higher in dry grass followed by black polythene than others. Present study reveals that better growth, yield and quality of fig can be achieved by using black polythene and dry grass for better performance under organic mulches.

III-31

Factors determining cultivation of underutilized fruits in Coorg region

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There is a potential for cultivation of underutilized fruits like Avocado, Rambutan, Litchi, Passion fruit, Kokum, Mangosteen, Karonda, Sour sop, in Coorg region. Central Horticultural Experiment Station, Chettalli and IIHR contributed to development of improved crop production technologies of Kaveri hybrid Passion Fruit, Rambutan varieties Arka Coorg Arun and Arka Coorg Peethab and also undertaken systemic studies for adoption of underutilized fruits. Factors determining cultivation of underutilized fruits listed by farmers are about 88.9% of farmers expressed lack of awareness about underutilized fruit crops and varieties, followed by shortage of genuine planting material of underutilized fruits (45%), elephant damage of farms (22.2%), lack of credit facilities (22.2%), and lack of interest and motivation for cultivation of underutilized fruits and profound involvement in remunerative crops like coffee and pepper (11%), prevalence of absentee landlordism(11%) and lack of awareness about organic fertilizers(11%) as major factors. Therefore, cultivation of underutilized fruits can be enhanced by considering these factors and certainly improve productivity in underutilized fruits, restore farmer's confidence and also enable diversification of cropping pattern.

Effect of season and pre curing of scion on soft wood grafting of jamun

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The work was carried out at Kittur Rani Channamma college of Horticulture Arabhavi to know the Season and Pre curing of scion on soft wood grafting of Jamun. The influence of pre-curing of scions on softwood grafting success was studied. Pre-curing of scions showed significantly higher graft success percentage with 10 days and 20 days pre-curing (70.50%) and lowest in control (30.50%). Cent per cent graft survivability was recorded in grafts which pre-cured for 10, 15 and 20 days. Maximum graft height was recorded in grafts which received 20 days of curing and minimum was recorded in control. Grafts with five days pre-curing recorded significantly highest number of leaves and least was recorded in control. Significantly higher per cent graft success was recorded in May month grafting (84.50%) and Lowest in January and December month (18.50%). The graft survivability at 125 days after grafting did not show significant difference among treatment. Significantly highest graft height was recorded in May grafted plants. Significant differences were observed for number of sprouts and number of leaves among the treatments.

III-33

Grafting in ber

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Ber (Zizyphus mauritiana) is an economically important tropical fruit tree, which is grown all over the drier parts of the Indian subcontinent, Africa and northern Australia for its fresh fruits. It is a particularly good tree to grow in dry regions, because it can withstand long periods of drought. It has a long taproot and can withstand high temperatures during the summer.Generally, vegetative propagation involves grafting of the budwood from a scion of a mature good quality tree onto a seedling raised from seed obtained from a selected rootstock tree. This guarantees the growth and fruit quality of the new tree. There are two main types of grafting, bud grafting (also known as budding) and shoot grafting. Bud grafting is the most common, economical and easiest method used for ber. The procedure is detailed below.Bud-wood becomes available during the active growth period in the summer. Buds from juvenile shoots should be collected. Juvenile shoots can be induced to grow by severe pruning of the mother trees. The bud sticks, with well swollen and recently matured buds (but still not open) should be collected. Immature and undeveloped buds from the upper part of the new shoots are unsuitable, similarly, over mature and inactive buds should not be used. Buds collected from a flowering shoot also give very poor success. After collection, the bud-wood may be stored for some period or may need to be transported. The bud-wood retains good viability when kept under ventilated conditions and wrapped in moist jute cloth or in polythene sheeting and moist sphagnum moss.

SESSION IV

BIOTIC STRESS - CURRENT SCENARIO AND MANAGEMENT STRATEGIES

LEAD PAPERS AND ABSTRACTS

Insect pests of tropical and sub-tropical underutilized fruits

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The tropical and subtropical regions are mainly distributed between 0 to 30° North and South latitude up to an elevation of 600-700m MSL on the globe besides some exceptions of special geographical conditions. The underutilized fruits in these geographical regions are acclimatized well and some of them have attained the status of commercial cultivation by virtue of their quality and nutritive value, productivity, responsiveness to various agricultural and horticultural technologies. The availability of these species are widely distributed in these regions with varying concentrations as some species have wide distribution while some are localized to certain specific pockets. The damage caused by most of the pests is often not very apparent in such crops, as many of these crops are not grown extensively, and have not been the object of any special investigation. If extensive cultivation of any of these crops is undertaken, there might be an environment which is favourable pest problem. Knowledge of these pests is very deficient as their life-history and habits have not been studied in detail. It is also quite probable that extended cultivation may bring many potential pests to light which at present escape our attention.

Jackfruit (*Artocarpus heterophyllus* Lamk.) is a hardy tree and do not have much effect of pests and diseases on it. However, some and pests sometimes cause heavy loss to the crop and plant. Jackfruit borer (*Diaphania caesalis Walker*) attacks the tender shoots, male and female spikes and fruits of all development stages. At flowering stage the larva bores into spike and feeds on internal tissues. At initial infestation, anthesis of the male spikes does not occur and later on the affected spikes are rotten and shaded off from the plant. Severely infested female spikes drop off before fruit setting. The jackfruit borer attacks the jackfruit at different stages of fruit development. Early infestation results in deformation of fruits and sometimes dropping off the immature fruits. The larvae bore into the mature fruit and cause damage to the edible part. Later infested fruits frequently get rotten due to entrance of rainwater in to the fruits. In nursery, caterpillars damage the tip of jackfruit sapling causing retardation of growth of the saplings and initiation of lateral branches. Other reported pests are *Aphis odinae* (van der Goot), *Aularches miliaris* (Linnaeus), *Ceroplastes rubens* (Maskell), *Cosmocarta relata* Distant, *Glyphodes caesalis* Walker, *Icerya aegyptiaca* (Douglas), *Icerya seychellarum* (Westwood), *Nipaecoccus viridis* (Newstead), *Ochyromera artocarpi* Marshall, *Oecophylla smaragdina* (Fabricius), *Olenecamptus bilobus* (Fabricius) and *Perina nuda* (Fabricius).

Custard apple is attacked by *Aonidiella orientalis* (Newstead), *Bactrocera zonata* (Saunders), *Coccus hesperidum* Linnaeus, *Ferrisia virgata* (Cockerell), *Howardia biclavis* (Comstock), *Icerya aegyptiaca* (Douglas), *Nipaecoccus viridis* (Newstead), *Pinnaspis strachani* (Cooley), *Planococcus citri* (Risso), *Pseudococcus jackbeardsleyi* (Gimpel and Miller) and *Rastrococcus iceryoides* (Green). Out of these pests, mealy bugs cause severe damage to fruits.

In India, the research works of Butani (1979) provided valuable information on insects pests of jamun. Kumar *et al*. (2010) have reported seventy eight insect species representing order and their species *i.e.*, Hemiptera (26 species), Coleoptera (8 species), Diptera (5 species), Lepidoptera (34 species), Thysanoptera (6 species). Among these, the Lepidoptera (34) shows the highest number of species, the Diptera (5) shows that the least number of species. Various pests reported on this crop are *Inderbabla* sp. *Acherontia styx* (Westwood), *Apoderus tranquebaricus* (Fabricius), *Bactrocera diversa* (Coquillett), *Carea angulata* (Fabricius), *Carea chlorostigma* Hampson, *Ceroplastes stellifer* (Westwood) , *Curculio c-album* Fabricius, *Homona coffearia* (Nietner), *Megatrioza hirsuta* (Crawford), *Metanastria hyrtaca* (Cramer), *Myllocerus discolor* Boheman, *Pseudococcus longispinus* (Targioni-Tozetti), *Psorosticha zizyphi* (Stainton), *Singhiella bicolor* (Singh), *Tambila gravelyi* Distant, *Trabala vishnou* (Lefèbvre). Out of these pests, the bark eating caterpillar is very serious pest on Jamun.

On Aonla, reported pests are leaf roller (*Caloptilia* (=*Gracillaria*) *acidula*), fruit borer (*Deudorix isocrates*), fruit piercing moth (*Othreis materna*, *O. fullonica*), bark borer (*Indarbela tetraonis*), aphid (*Setaphis bougainvilleae*), mealy bug (*Ferrisia virgata*), *Caloptilia acidula* (Meyrick), *Nipaecoccus viridis* (Newstead), *Rhodoneura emblicalis* (Moore), *Schoutedenia emblica* (Patel & Kulkarni), *Scutellera perplexa* (Westwood), *Virachola isocrates* (Fabricius), shoot gall maker (*Betousa stylophora* (Swinhoe), *Selepa celtis* Moore and *Indarbela tetraonis* (Moore) which belong the order Lepidoptera, whereas *Cerciaphis emblica* (Patel and Kulkarni), *Nipaecoccus vastator* (Maskell) and *Oxyrhachis tarandus* (Fabricius) of Homoptera. The pest species *Myllocerus discolor* (Boheman) and termites have also been reported to damage this crop. Out of these, shoot gall maker cause serious damage to crop.

Butani (1970) lists 8 other scale species that may be found on the tree, the young and adults sucking the sap of buds and flowers and accordingly reducing the crop. The mealybug, *Planococcus lilacinus*, is a leading pest of tamarind in India, causing leaf-fall and sometimes shedding of young fruits. Another mealybug, *Nipaecoccus viridis, is* less of a menace except in South India where it is common on many fruit trees and ornamental plants. *Chionaspis acuminata-atricolor* and *Aspidiotus* spp., suck the sap of twigs and branches and the latter also feeds on young fruits. White grubs of *Holotrichia insularis* may feed on the roots of young seedlings. The nematodes, *Xiphinema citri* and *Longidorus elongatus* may affect the roots of older trees. Other pests attacking the leaves or flowers include the caterpillars, *Thosea aperiens, Thalarsodes quadraria, Stauropus alternus,* and *Laspeyresia palamedes;* the black citrus aphid, *Toxoptera aurantii,* the whitefly, *Acaudaleyrodes rachispora;* thrips, *Ramaswamia hiella subnudula, Scirtothrips dorsalis,* and *Haplothrips ceylonicus;* and cow bugs, *Oxyrhachis tarandus, Otinotus onerotus,* and *Laptoentrus obliquis.* Fruit borers include larvae of the cigarette beetle, *Lasioderma serricorne,* also of *Virachola isocrates, Dichocrocis punctiferalis, Tribolium castaneum, Phycita orthoclina, Cryptophlebia (Argyroploca) illepide, Oecadarchis sp., Holocera pulverea, Assara albicostalis, Araecerus suturalis, Aephitobius laevigiatus,* and *Aphomia gularis.* The rice weevil, *Sitophilus oryzae,* the rice moth, *Corcyra cepholonica,* and the fig moth, *Ephestia cautella,* infest the fruits in storage. The lesser grain borer, *Rhyzopertha dominica* bores into stored seeds. Out of these pests *Cryptophelbia* sp on fruits and stored pests are serious.

On *Ficus* species, the reported pests are *Acanthodelta janata* (Linnaeus), *Amritodus atkinsoni* Lethierry, *Asota caricae* Fabricius, *Asota ficus* (Fabricius), *Badamia exclamationis* (Fabricius), *Batocera rufomaculata* (De Geer), *Ceroplastes ceriferus* (Fabricius), *Ceroplastes stellifer* (Westwood), *Euploea core*

(Cramer), *Glyphodes bivitralis* (Guenée), *Greenidea* sp., *Gynaikothrips uzeli* (Zimmermann), *Hyposidra talaca* Walker, *Icerya aegyptiaca* (Douglas), *Ocinara varians* (Walker), *Pauropsylla depressa* (Crawford), *Perina nuda* (Fabricius), *Phycodes radiata* (Ochsenheimer), *Somena scintillans* (Walker), *Stromatium barbatum* (Fabricius) and *Zanchiophylus hyaloviridis* (Duwal, Yasunaga & Lee).

The perennial nature of mulberry combined with monocultural practices, harbours several pests throughout the year with seasonal variations (Rangaswamy *et al*., 1976). The reported pests worldwide are pink mealy bug (*Maconellicoccus hirsutus),* papaya mealy bug *(Paracoccus marginatus),* leaf webber (*Diaphania pulverulentalis*), thrips (*Pseudodendrothrips mori),* spiralling white fly (*Aleurodichus disperses*), white grub *(Holotrichia sp.),* mite *Tetranychus sp.* jassid *(Empoasca flavescens),* termite (*Odontotermes obesus*), scale insect *(Saissetia nigra), Acanthophorus serraticornis* (Olivier), *Apriona germari* (Hope), *Aularches miliaris* (Linnaeus), *Glyphodes pulverulentalis* Hampson, *Luperomorpha vittata* Duvivier, *Maconellicoccus hirsutus* (Green), *Megapulvinaria maxima* (Green), *Myllocerus discolor* (Boheman), *Myllocerus viridanus* (Fabricius), *Peltotrachelus cognatus* (Marshall).

In Taiwan, more than 20 species of insect pests have been found in the carambola orchards. Among them, the fruit borer, *Eucosma notanthes* (Meyrick), is the most serious, followed by the Oriental fruit fly and citrus red mite. The plume moth, mealy bug and white fly are also of some importance. Tan (1992) reported forty-seven species from 17 families; with 16 species as flower feeders, 11 species attacking fruit, 23 species as leaf feeders, as well as one stem borer and one bark borer. Among 47 lepidopteran pests, only two serious pests of star fruit, namely, *Crytophlebia* sp. and *Diacrotricha fasciola* Zeller (a flower bud borer cum flower feeder). There were seven families of Hymenopteran. In a star fruit farm where insecticides were not used, parasitism on the larvae of Pterophorid flower moths, Lymantriid and the Limacodid leaf feeders, was respectively 35, 51 and 60 percents. *B. carambolae* is found in Malaysia, the southern (peninsular) area of Thailand and throughout western Indonesia. As per European and Mediterranean Plant Protection Organisation (EPPO, 2013) report the fly has restricted distribution in India.

No major production problem is encountered in Chalta (*Dillenia indica* (Linn). However, infestation of few pests has been observed in the fruit. Mite attack is sometimes observed which is caused by *Aculops dillenia* (Ghosh and Chakrabarty, 1989). The mites suck saps from the leaves causing them to dry up. Besides, in certain *Dillenia* growing areas, borer attack has also been found causing damage to the fruits. Recently a leaf webber has been recorded on this crop in Orissa, however its identity is yet to established.

The common insect pests of avocado (*Persea americana* Mill.) are scale insects, mealy bugs and mites. Adult bugs of *Amblypelta nitida* are green-brown and about 15 mm long. When disturbed, they may fly away, somersault to lower branches or quickly hide on the plant behind fruit or under leaves. The fruit-spotting bug is usually a slightly darker green than the banana-spotting bug. Damage is easily confused with that of the fruit-spotting bugs. In Florida, principal pests on avocado as reported by Pena and Johnson (2003) were mites (*Oligonychus yothersi, Oligonychus punicae, Tegolophus perseaflorae*), avocado lace bug (*Pseudacysta perseae*), mirids (*Daghbertus fasciatus, Daghbertus olivaceous, Rhinacloa sp.*), scale (*Chrysomphalus dictyospermi, Chrysomphalus aonidum, Ceroplastes floridensis, Hemiberlesia lataniae, Protopulvinaria pyriformis*), avocado tree girdler (*Heilipus squamosus*), red banded thrips (*Selenothrips rubrocinctus*) and red imported fire ant (*Solenopsis invicta*).

Various kinds of bugs, flies, thirps, and borers are found to infest kendu (*Diospyros melanoxylon* Roxb.) plant. Mealy bugs and pentatomid bugs are the major pests where as thrips and flies are of minor importance in *Diospyrus* sp (Kitagawa and Glucina, 1984).

Jungle Jalebi (Pithecellobium *dulce* (Roxb.) Benth) tree generally remain free from pests and diseases. However a number of defoliating and boring insect pests have been reported. Shot hole borer causes damage by making holes in the trunk which can be controlled by plugging cotton swabs soaked in petrol / kerosence. It is a favorite host for thorn bug (NAS, 1980). It has also been reported to be a host for lac insects. Browne (1968) mentioned various insects on *Pitheallobium*, which includes Coleopterus *Celosterna scabrator, Sternocera stermicornis*; Hemipterus- *Kerria lacca*, *Nipaecoccus vastator* and Lepidopterus-*Cryptophlebia illepida*, *Eucosma stereoma*, *Euproctis scintillans, Hypanartia hecabe,* and *Macroplectra nararia*. Root knot nematode species *Meloidogyne* sp. has also been reported as pest of Jungle Jalebi in Florida (Duke, 1983).

Hog plum amra (*Spondias pinnata* Linn. F. kurz.) is a hardy fruit plant grows wild in the system. No serious insect pests have been reported in this crop except that of some leaf damaging insect and fruit fly. In Brazil and other tropical region of the world where *S. mombim* is being cultivated, various polyphagus insects damaged the plant. In India, Sivakumar *et al.* (1975) from Coimbatore reported that fruit fly (*Gangara thyrsis* F.) which is a minor pest of coconut also reared from hog plum in the North West peninsula. This fruit fly is known to occur in Latin American countries like Brazil, Panama, Peru. In view of the severity of problem, bio-control measures to control the pest have been attempted in Brazil where Carvalho (2005) studied the diapausing behaviour of different parasitoids in fruit fly. Leaf defoliator (*Podontia quatuordecimpunctata* L.) in hog plum has been reported from Assam (Dekha and Kalita, 2002a, 2002b, 2003; Sardar and Mondal, 1983). Dekha and Kalita (2002a) reported seasonal occurrence of defoliator on S*pondias pinnata* under Guwahati condition. The pest initially appears during April-May with 12-18 adult and larval/100 leaves and reaches to its peak by June-July with approximately 96-180 larval and adults/100 leaves. Pest population is highly correlated with the environmental temperature and 30^{o}C has been found to be the most favourable for the pest. Low infestation was observed during October-November which was due to decrease in temperature and rainfall. Hibernation was observed during last week of November Deka and Kalita (2002b) estimated the extent of foliage loss due to defoliator. The average leaf area eaten by larva during whole life was 206.8, 229.8 and 291.4 cm^2 in case of tender half matured and matured leaves of hog plum, respectively. Sardar and Mondal (1983) studied the biology of pest. They reported that under laboratory conditions (28.7^{0}C and 82.4% RH) the egg stage lasted for 5.3 days, 4 larval instars in 4.3, 4.1,4.1 and 4.1 days, prepupal stage 2.4 days, pupal stage 26.8 days for male and 29.5 days for females, adult stage 37.7 days for male and 45 days for female, pre oviposition period for 20.2 days and the oviposition period for 9.2 days. Females lay on an average 58.7 eggs each out of which 67.1 % finally hatches. The adult first appear in field between March-April on new shoots of hog plum.

The most serious pest of the Barbados cherry (*Malphighia punicifolia* L.) is the root-knot nematode which weakens the plant, causing it to drop leaves and display symptoms of malnutrition. Severe infestation of nematode inhibits the growth and fruit production. This nematode becomes more serious problem in sandy soils. Preventive measures include use of sterilized soil in propagation, fumigation of the planting site and heavy mulching around the tree.

Frequently, the Barbados cherry fruit is attacked by plant bugs which sting the fruit, giving it a dimpled appearance. This may result in off flavors and reduced fruit size. Other insects which attack the West Indian Cherry plant include various scale insects, whiteflies, aphids and caterpillars. Pareek and Vishal Nath (2006) mentioned that insect pests such as scales, aphids, mealy bugs, mites, leaf eating caterpillars and soil borne insects often cause excessive damage to West Indian Cherry. To manage nematodes, infested locations should be avoided and resistant rootstock (*M.suberosa* L.) should be used.

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Major diseases and pests of tree spices

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India is a store house of a wide range of spices and it holds a conspicuous position in world spice spectrum. The present production of different spices in India valued approximately 4 billion US $. Because of the varying climates prevailing in the country, from tropical to sub-tropical to temperate, almost all spices grow very fabulously and almost all the states and union territories of India grow one or the other spices. According to the recent statistics (2012-13 DASD Kozhikode), the total area under spice cultivation in the country is 3172468 hectare with a total production of 5801114 tonnes. Under the act of Parliament, a total of 52 spices are enlisted of which ten were tree spices. The other spices include black pepper, cardamom, ginger, turmeric, seed spices and herbal spices. The major tree spices of importance include Clove (*Syzygium aromaticum*), Nutmeg (*Myristica fragrans*), Cinnamomum (*Cinnamomum verum*), Cassia (*Cinnamon cassia*), Tejpat (*Cinnamon tamala*), Tamarind (*Tamarindus indica*), Kokam (*Garcinia indica*), Cambodge (*Garcinia cambogia*), Star anise (*Illicium verum*) and Allspice (*Pimenta dioica*). Plant parts like, bark, leaf, unopened flower buds; seeds, kernel mace etc are used as the spice of commerce from these tree crops. Among the spices Clove, Nutmeg and cinnamon are the three main spices of importance to India. The major threats facing these crops are losses due to severe pest and diseases incidence.

Clove

Clove *Syzygium aromaticum* (L) Merr and Perry. belonging to the family Myrtaceae. The clove of commerce is the unopened flower buds of the clove tree. In India clove is grown mainly on the eastern slopes of western Ghats in an area of around 2060 ha with a production of 1060 tones (Spices Board Statistics). Other major producers of clove are Zanzibar, Tanzania and Indonesia. Rich loamy soils of the humid tropics, red soils of the midlands of Kerala and hilly terrain of Western Ghats of Tamil Nadu and Karnataka are suitable for the cultivation of clove. The crop cannot withstand under heavy waterlogged conditions and is susceptible to a number of fungal diseases. The diseases are prevalent in the nursery as well as in the grown up plantations.

Diseases of clove

Seeding wilt

Seedling wilt is the most common disease occurring in the nurseries. The disease is characterized by losing the natural luster of leaves and droop off of leaves. The root system and collar region of the seedlings show varying degrees of discoloration and decay. *Cylindrocladium sp, Fusarium sp,* Rhizoctonia *bataticola* and *Phytophthora* species are found associated with the disease. As the infected plants serve as the source of inoculum for further spread, removal of infected plant /parts as and when noticed is effective in checking the disease. Besides spraying with fungicides like carbendazim 0.1%, foliar spray with 1% Bordeaux mixture and soil drenching with 0.2% Copper oxychloride is also effective in reducing the disease.

Leaf rot / Leaf blotch

Leaf rot occurs both in the nurseries and in plantations. The infection starts as water soaked lesions from the margin or tip which coalesce to form chocolate brown colored areas resulting in rotting of leaves. Severe infection leads to defoliation and death of seedlings. In case of leaf blotch disease, the symptoms appear as minute spots with a chlorotic halo on the leaf lamina which enlarge and form irregular necrotic patches, the centre of which become dirty brown in colour. In the nursery, the infected seedlings show downward curling of the leaves while in mature plants the leaves become crinkled and distorted which later lead to defoliation. Both the diseases are caused by *Cylindrocladium quinqueseptatum* Boealijin *and* Reitsma, The diseases can be managed by spraying Bordeaux mixture 1% or Carbendazim 0.3% during the onset of monsoon rains.

Twig blight

Twig blight appears in the nursery as well as in grown up plants and occur throughout the year but severe during the monsoon season. The diseases appear in the form of leaf spots, twig blight and flower shedding. In case of leaf spot, brown pinhead like dots scattered all over the lamina, adjacent spots coalesce to form irregular necrotic patches with ashy-grey centre and darker margins with numerous acervuli. In severe cases the leaves withered and drop off. Infection spreads to petiole resulting in twig blight which appears in the form of light brown elongated spots or streaks of variable size with plenty of acervuli. Later branches defoliate leaving behind the skeleton of dead twigs. Flower buds are also found infected. The symptoms on flower bud appear as blackening of the flower buds and shriveling and drying of the pedicel resulting in dropping of the flower buds. The disease is caused by *Colletotrichum gloeosporioides* Penz. Management is by spraying the trees with 1% BM prior to flower setting and repeat at an interval of 45 days.

Grey blight

Grey blight is another common disease observed in the mature leaves of young trees in the age group of 1-10 years. The disease appears during monsoon season. Small yellow brown oval spots develop on leaves which later become whitish to grey with a dark brown border. The spots enlarge and form necrotic patches. As the disease advances, a major portion of the leaf lamina dries up and blown away by wind. In the nursery stage, circular and whitish grey spots develop on leaves. The disease is caused by *Pestalotiopsis palmarum* (Cooke) or *Pestalotia versicolor*. Carbendazim 0.3% and Bordeaux mixture 1% are effective in controlling the disease. Shade and overcrowding favours the proliferation of the pathogen which usually spread by dispersal of spores.

Leaf spot

Leaf spot disease appears as minute circular spots on leaves which enlarge to about 0.5-1mm in diameter with a greyish center and brown or purplish margin. The causal organism is *Colletotrichum gloeosporioides* (Penz.) Penz and Sacc. *Alternaria citri* Ellis and Pierce can also cause leaf spots. It appears as small light brown specks in any part of leaf lamina which enlarge slowly and got zonated. Infected mature leaves are found early detachable. Spraying Indofil M45 0.3% twice at fortnightly intervals is effective in controlling the disease.

Leaf blight

Leaf blight appears as brown spots on the lamina, which later turns dark brown and coalesces and cover the entire lamina and in advanced stages defoliation occurs. The disease is incited by Botryodiplodia *theobromae* Pal. Pycnidia of the fungus can be seen on infected leaves. A prophylactic spraying with Bordeaux mixture 1% with the onset of south west monsoon can prevent the incidence of the disease.

Little leaf of clove

The little leaf of clove appears as shortening of internodes. The leaves become reduced in size and fresh leaves fail to emerge and in certain cases the leaves were found twisted or crinkled and finally the affected seedlings collapse. It is suspected to be caused by MLO, but further research is required to confirm the etiology.

Sudden death

It is the most threatening disease of clove tree in Zanzibar and Pemba. The periodical incidence of this disease has resulted in the destruction of about half the mature trees of Zanzibar islands. The disease was reported from Kerala also. The first visible symptom appears as slight chlorosis followed by a very rapid leaf fall and wilt. The leaves dry up on the tree without abscessing and become a bright russet-red with in a few days. The fine ramification of the root system has completely disappeared and the plant dies as a result of water stress. The cambial regions of the collar portion of the trees are stained bright yellow which spreads up the trunk and after some months, the yellow stain becomes widespread . The causal organism is *Valsa eugineae*. In Indonesia the disease was reported to be caused by *Pseudomonas psidi*. The signs of fungal infection could be observed 3-4 months after the death of the plant by the formation of perihelia. Ascospores are formed during the rainy period and washed down into the soil which again infects the root system. No management strategies have been yet been worked out.

Juvenile Decline

Juvenile Decline is also reported to be caused by Valsa *Eugenia.* It is also called immature die back and slow decline. Here the symptoms are characterized by gradual reduction of young trees canopy resulting in the death of twigs and branches from bottom upwards. Dead twig and branches break off so that the lower part of the stem becomes devoid of branches. In the initial stages affected trees are left with a small canopy restricted to the top of the trees. The leaves become smaller and chlorotic. Root rot was also reported in some cases.

Die-back

Die-back is caused by *Cryptosporella euginiae* characterized by slow death of the trees. Initially, the branch of trees slowly dies back with the leaves turning brown. The infected tree may take a few to many years to die. Affected branch when split open, a reddish brown discoloration occurs between the dead and living tissues and mycelium of the fungus can be seen in the stained stone. The pathogen progresses down the branch often girdling it and gradually reach the main trunk. Pycnidia and perithecia develop at or near the point of entry. For the management of the disease, cutting off the branch cleanly below the stained infected area and the painting the cut surface with a fungicide is usually effective. Care should be taken to avoid breaking the branches at harvesting. Die-back is mostly associated with some form of injury to the tree.

Sumatra disease

Leaf fall and twig die back are the characteristic symptoms of Sumatra disease. Trees of 6-18 months are usually affected. Die back initially appears on a part of the crown, which extends down on one side of the tree and killing a vertical series of branches. Over the rest of the canopy the foliage usually shows signs of physiologic stress. Intervenal chlorosis with marginal scorches and subsequent leaf shedding progresses rapidly and the tree dies usually within a year. Nutritional disorder is considered to be the possible cause of the disease. Affected leaves had high manganese and aluminum and low levels of Phosphorus and potassium. *Endothia* sp. *Phymatotrichum* sp. *Phytophthora* sp.etc. are reported to be associated with the disease. The etiology and management strategies are not yet studied in detail.

Mutibudjanj

The disease was reported from many parts of Indonesia. The disease is characterized by a general decay of the feeder roots which results in secondary leaf shedding and die back. This is followed by slow decline leading to complete death of the tree within two or three years. No casual organism was reported but attributed the disease to unfavourable soil conditions, as the disease is more prevalent in areas of poor physical soil .

Insect pests of clove

Teak sapling borer (***Sahyadrassus malabaricus*** (Moore) (Order:Lepidopera, Family: Hepialidae)

The teak sapling borer is distributed mainly in South India . The pest has been recorded from many parts of Kerala and Tamil Nadu districts. The borer infests the main stem of young clove trees at the basal region. The larva girdles the stem and bores downwards. The girdled region and the bore hole are covered with a mat-like frass. The infested trees show wilting. The moths of the borer are large and greyish brown with mottled forewings with a wing span of about 11 cm and body length of 5.5 cm. Full grown larvae are large, caterpillars are measuring about 8.5 cm in length. They are creamy white with a black head capsule. The dorsal sclerites of the thoracic and abdominal segments are brown.

The infestation of teak sapling borer in a plantation can be reduced by keeping the basins of clove trees free of weeds and swabbing the basal region of the main stem with carbaryl paste. In case of infested trees, quinalphos 0.1% may be sprayed around the bore hole and also injected into it and plugging its opening suitably, after removing the frass.

Scales

Three types of scales are noticed in clove viz. Wax Scale (*Ceroplastes floridensis* Comstock), Green shield scale (*Pulvinaria psidii* Maskell) and Coconut scale (*Aspidiotus destructor* Sign.). All belonging to Order Homoptera and Family Coccidae .

The wax scale (*Ceroplastes floridensis* Comstock) on clove has been recorded in Kozhikode District (Kerala). Adults and larval stages of the wax scale suck sap from tender stems and leaves. The scales produce honeydew on which sooty moulds develop. The infested leaves turn yellow, wilt and drop, resulting in loss of plant vigour and mortality of seedlings in the nursery. The adult female wax scales are oval, greyish-white coated with a thick layer of pinkish-white wax and measuring about 2.5 x 2.0 in size. The eggs are laid under the adult female scale's wax covering. The pest infestation is generally more severe during the post monsoon and summer seasons.

Green shield scale (*Pulvinaria psidii* Maskell) adults and larval stages of the green scale suck sap from tender shoots and leaves of clove especially on seedlings. The scales produce copious honeydew on which sooty moulds develop. The pest infestation results in yellow spots on leaves and severe infestations lead to wilting, defoliation and loss in plant vigor and mortality of seedlings in the nursery. Adult females are oval, pale green to yellowish brown and measure about 4.0 x 3.0 mm in size. Males are not known in this species and females reproduce by parthenogenic means. Eggs are deposited beneath the body of the adult scale.

Coconut scale (*Aspidiotus destructor* Sign.) is common in tropical and sub-tropical regions worldwide. Adults and larval stages of the coconut scale suck sap from tender shoots and leaves. The pest infestation results in yellow spots on leaves and severe infestations lead to wilting, defoliation and loss in plant vigour. Adult female scales are circular and light yellow and measure 1.5–2.0 mm in length. The eggs are yellow and are laid under the scale around the body of the female. Males are weak bodied with a pair of wings. Reproduction is primarily by parthenogenic means though sexual reproduction also occurs.

All the three types of scale infestation can be controlled by spraying dimethoate 0.05%.

Cinnamon

Cinnamomum verum of family *Lauraceae* is cultivated for its dried inner bark, which is used as the spice of commerce. It is mostly cultivated in Sri Lanka, Malagasy Republic and Seychelles. It has originated in the central hills of Sri Lanka. In India, it is grown in one or two locations in Kerala. Cinnamon is a hardy plant and is cultivated in Sri Lanka under varying conditions ranging from semi dried to wet zone conditions . The ideal temperature for growing cinnamon is between 20-30 degree C and rainfall between 1250 to 2500 mm. It thrives well as a forest tree at 300-350 meter above MsL. Cinnamon plants are grown as bushes and when the plants are of two years age, they typically measure at about 2 meter in high and 8-12 cm at the base, it is at this stage they are ready for harvesting. The plant is susceptible to more than 30 diseases, of which the infection of the bark causes maximum economic loss.

Diseases of cinnamon

Stripe canker (Bark canker)

Stripe canker appears as *v*ertical stripes or dead barks, particularly near the ground level. The first visible symptom of the disease is the formation of sunken necrotic zones on the bark upto 5cm wide along the main trunk. These zones are parallel, narrow and exceeds 10mm in length. The interior discolouration is characteristically brown and gunny, sometimes reddish and exudes an amber coloured liquid. The disease is caused by *Phytophthora cinnamomi* Rands. The disease is found on the trunk and branches of young trees of *Cinnamom verum* or on *C. burmanni* in Indonesia. The disease is more prevalent under waterlogged conditions.

Sooty mould

The disease is characterized by a black superficial growth of the fungus on the upper surface of the leaf lamina. There are two types of symptoms. One type was characterized by the superficial growth of the fungus as black encrustations on the upper surface of the leaf lamina. The other type symptom is characterized by the formation of black coating or crust of the fungus on the under surface of the leaf. In both the cases the growth of the fungus was found associated with scale insect infestation especially scale insects. Though the fungal growth was superficial, the vigour of the plants reduced and growth retardation results due to infection. Sooty mold is due to *Phragmocapnias betle* Thesis and Syed. A hyperparasite viz. *Spiropes bolladynno* was also identified on the sooty mould.

Root root

The occurrence of this disease was observed under conditions of excessive moisture and poor drainage. The growth of the infected trees are very slow and leads to slow decline. The disease is characterized by the appearance of white and compact mycelial growth of the fungus on freshly infected root surfaces which turns reddish brown on ageing. The disease is caused by Ganoderma pseudoferream Wakef. Spores are reddish brown above and grayish white below shelving or sessile and sometimes zonate and can be seen on the older dead parts in the base of the trunk. The other fungi reported to be associated are root rots by Rosellina spp., brown rot by Phellinus lamaensis (Murr.) Heim and a white rot by Leptoporus lignosus (Klot.) Heim.

Red leaf spot

Leaf spot infection appears as small red circular spots near the margin of the leaves, which later extends and cause reddish elongated spots with dark red margins. In severe cases, the symptoms can be seen on the entire leaf lamina, leading to drying and defoliation. Shot hole symptoms were also observed. The disease is caused by *Colletotrichum capsici*.

Leaf spots and die back

The disease is found in the nursery seedlings as well as in mature plants. In seedlings small dark brown specks develop on the leaf lamina, which enlarge and coalesce results in drying of the leaf. The infection spreads to the stem leading to necrosis. In mature trees, small specks are found scattered over the leaf lamina, which enlarge and form necrotic patches and later become papery white with red brown margins. Under changing wet and dry conditions, characteristic concentric zonations develop on these spots. These zonated spots were limited from green healthy area by a well-defined dark brown band.
In some cases shedding of the papery necrotic tissue occurs leaving the red brown margins and form shot hole like symptoms. The causal organism is C*olletotrichum gloeosporioides Penz.*

Grey blight

Disease appears as small yellow brown spots on leaf lamina which later become whitish to grey with dark brown borders. The spots vary in shape from oval to irregular and small adjacent spots coalesce forming big necrotic patches. In advanced stages of infection a major portion of the affected lamina dries up and blown by wind. Dark acervuli could be noticed on the upper surface of the central necrotic patches. The disease is caused by *Pestalotiopsis palmarum* (Cooks) Stoyaert. Seedling blight is another disease caused mostly by *Diplodia* sp. Here light brown patches girdle the stem resulting in the death of the plant. Spraying 1% Bordeaux mixture can control both the diseases.

Pink Disease

This is the most important disease of cinnamon in India, Sri Lanka and Indonesia and caused by *Corticium salmonicolor* (C. *javanicum*). The initial symptom is the formation of a pale pinkish white brittle layer (crust) on young stems or branches which spread destroying the bark and finally killing shoots. *Aecidium cinnamomi* Rac. *Leptospheria* spp. and *Exobasidium* spp. etc are also reported with the disease. *P. cinnamomi* is also found associated with the disease.

Phytophthora Leaf rot

The leaf rot is characterized by the appearance of reddish brown spreading necrotic areas on the margin of the leaf lamina The disease occur during the monsoon season. *P citrophthora* is found associated with the disease.

Insect pests of Cinnamon

Cinnamon butterfly (*Chilasa clytiaare*)

In India and Sri Lanka caterpillars of the cinnamon butterfly is the most destructive pest. The pest normally appear in December when tree produces new flushes and quickly defoliate trees, especially in new plantations. Infestation adversely affects the growth and can also cause death of new planted seedlings

Shoot borers

Shoot borers cause significant damage to individual trees and reduce bark quality. In India and Srilanka shot hole borers, *Xylosandrus* spp. is frequently recorded.

Leaf miners

Leaf miners *Phyllocnistis crysophthalma* and to a lesser extent *Acrocercops* spp. are also important when they reduce the rate of shoot growth by defoliation.

Other minor pests

Gall and leaf mites *Eryophyes bois* and *Typhlodromus* spp., Caterpillars of the leaf webber, *Sorolopha archimedias* and arboreal ants *Oecophylla smaragdina* are also noted pests of cinnamon that can reduce shoot growth by defoliation. Agrotid larvae or mole crickets, *Gryllotalpa* spp. also infest cinnamon seedlings and grownup plants. Larvae of various *Popllia* spp. like *Popillia complanata* and *P. discalis also* attack roots and cause damage in nurseries and on young seedlings.

Nutmeg

Nutmeg (*Myristica fragrans* Hoult) is one of the major spice crops in India. It is cultivated as an intercrop in coconut and arecanut gardens. It produces two separate spices, namely nutmeg and mace which are of great commercial value. Nutmeg is cultivated in an area of 18730ha with a production 12730 tonnes and recently the area under nut meg cultivation is expanded to al large extent due to the increasing price of the crop. The plant is susceptible to a number of diseases

Diseases of nutmeg

Fruit Drop

Fruit drop is an important disease of nutmeg which causes severe crop loss. The disease makes its appearance during the monsoon season when there is heavy and continuous rainfall. Symptoms are expressed only on half matured or unripe fruits. Water-soaked lesions develop at the base or any part of the fruit, which later turn brown in color followed by premature splitting of the pericarp and rotting of the mace and seed. As the disease progresses the internal tissues become rotten. The infection of the pathogen on the fruit stock results in dropping off of the fruit. A number of organisms are found associated with the disease like *Diplodia natalensis, Thielvaviopsis paradoxa*, *Colletotrichum gloeosporioides, Botryodiplodia theobromae etc.* A premature fruit fall found in Indonesia and Malaysia is reported to be associated with the fungus *Coryneum myristicae* but it is not certain.

Leaf spot and shot hole disease

The disease is prevalent in Kerala resulting in large-scale destruction of the crop. The disease was first reported from Meghalaya and also from Maharashtra. The infection is restricted to the foliage and the pathogen infects at all stages of leaf growth. However young leaves are more prone to infection. The disease is characterized by the appearance of small necrotic spots of 2-3mm diameter on both sides of the leaf. They are surrounded by yellow chlorotic halo. Several such spots coalesce and form bright necrotic patches covering about half of the leaf area, and reduce the photosynthetic area. In advanced stage, the leaf tissues wither and impart a shot hole effect. It is the most characteristic symptom of the disease. It is observed within 15-20 days after appearance of the visible initial spot. *Cladosporium oxysporum* and *Colletotrichum gloeosporioides* were associated with the disease. The disease can be effectively controlled by spraying fungicides such as carbendazim (0.1%) or Bordeaux mixture 1%. First spray should be given with the appearance of initial symptoms followed by one or two sprays at monthly intervals.

Root rot

The symptoms appear as yellowing of the foliage and defoliation. The above ground parts of the plants show decline symptoms due to malfunctioning of the root system. The fruits become dry and shrivel resulting in die back. The fungus invades the root system forming a black layer over the root. It penetrates the wood and ultimately kills the plant.

The disease is reported to be caused by *Rosellinia pepo* Pat. The fungus develop black shaft hair like structures which produces conidia that are hyaline. Perithecia are black, imbedded, and globose and contain ascospores that are brown, straight and pointed at each end. Root rot by *Fomes noxius* Corner and the brown root rot *F.camoensis* occur in Indonesia Trench isolations of infected trees followed by cutting and burning in situ and application of systemic fungicides was found effective

Thread blight

Thread blight is a threatening problem in nut meg. Two types of thread blights are noticed viz. white thread blight and horse hair blight

White thread blight, white hyphae aggregate to form fungal threads that traverse along the stem underneath the leaves in a fan shaped or irregular manner causing blight in the affected portions .Dried up leaves with mycelium form the source of inoculum for further spread. The disease is caused by *Marasmius pulcherima* . Cultural practices like Phytosanitation and shade regulation are essential for the control of the disease since infected plant debris act as secondary source of inoculum for the spread of the disease

Horse hair blight, fine black silky threads form an irregular, loose network on the stem and leaves leading to blight of stem and leaves.The threads hold up the detached dried leaves on the tree, giving the appearance of a birds nest when viewed from a distance. The fungus involved is *Marasmius equirinus*. Fungi survive on dried leaves. Disease emergence is favored by heavy shading of plants. Dried up leaves with mycelium form the source of inoculum for further spread. Cultural practices like pPhytosanitation and shade regulation are essential for the control of the disease since infected plant debris act as secondary source of inoculum for the spread of the disease. In both cases, a foliar application of 1% Bordeaux mixture is effective . A prophylactic spraying during the onset of monsoon prevents the incidence of the disease to a great extent.

Pink Disease

The disease is characterized by the formation of threads of fungal mycelium traverse on the aerial parts of the plant. The fungal threads composed of fine parallel, mycelial filaments that grow more or less superficially along the lower surface of branches and twigs. The infection advance up the petiole and fan out over the leaf blade, which later becomes brown and dry. The infection extends to the branches to the petiole and fruits. The mycelium survives in the aerial parts of the host. External appearance is of a rosy pink, resupinate, relatively thin over growth that may extend many inches along the branch. The fungus is found invading the cambium and cortex. The disease is caused by *Botryobasidium salmonicolor* (Berk and Br.) Venue.

Nut rot/ Fruit rot

The disease is of common occurrence during the monsoon period. The disease cause severe crop loss due to premature fruit fall. Sometimes the fruits become covered with greenish black spots and the tissue on the lower side is brown. The infection initiates as water soaked, dull green to dark brown lesions on the rind near the stalk portion. These discolored areas later develop typical rotting and spread to the entire fruit resulting in fruit fall. Rotting extends to the mace also. Mycelial growth of the fungus formed on the rotten areas of the fallen fruits. Sometimes the damage is light, but the quality and yield is reduced. The disease was reported to be caused by *Coryneum myristica* stein. But recently *Colletotricum gloeosporioides* is also found associated with the disease.

Bacterial wilt

Bacterial wilt was noticed in plants of age group between 10-15 years characterized by the formation of water soaked glistening golden brownish patches on the leaves with irregular margin delimited by veins. Later the infected leaves dry up and remain attached to the plants without defoliation. The disease also causes damage to the root system. Infection in the root system is characterized by decaying and shredding of roots, girdling and peeling of the cortex tissue with brown vascular discoloration. The plant wilts within 2-3 weeks of infection. *Pseudomonas solanacearum (*Smith*)* Smith was reported as the causal organism. Carefully removing and burning the infected plants is essential to prevent the spread of the disease. Spray and drench Bordeaux mixture1% to surrounding plants is recommended.

Insect pests of nutmeg

Nigra scale (*Parasaisettia nigra* (Nietner) Order: Homoptera, Family: Coccidae

The pest has a cosmopolitan distribution. On nutmeg adults and larval stages of the nigra scale suck sap from tender stems and leaves. The scales produce honeydew on which sooty mould develops. Yellowing, wilting, defoliation and loss in plant vigour may result due to severe infestation. Adult females are dark brown to shiny black, oval and dome-shaped measuring about 4.5 x 3.5 mm in size. The eggs are laid under the body of the adult female. Reproduction is entirely by parthenogenesis. The pest infestation is generally more severe during the post monsoon and summer seasons. The infestation can be controlled by spraying dimethoate 0.05%.

Scales

Nut meg is also affected by two different types of scales viz. white scale (*Pseudaulacaspis cockerelli* (Cooley) and shield scale **(*Milviscutulus mangiferae* (Green)** (Order: Heteroptera, Family: Diaspididae). Adults and larval stages of the white scale suck sap from leaves on seedlings. The pest infestation is characterized by yellow spots on leaves and severe infestations lead to wilting, defoliation and loss in plant vigor. Adult females are white, flat and pear shaped and measure about 2.5 x 1.5 mm in size. The white scale can be controlled by spraying dimethoate 0.05%. The shield scale occurs in most tropical and subtropical countries. On nutmeg, adults and larval stages of the shield scale suck sap from leaves especially on seedlings in the nursery. The scales also produce honeydew on which sooty moulds develop. As in white scale, shield scale infestation also results in yellow spots on leaves and severe infestations lead to wilting, defoliation, and loss in plant vigor. Here adult females are pale brown, flat and triangular shaped and measure about 4.5 x 3.5 mm in size. Both the scales can be controlled by spraying dimethoate 0.05%.

Garcinia

Cambodge (*Garcinia cambogia, Garcinia gummi gutta)* belongs to the family Clusiaceae , the outer rind of which is used as a spice. It is a tropical medium size evergreen dioecious tree. It is commonly known as 'Malabar Tamarind' is a native of Western Ghats of Kerala (India). It is also found in Sri Lanka and Malaysia.

Diseases of Garcinia

Thread blight

Thread blight is a common disease of Garcinia in Puerto Rico. The symptoms are seen on leaves, young branches and young fruits in the form of spots which gradually enlarge. Fruits and leaves may be covered with a fine web of filaments. Infected leaves may become brown or black and abscises from the tree and remain suspended by the filamentous web. Factors that favour the spread of the disease are high humidity and dense shade. The disease is caused by *Corticium* (*Pellicularia*) *koleroga* Cooke. Removing of shade plants and improving drainage help in reducing the humidity of the area which further help to reducing the infection. Spraying with copper based fungicides is effective.

Stem Canker

Stem canker was reported from Malaysia as caused by *Zignoella garcineae* P.Henn. The fungus form galls on young stem which persist on mature branches and eventually cause the death of the infected wood. In serious infection the tree may die and it is recommended to cut out and burn the infected trees to prevent spread of the disease.

Brown root rot/ Red root rot

Lesions develop on the trunk followed by wilting of the foliage. Disease caused by *Phellinus noxius Corner* G.H. Cunn (Brown rot) and *Ganoderma* sp. (Red root rot) . Both diseases results from an infection of root through contact with spores from decaying slumps of crops such as oil palm. Control consist mainly of removing or burning old trunks of felled. Brown rot lesions may be treated with a fungicide. The diseases have been reported from Malaysia and may become economically serious

Post-harvest diseases

The pathogens associated with Post-harvest disease**s** include *Botryodiplodia theobromae* pat, *Diplodia* sp. *Gloeosporium* spp., *Pestalotia flagisettula*, *Phomopsis* spp. and *Rhizopus* sp. These usually result in the hardening of the pericarp and decay of the aril.

Insect pests of Garcinia

Leaf hopper (Busoniomimus manjunathi Viraktamath & Viraktamath) Homoptera,
Family: Cicadellidae

Adults and nymphal stages of the leaf hopper suck sap from tender stems and leaves of garcinia resulting in defoliation and wilting of branches and mortality of seedlings in the nursery. The leaf hopper also produces honeydew on which sooty mould develops. The adult hoppers measure about 5.00 x 1.75 mm in size with yellowish-brown pronotum and scutellum. The forewings are brown and the hind wing membranous and transparent. The nymphs have a reddish black thorax and dark colored head. The pest infestation is generally more severe during the post monsoon season and can be controlled by spraying dimethoate 0.05%.

All spice

All spice (*Pimenta dioica*) (Gandamenasu, sarvasugandhi) belong to the family Myrtaceae. Its fruit and seed are used as spice. However the leaves which have the property of all the spices, is now used as a flavoring agent in culinary preparations. They are evergreen medium sized trees. There are male and female trees and are similar in appearance and cannot be distinguished till flowering commences. The tree is indigenous to West Indies (Jamaica) but is also found in Central America. In India, it is grown in many places in Maharashtra, Tamil Nadu, Karnataka and Kerala etc. Growing area, stage of maturity of berries at harvest and storage conditions affect the quality of all spice. Berry, berry oil, oleoresin, leaf oil are products of economic use. It is used mostly in Western cooking and less suitable for Eastern cooking. It has medicinal, anti-microbial, insecticidal, nematicidal, anti-oxidant and deodorant properties.

Diseases

Leaf rust

Leaf rust caused by *Puccinia psidii* is most prevalent in areas where there is frequent fog or heavy dews. The fungus attack young leaves and shoots and inflorescens become covered by a bright yellow powdery mass of uredospores. Severe infection results in defoliation finally death of the plants.

Dieback (Fire blight)

Dieback is caused by *Ceratocystis fimbriata* . It is a wound parasite which seldom affects young trees. The disease is called dieback or canker and locally known as firelight. The disease is wide spread but can be very local. Pruning and burning diseased branches is the most efficient control method.

Insect pests

Caterpillars : Caterpillars of the bagworm *Oeceticus abboti* and related species are recorded which damage the trees by eating leaves and young shoots.

White fly :*Aleyrodidae* as well as red-banded thrips, *Selenothrips rubrocinctus* may attack young leaves.

Weevils: Aduts of the weevils *Prepodes* spp. and *Pachnaeus* spp. feed on leaves and their larvae damage roots. Larvae of scrab beetles cause damage to roots and even flowers.

Borers: Borers can also cause damage but negligible. The greatest damage is due to secondary infection by pathogenic fungi like *Cyrtomenus*, *Cylindera* and *Neoclytus* spp.

Scale insects: Scale insects are reported but do little damage.

Black ants: Black ants, *Crematogaster brevispinosa* cause little physical damage but making harvesting unpleasant and they are responsible for spreading scale insects between trees**.**

Staranise

Star anise (*llicium verum)* belong to the family Illiciaceae. The dried fruit is the spice of commerce. It is an evergreen tree attaining a height of 8-15 meters. Star Anise is indigenous to South Eastern China. Commercial production is limited to China and Vietnam. To a small extent it is cultivated in Arunachal Pradesh in India. The crop requires specific agro climatic conditions available only in the traditional growing areas. It is used to flavor vegetables, meat, and to marinate meat. It is used as a condiment for flavoring curries, confectionaries, spirits, and for pickling. It is also used in perfumery. The essential oil of star anise is used to flavor soft drinks, bakery products and liquors. The fruit is anti-bacterial, carminative, diuretic and stomachic. It is considered useful in flatulence and spasmodic.No diseases / pests are reported from star anise

Conclusions

Diseases and Pests are major constraints in tree spice crops especially Clove and Nutmeg which limit the production to a great extent. With the change in climatic conditions, pest incidences were on the higher side and also emergence of new pests is noticed. So also minor pathogens become major pathogens causing damage to the crop The diseases which are not common earlier are now being prevalent in most of the plantations. So climatic conditions play a major role in the occurrence and spread of many of these diseases and pests which account for the major crop losses. Since not much research effort has been made on the plant protection aspects of these tree spices , a detailed research is warranted on the etiology , epidemiology and management of many of the diseases of these spice crops which is of great value to the country. Of course, plant sanitation and timely application of suitable fungicides/insecticides are to be taken up at the outbreak of such diseases/pests for checking their spread.

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IV-1

Scope of host plant resistance in selected under-utilized fruit crops: An appraisal of germplasm evaluation

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Host plant resistance (HPR), though elusive, is a viable and sustainable component of integrated pest management strategy. The HPR attains an increased value in case of underutilized fruit crops, which are not only poorly studied but also are yet to figure in intensive horticulture calendar. Identifying potential resistance sources is the first step to exploit the resistance mechanism. A systematic field evaluation of the germplasm of important underutilized fruit crops like aonla, Annona, ber, jamum and pummelo for resistance to major insect pests was carried out during 2006-07 to 2011-12 at Indian Institute of Horticultural research, Bengaluru. The pests studied were fruit borer, *Deudorixisocrates*Fab. and aphid, *Schoutedoniaemblica*Patel&Kulkarnyinaonla, mealybug, *Ferresiavirigata*Cock.and fruit fly, *Bactroceradorsalis*inAnnona, fruit borer,*Meridarchysscyrodes*Meyrick. and ash weevil, *Mylloceros* sp. in ber, fruit weevil, *Balaninus c album* (L.) and leaf miner, *Acrocercops*sp. in jamun, and citrus leaf miner, *Phyllocnistiscitrella* St.in pummelo. Observations were recorded on four trees of each genotype with each tree constituting one replication. In case of fruit fly, matured fruits were brought to the laboratory and observed for the incidence. Significant variations were recorded in the infestation levels among genotypes. In certain cases like fruit fly and mealybug in Annona, field resistance or susceptibility was found to be significantly influenced by fruit morphological characters. For instance the depth of grooves on fruit surface played a vital role in mealybug preference.In aonla, period of fruiting affected the borer damage with early bearers like NA-10 showing the least susceptibility. Though the available genetic base was not very wide, promising results were obtained and the presence of variability was established and 2-3 collections in each crop were identified which could be of value for further work on host plant resistance. In the light of the findings, the status and scope of HPR and management of major pests in underutilized fruit crops is discussed.

Anthracnose disease of minor fruit crops caused by *Colletotrichum gloeosporioides*

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Colletotrichum gloeosporioides is one of the most important plant pathogen worldwide. It causes anthracnose and post harvest rots in minor fruit crops like Avocado, Jamun, Carambola, Bael, Kokum, Passion fruit crops etc. These minor fruit crops are the predominant hosts and are regularly damaged by the pathogen in one or the other stage of crop development. As these crops are perennial in nature, there is regular and constant availability of the host for development of the pathogen and its survival. With increase in area of jamun fruit crop, there was increase in the disease severity of anthracnose in the form of localized epidemics in various parts of Southern India.The fungus infects young stems, leaves, flowers and fruit but infection does not develop fully until the tissue is injured or begins to ripen. Infected tissue then rapidly decays. Fungicides form an integral part of disease management under intensive cultivation of fruit crops. There are many reports revealed that carbendazim, the most widely adopted fungicide for control of diseases caused by *C. gloeosporioides*. Prochloraz although is not yet commercially available for general use in India, it has emerged as a promising alternative against *C. gloeosporioides* worldwide (Joshi et al., 2013).

IV-3

Post harvest diseases of rambutan (*Nepheliumlappaceum* L.)

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Rambutan (*Nepheliumlappaceum* L.) is a fruit tree of Malaysia, Indonesia and distributed throughout southern China. It is a tropical fruit tree best grown in the temperature range between 22°C to 35^{0}C, with 2000 to 3000 mm of well distributed rainfall. In India, there are no large orchards or commercial plantings of rambutan. Polyphenol-oxidase enzymatic browning associated with mechanical injury, desiccation and post harvest diseases are reported as being the most significant causes of loss of rambutans. Among the post-harvest diseases of rambutan, anthracnose, stem-end rot and brown spot are identified as the most common in the rambutan growing regions causing heavy losses of fruit quality. The causative organisms of these diseases are identified as *Colletotrichum gloeosporioides*, *Botryodiplodiatheobromae* and *Gleocephalotrichummicrochlamydosporum*, respectively.*B.theobromae* and *G. microchlamydosporum*causes infections only when wounds were present on the surface of fruit, where as *C.gloeosporioides* infects both wounded and unwounded fruits. Hence, the avoidance of fruit injury during harvest should prevent the incidence of brown spot and stem-end rot. It has been reported that (Meha*et al*., 1991) harvesting of fruits with 1 cm of the fruit stalk intact prevents injury to the fruit and as result also the occurrence of post-harvest diseases. Therefore if this harvesting method is adopted by the growers in rambutan growing areas, the occurrence of postharvest diseases could be prevented (Sivakumar et al., 1997).

IV-4

Pollinators diversity and their role in pollination of rambutan

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Rambutan (*Napheliumlappaceumvarlappaceum)* is a humid tropical fruit of south east Asia. The trees produces male or hermaphrodite flowers. The flowers sweet scented and has functional nectars at the ovary base. Cross pollination is necessary because the anther is absent in most of the female flowers. Female flowers produce two three times more nectar than male flower therefore Rambutan is an important nectar source for bees. Although apomixes may occur in Rambutan crop pollinators may maintain a fidelity to either male or hermaphrodite flower, thus pollinators play an important role in fruit set. Thus, an experiment was carried out with an objective to find out major insect pollinators diversity and abundance on rambutan for pollination at CHES, Chettalli during 2013-14. The observations were recorded at flowering stage during March to April, 2013. Among the pollinators visitors group, Hymenopteran order constituted the major pollinators such as *Apisflorea*(62.65%)*Tetragonula*species (13.7%), and *Apisdorsata* (5.82%), *Apiscerana* (7.58%) also ants (7.75%), was p(2.5%). However, it was observed that the peak foraging period for *Aphis florea* and *Tetragonulasps* was from 9.00-12.00 hrs, *Apiscerana* was 7.00-8.00 am. It was observed that peak foraging period of *Apisdorsata* was only 6.00-7.00 am, ants 9.00-10.00 am and wasp 11.00-12.00 am . In case of open pollination observed higher number of fruit set 1.28% than fruits covered by bag (0.44%) per bunch of flowers.

Significance of rhizopus rot of jack fruit

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Jack fruit (*Artocarpus heterophyllus)* is native to India, cultivated in other countries like Malaysia, Myanmar, Srilanka. In India it jack fruit is mainly cultivated in Kerala, Tamil nadu, Bihar, Assam etc. and it is the national fruit of Bangladesh. This fruit crop is prone with many fungal diseases, among fungal diseases *Rhizopus* rot is a common fungal disease of jackfruitflowers and fruit. There are three species of *Rhizopus* involved in causing *Rhizopus* rot in jack fruit: *Rhizopus oryzae, R. artocarpi* and *R. stolanifer*. Rot is more likely to occur inhigh-rainfall areas or during and after stormy periods.When warm, humid, wet weather coincides with theflowering and fruiting season, *Rhizopus*rot can causetotal loss of fruit in jackfruit trees. This disease can manage easily by adopting simple cultural practices rather than using chemicals. Pruning of tree to encourage good ventilation and to reduce relative humidity in the canopy, avoiding of wounding of fruit, keep the fruit from contact with the soil or decaying organic material and storing of fruits after harvest in well ventilated containers. Where there is severe incidence, protect fruit with periodic sprays of copper fungicides.

IV-6

Anthracnose of carambola – A menace in quality fruit production

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Carambola (*Averrhoa carambola*.), is native to Southeast Asia. It is a woody plant in the family Oxalidaceae grown for its fruit known as starfruit. Carambola is not an economically significant crop in India, one can come across this fruit-cum-ornamental tree in several gardens. The fruits are immensely important as they are delicious, have high food value, contain a juicy pulp which may be acidic or sweet depending on type and good source of minerals and vitamin- A, B,C. Carambola fruits are known to possesstherapeutic properties. It is being valued as medicinal plant to treat chicken pox, scabies, ring worms and also used as antidote for poisoning. Hence, they are consumed by many people of the world. The diseases are spreading faster and becoming a major limiting factor in attaining high yield. Carambola is suffering from several diseases like anthracnose, caused by *Colletotrichum gloeosporioides* which has become a destructive disease both under orchard and post-harvest storage conditions resulting in reduction of fruit yield and quality while, after harvest it reduces the market value of fruits.The natural latent infections of *C. gloeosporioides*builtup in the fruitduring the rainy growing season, gradually decreased during the dry harvest season. Pre-harvest sprays with benomyl, carbendazim gave some control against post-harvest diseases. The length of the ripening time had an influence on the incidence of post-harvest diseases and any treatment which extended shelf-life also increased disease incidence. This increase could not be fully counteracted by application of fungicides to the fruit. Moisture of any source on the fruit at harvest greatly aggravated post-harvest diseases. Reasonable control of post-harvest diseases was achieved by post-harvest application of the fungicide, prochloraz.

IV-7

Avocado pre- and post- harvest disease and their control

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The avocado or butter fruit (*Perseaamericana)* is a subtropical, evergreen fruit tree native to southern Mexico. It has become an important fruit in the international trade; Mexico, Brazil, USA, Israel, New Zealand, South America and South Africa are the major producers of avocado. In India, it is grown as a backyard tree and is found in small pockets on hill slopes of Tamil Nadu, Kerala, Karnataka and Maharashtra. The most important pre-harvest fruit disease of avocado are Cercospora spot caused by *Pseudocercosporapurpurea;* anthracnose caused by*Colletotrichum gloeosporioides*; stem-end rot, caused by*Colletotrichum gloeosporioides, Dothiorellaaromatica, Phomopsisperseae*and to a lesser extent*Pestalotiopsisversicolor, Botryodiplodiatheobromae, Rhizopusstolonifer, Fusariumsolaniand Drechslerasetariae. P. purpurea*infections taking place early in the growing season resulted in the highest disease incidence. A three-month latent period occurred in the disease cycle and it can be controlled by timely application of benomyl, Cu-oxychloride and Cu-hydroxide (Dharvas and Kotze, 1987). Infections taking place later in the growing season resulted in a higher post-harvest disease incidence. The natural latent infections of *C. gloeosporioides*built up in the fruit during the rainy growing season, gradually decreased during the dry harvest season. Pre-harvest sprays with benomyl, captafol, Cu-oxychloride and Cu-hydroxide gave some control against post-harvest diseases. The length of the ripening time had an influence on the incidence of post-harvest diseases and any treatment which extended shelf-life also increased disease incidence. This increase could not be fully counteracted by application of fungicides to the fruit. Moisture of any source on the fruit at harvest greatly aggravated post-harvest diseases, whereas sealing of the cut-end of the fruit pedicel with wax plus fungicides, as well as removal of the pedicel, reduced losses due to stem-end rot.

Phytophthora root rot - A serious menace in avocado

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The avocado (*Perseaamericana*Mill.) is a relatively new crop in areas of the world outside its nativerange in the American tropics. It has proved to be a profitable commercial crop, both for local sale and for export. It hasdeveloped three horticultural races (West Indian, Guatemalan and Mexican),which are adaptable to a wide range of soil and climatic conditions. Even then, it is known to be affected by many diseases such as root rot(*Phytophthora cinnamomi*), fruit rot (*Erwinia*spp.), sunblotch (Avocado sunblotch viroid), wilt (*Verticilliumdahliae*) and Anthracnose (*Colletotrichumgloeosporioides*). Among them, root rot caused by *Phytophthora cinnamomi* is a serious disease resulting in poor yields. Pathogen attacks the crop in two distinct methods on both seedling and mature trees. The first is characterized by chlorosis followed by sudden wilting and death. The second is a slow decline of the trees characterized by die-back of the branches and death usually follows within 1-2 years. A shallow and poor drained soil also favours the disease. Hence an integrated management strategy including mechanical, chemical and biological methods should be inculcated inorder to boost up the yield.

IV-9

Insights into nematode problems in passion fruit

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Passion fruit (*Passiflora edulis* Sims), a native of southern Brazil, is grown in the Nilgiris of Tamil Nadu, Kerala and in various parts of northern and north eastern states of India. Two types of passion fruits, purple passion fruit (*P. edulis*) and yellow passion fruit (*P. edulis f. flavicarpa*) are commonly grown, of which the purple is mainly consumed fresh and the yellow is processed for juices. Plant parasitic nematodes are the major biotic constraints that hinder the production of passion fruits. Although many nematodes are associated with passion fruit, the major nematodes that cause economical damage are the root-knot nematode, *Meloidogyne* spp. (*Meloidogyne incognita, M. javanica*) and the reniform nematode, *Rotylenchulus reniformis.* Both these nematodes severely affect the fruit production and plant longevity. Other nematodes associated with passion fruit include the spiral nematode *(Scutellonema* spp. and *Helicotylenchus* spp.), and the lesion nematode *(Pratylenchus* sp.). These nematodes are not only pathogenic by themselves, but also predispose the wounded roots to easy entry of other pathogenic fungi and bacteria like *Phytophthora* and *Fusarium* which aggravate the disease severity and yield loss. Above ground, the nematode affected plants often show symptoms of stunting, wilting and chlorosis (yellowing) with unthrifty appearance with reduced flowering and fruit set.Below ground, the symptoms of root knot nematodes are quite distinctive. The roots turn darker and swollen with galls or lumps ranging in size from 1 to 10 mm in diam. In severe infestations, heavily galled roots rot away, leaving behind a poor root system with a few large galls. Once established, the nematodes are difficult to be eradicated totally and need to be managed by integrated management methods. Biological control with *Paecilomyces lilacinus, Pseudomonas fluorescens, Bacillus subtilis* and *Trichoderma viride/ harzianum* has proved their antagonism against root knot and reniform nematodes in several horticultural crops like banana, papaya, capsicum, tomato, carrot, gerbera, carnation etc. There is a need to develop INM methods for the management of nematodes in passion fruit using these biopesticides. Also grafting with nematode resistant yellow passion fruit root stocks hold a promise for reduction in nematode damage.

IV-10

Management of post harvest fungal rot in aonla fruits

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In harvested fruits of aonla, post harvest fungal rot pathogens *viz., Botryodiplodia, Aspergillus, Penicillium, Curvularia* and *Colletotrichum* were incited due to latent infection. An *in vitro* experiment was conducted on management of post harvest fungal rot pathogens at Regional Research Station, Aruppukottai from 2009 to 2011. There were six treatments replicated thrice and in each treatment, ten fruits were selected and dipped for 10 minutes in Sodium chloride solution (2%), Potassium metabisulphite (3%), Borax (3%), Paushamycin (0.05%) and Carbendazim (0.1%). The dipped fruits were stored separately in polythene bags at room temperature (30 ± 2^{o} C). The pooled results revealed that dipping of aonla fruits in 2 per cent sodium chloride solution for 10 minutes reduced the post harvest fungal rot which recorded 2.3 PDI compared to other treatments and untreated control which recorded 23.3 PDI.

IV-11

Control of aonla diseases for extending shelf life

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Aonla is medicinal and nutrient rich fruit. It is infected by various diseases in field as well as during post harvest conditions in Konkan region. The various diseases recorded are wilt, frost injury, sooty mould, lichen, Blue mould, Anthracnose, soft rot, Black soft rot, fruit rot and dry fruit rot. For reducing the post harvest losses due to disease incidence and extending the shelf life of Aonla the experiment was conducted at Regional Fruit Research Station, Vengurle. Six different treatments were tried. Among the various treatments selected for the experiment, the KMS 50ppm and hot water dip treatment were found to be promising. Aonla fruit can be preserved up to 8 days during post harvest processing if fruit are harvested and preserve without injury and treated with KMS 50 ppm 5 min dip which was effective to reduce post harvest losses of Aonla. This was followed by hot water treatment 500C for 10 min and Sodium benzoate 200 ppm were effective.

IV-12

Reaction of aonla (Emblica *officinalis* Gaertn.) varieties to shoot gall maker, *Betousa stylophora* (Swinhoe) (Thyrididae: Lepidoptera) in Eastern India

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Aonla, *Emblica officinalis* (Gaertn. Syn. *Phyllanthus emblica*) commonly known as Indian Gooseberry or Aonla is an important fruit crop in some parts of India, but it remains as underutilized crop in the state of Orissa though wild as well as organized plantations are seen. It is also now- a- day gaining popularity among farmers and consumers and has immense potential of cultivation in wasteland. This crop has inculcated interest among the scientific workers because it is one of the richest natural sources of vitamin 'C' (Ascorbic acid). Though, it is considered to be a hardy fruit crop, not less than 30 insect and mite species have been recorded feeding on this scared tree from different places, mostly from India (Lakra, 1996). Due to the repeated attack of various insect pests and diseases, the growth of plant is stunted. Shoot gall maker *Betousa stylophora* (Swinhoe) causes severe damage in this crop by making galls in the emerging shoots. The larvae of gall maker penetrate into the new growth of twigs. In the

beginning of the infestation, terminal shoots swell, which increases in size with the passage of time. The gall resembles "Snake chamber's flute" at the apices of growing twigs. The infestation adversely affects the growth of twigs. The infestation of the pest commences from first fortnight of June and continues till the end of December and full size galls can be seen in the month of October-November. Studies on differential damage of gall forming insect (*Betousa stylophora* Swinhoe) were conducted on 10 notified varieties of Aonla during 2010 to 2012 at Central Horticultural Experiment Station, Bhubaneswar having hot and humid climate . A total of 11 varieties in row plantation namely Chakaiya, Francis, NA-6, NA-7, NA-9, NA-10, Anand-2, Baranasi, Kanchan and Krishna were included in the study. The observations on gall maker were recorded during peak period of infestation. Total number of shoots in each variety was counted followed by shoots having insect galls. The galls were cut open to ensure the damage of the pest. The results revealed that variety Chakaiya (7.97 per cent shoot) and Krishna (6.55 per cent shoot) were found to be least preferred by *B. Stylophora*. The highest damage was recorded in Kanchan (22.35 per cent shoot damage and Francis (19.67 per cent shoot). The damage in rests of the varieties was recorded as Anand 2 (15.02%), Banarasi (11.17%), NA-9 (10.66%), NA-7 (12.90%), NA-10 (13.40%), NA-6 (11.93%).

IV-13

Prospects of biological control of *Helopeltis antonii* Signoret by using entomopathogen *Beauverai bassiana*

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The guava mosquito bug *Helopeltis antonii* Signoret is a serious pest of guava in the recent years. Nymphs and adults desap all parts of the plant such as terminal shoots, young leaves, and flowers and just formed fruits causing up to 60 % fruit loss. Application of chemical to control. *H.antonii* could result in the out break of other sucking pests such as mealy bugs, whiteflies and green shield scales which otherwise are kept check by parasitoids and predators. Taking into consideration these negative impacts of pesticides, an alternative control method was developed to control *H.antonii* using the fungal pathogen *Beauverai bassiana* Vull. isolated by Indian Institute of Horticultural Research, Bangalore from adults of *H.antonii* .Field experiment conducted at Indian Institute of Horticultural Research farm, Bangalore, on var. Allahabad Safeda in RBD. Three sprays at 5 days interval were given at onset of fleshing and bud setting.. The IIHR isolate *Beauveria bassiana* recorded significant reduction in fruit damage at harvest that was at par to chemical treatment. Based on the results it could be concluded that the above strain is a promising one that could be utilized for management of *Helopeltis* spp on guava and other fruit crops including minor and under utilized fruits

IV-14

Evaluation of jackfruit germplasm against shoot and fruit borer *Diaphania caessalis* (Wlk.) (Lepidoptera: Pyralidae)

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Jackfruit *Artocarpus heterophyllus* Lam.is native to parts of South and South East Asia. In India, 39 species of insects are known to attack jackfruit. Among them shoot and fruit borer, *Diaphania caessalis* (Wlk.) is a major pest. Sixty nine germplasm collections of Jackfruit were screened for the relative susceptibility to shoot and fruit borer *D. caessalis* under field conditions at Indian Institute of Horticultural Research, Bangalore, during June 2013- May 2014. A significant variation in the level of infestation by *D.caessalis* was observed among the jackfruit germplasm. A total of 5 accessions viz., G-9, G 61 and G-72 to G-74 showed resistance (no infestation at all throughout the year) to jackfruit shoot and fruit borer. Whereas 21 accessions viz., G-34, G-38, G-46, G-49, G-50 to G-53, G-57 to G-60, G-65, G-70, G-71, G-75 to G-80 were found to be least susceptible (0.2 to 0.6 damaged buds/30 buds). Accessions G-7 and G-31were recorded as highly susceptible (6.3-7.0 damaged buds/30 buds), where as the remaining accessions were found to be moderatively susceptible (1.0-5.8 damaged buds/30 buds). The identified resistant accessions forms a basis for further studies on morphological and biochemical analyses of resistance to understand the host plant resistance mechanism to the pest.

IV-15

Screening of Jamun (*Syzigium cumini*) germplasm against leaf damage by insect pests

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Eighty nine accessions of Jamun (*Syzigium cumini*) collected from Karnataka, Kerala, Andhra Pradesh and Andaman & Nicobar Islands were screened for leaf damage during 2012-14. The lowest leaf damage was recorded in accessions collected from Khanapur of Belgaum district and surrounding areas and was maximum in accessions collected from Srisailam and surrounding areas from Andhra Pradesh. This Observation gives a preliminary indication on pest incidence among 89 accessions procured from different agroclimatic zones. Thus, accessions from Belgaum could be a source of less pest incidence which needs further confirmation.

Response of chafer beetles, *Protaetia alboguttata* (Vigors) to fruit volatiles of karonda, *Carissa carandas*

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Cetoniids are popularly called fruit and flower chafers, flower beetles and flower scarabs. They are usually diurnal and visit flowers for pollen/ nectar. However, swarms of beetles were found damaging ripe fruits of Karonda, *Carissa carandas* at Bangalore. Considering the polyphagy of cetoniids and their confined seasonal flight habit during monsoon showers, *P. alboguttata* beetles can pose direct threat to the cultivation of several fruit crops that bear fruits in the months of May and June. In the present study, we compared the volatiles of fresh and damaged fruits of *C. carandus* for their attractiveness to *P. alboguttata*. Headspace samples of volatiles from ripe fruits (fresh and damaged) of *C. carandus* (cv.sweet type) were collected by air entrainment and chemical composition of Porapak Q elutes were analyzed by GC-MS/MS. The behavioral responses of the adult *P. alboguttata* beetles to headspace samples of fruit volatiles were tested in dual-choice glass Y-tube olfactometer bioassays and gas chromatography coupled electroantennographic detector (GC–EAD). The adults showed preference for damaged fruit volatiles over fresh fruit volatiles. GC MS profiling exhibited significant differences in the number and amount of volatile fractions emitted by both fresh and damaged fruits.

IV-17

Seasonal incidence of sapota seed borer and bud borer in Thane district of Maharashtra

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Sapota seed borer *Trymalitis margarias* Mayrick and bud borer *Anarsia achrasella* Bradley are the major pest of sapota. The incidence of bud borer is prevalent in Thane District since long back. However, the incidence of seed borer was noticed first time during 1999. To know the exact situation of these pests in Thane District the studies on seasonal incidence was undertaken at Agriculture Research Station, Palghar and selected ten villages of Thane district during 2005 to 2007. The results indicate that the incidence of seed borer was high during January, February and October to December with peak incidence during December (19.54%), whereas, the incidence of bud borer was high during March to May with

peak incidence in the month of May (15.88%). These results indicate that there is necessity of control measures during October to January for management of sapota seed borer and during March to May for the management of sapota bud borer.

IV-18

Incidence of banana skipper (*Erionota thrax*) (Lepidoptera: Hesperiidae) in Southern plains of Karnataka

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India is a front runner in banana (*Musa* sp.) production with share of 25.6 % in world production with good export potential and is the second most important fruit crop in India next to mango. Attributes like year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit. Recently damage by the Banana Skipper (*Erionota thrax*) (Lepidoptera: Hesperiidae) caterpillars was reported from coastal Karnataka and Kerala. Hence, a roving survey in five districts of Southern plains of Karnataka *viz.*, Bengaluru Urban, Bengaluru Rural, Kolar, Tumkuru, Chikkaballapura and Coorg was undertaken during 2014. Percent presence in surveyed villages was up to 100 %. On an average skipper damage up to 20 % was recorded during the survey. The white waxy coated caterpillars were observed cutting the leaves at the edges to make a series of cylindrical rolls for pupation. The feeding and rolling destroys the leaves, significantly reducing the plant's leaf area and leading to reduced fruit production. The incidence of the banana leaf roller is observed for the first time in most villages and no management measures are in place. Management by mechanical collection of larvae and its destruction is suggested and in case of severe infestation application of ecalaux (1.5 ml /l) is recommended.

Studies on biology of sapota seed borer *Trymalities Margarias* Mayrick

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The infestation of unidentified pest of sapota was reported in Thane district of Maharashtra during 1999. The pest was later identified as *Trymalitis margarias* Mayrick. The studies were conducted at Agriculture Research Station, Palghar to know the biology of sapota seed borer under the ICAR sponsored scheme 'Study of sapota seed borer in Thane district'.The eggs were laid on leaves and the incubation period was ranged from 8 to 11 days with an average of 10.12 days. The full grown larvae was pinkish coloured with average length of 11.56 mm. The total larval period ranged from 11 to 14 days with an average of 12.84 days. The pupation took place on leaves and the average pupal duration was 11.08 days. The female moth was slightly bigger in size than the male moth. The average duration of life cycle was 38 days in case of male, where as, in case of female it was 38.5 days and the sex ratio of male: female was 1 : 2.09.

IV-20

Major fungal diseases in rambutan: Causes, status and need based management - A thought

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Rambutan(Nepheliumlappaceum) is an important fruit tree humid regions of the South East Asia, especially Indonesia, Malaysia and Thailand. In the recent past, this tropical fruit has spread to other humid tropical regions of the world including India.In India it is being cultivated in the states of Kerala, Tamilnadu and Karnataka. It is because of uniqueness of the fruits resembling Litchee, nutraceuticals value, and providinghigher economic returns even to small-holder livelihoods.Rambutan is strictly a tropical fruit requiring a moist warm climate with a well distributed annual rainfall of at least 200 cm. It has been introduced in Kodagu region in Karnataka state of our country. Kodagu has an average temperature of 15 °C, ranging from 11°C to 28 °C with the highest temperatures occurring in April and May. In July and August, rainfall is intense, and there are often showers into November. Yearly rainfall may exceed 4,000 mm in some areas. Though, such a climate is suitable for the Ramburan cultivation, yet is very conducive for the fungal diseases inflicting the crop and may result in high economic losses, if not managed properly.

Among them Powdery Mildew (Oidiumnepheli), Fruit Rot (Phytophthora nicotianae var. parasitica), Anthracnose (Colletotrichum sp.), Pink Disease (Corticumsalmonicolor)Sooty Mould (Meliolanephelii) and(Pseudocercosporanephelii) are most important. Besides these Botryodiplodiatheobromae, Colletotrichum gloeosporioides and Gliocephalotrichummicrochlamydosporum which cause the postharvest diseases known as stem-end rot, anthracnose and brown spot, respectively are also equally harmful not only reducing the storage life and deteriorating the quality of the fruits but also incurring huge losses. Several fungicides, namely, Mancozeb, Thiophanate methyl, Carbendazim, Tridemorph,Metalaxyl in combination with copper and Mancozeb are being recommended for control of above diseases in individual cases. Alternatively plant extracts viz. Neem oil, Citronella oil,Clove leaf extract, Cinnamon leaf extract and use of bio controlare reported to control the disease better than that of recommended fungicides. Similarly,Cinnamaldehydeimpregnated blotting sheets used in commercial packaging reduced the incidence and severity of all three postharvest diseases and retained colour, overall quality and sensory characters.In view of word wide concern for reducing or facing out the use of fungicides especially in fruits, it utmost need to develop an integrated, safer and economically viable disease management protocol for Rambutan. Possibilities of such holistic protocol with the consideration of climatic factors has been discussed in the paper.

IV-21

Production of disease free planting material for cultivation of some underutilized fruits

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India is endowed with vast horticultural wealth across the country covering different agroclimatic zones. Recently, there has been a lot of interest in growing several fruits that are categorized as 'underutilized' because of their useful novel, nutraceutical, medicinal, properties and economic potential were not fully exploited. Among them Jack fruit, Passion fruit, Durian and Rambutan are attracting growers in the 'Kodagu' region which posses an average temperature of 15 °C, varying from 11°C to 28 °C with the highest temperatures occurring in April and May. In July and August, rainfall is intense, and there are often showers into November. Yearly rainfall may exceed 4,000 mm in some areas. Though, such a climate is suitable for the cultivation of such crops, yet is very conducive for the several diseases inflicting the crop that may result in high economic losses, if not managed properly. There has been a huge demand for the planting material of such crops. In 'Jack fruit' propagation of true to type quality fruiting plants vegetative method is preferred; Stooling or mound layering is successful with IBA treatment to improve rooting of layered shoots. Serious diseases inflicting Jack fruit are Pink disease (Botryobasidium salmonicolor, Leaf spot (Colletotrichum gloeosporioides Die-back (Botryodiplodia theobromae). 'Passion fruit' can be propagated through seed, stem cutting, grafting as well as serpentine-layering. Seedlings and grafted plants are more vigorous than the plants raised by cuttings while vines raised from cutting or grafting

start fruiting much earlier (7-6 months) than those from seeds (10-12 months). Seed propagation may be employed for raising rootstocks. Collar rot (Haematonectria haematococca (anamorph: Fusarium solani); Fusarium wilt (Fusarium oxyporum f. sp. passiflorae) Phytophthora root and Crown rot (Phytophthora cinnamomi, P. nicotianae), Anthracnose (C. gloeopsporiodes syn. Glomerella cingulata) and Septoria blotch (spot) (Septoria passiflorae, Septoria fructigena) are major fungal diseases whereas and Passion fruit mosaic virus (CMV), Passiflora latent virus (PLV), Passion fruit distortion and woodiness (Pa WV), Passion fruit yellow mosaic virus (PaYMV), Passion fruit green spot virus (PGSV) are serious viruses resulting great losses in Passion fruit. 'Rambutan' is propagated by seed, budding, grafting and layering. Seed propagation is easy but is not recommended for commercial cultivation as more than 50 per cent of the progeny produce only male flowers. The seedlings can be used for rootstock purpose. Vegetative propagation is essential as Rambutan seedlings take long time for fruiting and female to male trees is 4 or 5 to 7. Rambutan can be vegetatively propagated by approach grafting, air layering and budding. Powdery Mildew (Oidium nepheli), Fruit Rot (Phytophthora nicotianae var. parasitica), Anthracnose (Colletotrichum sp.), Pink Disease (Corticum salmonicolor) Sooty Mould (Meliola nephelii) and (Pseudocercospora nephelii) are most important diseases in Rambutan. In Durian 'modified cleft grafting technique' is employed for multiplication of planting material. Anthracnose (Colletotrichum gloeosporioides), Pink disease (Erythricium salmonicolor) Root and stem rot disease (Phytopthora palmivora) Leaf blight (Rhizoctonia solani), Leaf spot /Crown rot disease (Phyllosticta durians) and Powdery mildew (Odium zebethii) are major diseases of Durian. Thus, mostly vegetative means are employed for the multiplication of these crops and the mother plant as well as tissue employed for multiplication may be infected with such diseases in respective crops. This in turn can result in a serious spread and outbreak and introduction of the diseases, if not controlled both. Thus, there is a serious need to inspect, quarantine and treat the sources of tissue to be employed multiplication of planting material for the eradication for such diseases which spread from the parent plants already harbouring the infection. The strategy for the effective detection and management of diseases with appropriate use of biotechnological tools including judicious and need based application of fungicides and bactericide for the production of healthy planting material has been discussed in the paper.

SESSION V

POST - HARVEST MANAGEMENT AND VALUE ADDITION

LEAD PAPERS AND ABSTRACTS

Post harvest management and value addition of tropical and subtropical under-utilized fruits

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There are several fruits and vegetables, Indian and exotic, which are not grown commercially on large scale, but consumed locally in specific locations. Under-utilized or minor fruit are defined as "those which are neither grown commercially nor traded widely". Most of these minor fruits are rich in certain phytochemicals, vitamin, minerals, and nutrients, and therefore have specific medicinal value. The under-utilized fruits have the potential to contribute to poverty alleviation, food, nutrition and health securities, and employment and income generation for rural and tribal masses. These fruits are easy to grow and hardy in nature, even under adverse soil and climatic conditions. India is one of the richest reservoirs of genetic variability and diversity of under-utilized fruit crops like carambola (*Averrhoa carambola*), jalpai (*Elaeocarpus floribundus*), star aonla (*Phyllanthus acidus*), aonla (*Emblica officinalis*), jack fruit (*Artocarpus heterophyllus*), bael (*Aegle marmelos*), jamun (*Syzygium cumini*), karonda (*Carissa carandas*), amra (*Spondias pinnata*), passion fruit (*Passiflora edulis*), ber (*Ziziphus mauritiana*), fig (*Ficus carica*), *Annona* spp., tamarind (*Tamarindus indica*) and many others. At this point of time when health and nutritional professional are looking at fruits and vegetables as a natural source of remedy for several ailments, documentation of information on their nutraceutical and health promotional values, postharvest handling, preservation and processing are of utmost importance. An effort has been made in this chapter to highlight salient features of such fruits from its utility perspective to address the above issues.

Aonla (*Phyllanthus Embilica*)

Aonla / Amalaki/ Amla (Indian Gooseberry), also known as *Dhatri (*in Ayurveda*)*, is said to be indigenous to tropical south-eastern Asia, particularly in central and southern India. The fruit is widely used in ayurvedic preparation due to its pharmacological properties. Aonla fruits are one of the richest sources of vitamin C (20 times more than oranges), iron and polyphenols. It is considered as the **strongest rejuvenator in Ayurveda**, and used in plenty of ayurvedic preparations. Hundred grams of fruit pulp contains 14 g of carbohydrate, 0.5 g protein, 1.2 g iron, 0.3 mg vitamin B and 600-1000 mg of vitamin C. The fruit contains two hydrolysable tannins *Emblicanin A* and *B*, which have antioxidant properties. *Emblicanin A* on hydrolysis gives gallic acid, ellagic acid and glucose whereas *Emblicanin B* gives ellagic acid and glucose. It is a vital component of the 'Ayurvedic' and 'Unani' systems of medicines for curing various ailments such as indigestion, anaemia, heart complaints, eye diseases and urinary problems. The seeds, leaves, roots, barks and flowers, are also used in traditional medicine and have water purification properties. Aonla is a non-climacteric fruit and takes 8 months from flowering to mature. On maturity the colour changes from light green to dull greenish yellow with a pink tinge. In its marketing, the fruits are generally packed in gunny bags or polyethylene bags. However, CFB boxes were found to be superior for long distance transportation. The critical temperature for storage of aonla is 15°C and 90-95% RH. At this temperature the fruits have 2-3 weeks of shelf life. Raw and fresh aonla fruits are used in the preparation of pickles all over the country. Aonla murabha (preserve) is one of the processed products traditionally made in India. It can be candied using sugar syrup and dried. Aonla is dried into chips and used for making mouth freshener (supari). Aonla juice and its blends with others, like *aloe vera and jamun,* are very popular as a ayurvedic health supplement. It is one of the main ingredients in 'Chyavanprash', an ayurvedic preparation. In certain parts of the country aonla is used for making wine at home. Aonla is also used for making several industrial products like inks, dyes, shampoos, cosmetics and also in tanning industries. Traditionally bagful of aonla is used as a natural clarifying agent of water from wells.

Avocado (*Persea Americana* Mill *)*

Avocado is an important subtropical fruit grown mainly in West Indies, Guatemala and Mexico. It is also grown in several tropical and subtropical regions of India. It is a climacteric fruit and very rich in fat. The maturity is determined based on oil / fat and dry matter content. A mature fruit, though green, should ideally have around 22% dry matter and 8% fat. Wooden boxes or gunny bags were used in earlier times to pack the harvested fruits, but now CFB boxes and plastic crates are used to pack avocado fruits. The optimum temperature for storage of green avocado is 5-13°C and 2-4°C for ripe and ready to eat fruits. At these temperatures fruits had a storage life of 2-3 weeks. However, at ambient temperature avocado does not have a shelf life of more than 6-7 days. Among the postharvest treatments, 1-MCP, wax and other edible coating has proved to prevent or delay the ripening of avocado during trans-shipments. The most popular avocado product is minimally processed pulp which is used for making spreads and dips. Canning of avocado into guacamole using 60% sugar syrup was found to extend the shelf life and quality. Frozen avocado halves and pitted and dried fruit have been successfully attempted. Avocado powder was developed where the oil is separated from the pulp by mild heat and the paste thus obtained was drum dried / spray dried. Avocado milk shake is prepared using fresh, or frozen or refrigerated avocado pulp / paste. The avocado oil is considered to have several health benefits because of which it is used in health supplements, processed food and cosmetic industry.

BaeL (*Aegle marmelos,* L. *)*

Bael (*Aegle marmelos*, L.) is an important indigenous fruit of India. The importance of bael fruit lies in its curative properties. The fruit pulp has 1.8% protein, 0.39% fat and 31.8% carbohydrate. 100 g of pulp contains 55 µg of carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niacin and 8 mg vitamin C. On attaining the maturity the fruit surface colour changes to light brown and pulp turns yellow or orange based on the cultivar. The ripe and unripe fruits, roots, leaves and branches are all used in traditional medicine. The ripe fruit is used to treat chronic diarrhoea and dysentery; the leaves are used to treat eye disorders and ulcers and fresh leaves are used for dropsy and beriberi. Bael fruit is used in different ways in different parts. The fruit pulp is dressed with palm sugar and eaten for breakfast in Indonesia. The pulp is processed as nectar or "squash" (diluted nectar), and 'sherbet'. The sherbet is a popular drink made by beating the seeded pulp together with milk and sugar. A beverage is also made by combining bael fruit pulp with that of tamarind. Mature but still unripe fruits are made into jam, and the ripe pulp is used to make marmalade. This marmalade is given to those convalescing from diarrhea and dysentery. A firm jelly is made from the pulp alone, or combined with guava to modify the astringent flavor. Bael pulp is also pickled.

Ber (*Zizypus mauritiana* Linn)

Indian ber (*Zizypus mauritiana* Linn) is cultivated in India, Pakistan, Iran, Lebanon and Africa. Chinese jujube (*Zizypus jujube*) is cultivated mainly in China and to some extent in Russia and Korea. With wide variability in size and shape there are several varieties grown throughout the country. Generally the maturity is judged based on size and colour specific to a given variety. The fruit matures in about 4-5 months after fruit set with gradual change in colour from green to light green or pale yellow. When fully ripe the skin turns brown. Ber is a climacteric fruit reaching prime eating quality at the climacteric peak. It also favourably responds to exogenous ethylene application. The fruits are packed in polyethylene net bags of 1 kg capacity for retailing. Ber is highly perishable with a short shelf life of 2-4 days at ambient conditions. Postharvest treatments like cold water dip for 2 hours and dip in 500 ppm thiabendazole (TBZ) were reported to decrease the respiration rate, control decay and prolong shelf life. 1-MCP in combination with chitosan coating (0.5%) or chitosan and cinnamon oil coating also improved the storage life significantly at ambient temperature by controlling the decay due to *Penicilium citrinium*. Ber is not commercially processed. However, dried ber, preserve, jujube butter are some products attempted on very small scale. Zuzube juice, zuzube-carrot juice blends, spray dried zuzube powder, jam and osmotic dehydrated zuzube are a few other products developed on experimental basis.

Carambola (*Averrhoe carambola* Linn)

Though three cropping seasons are reported in certain countries, in India carambolas are available during September-October and December-January. Ripe fruits are yellow and color break (half to three-quarter yellow) is used as maturity index commercially. It is a non-climacteric fruit and produces very low levels of ethylene after harvest, but sometimes 100 ppm ethylene exposure helps to degreen the fruits faster as in case of citrus fruits. Because of its star shape the ridges are vulnerable to bruise damage during postharvest handling. Therefore, proper packaging is an important aspect in carambola. The fruits should be packed with stem end down at 45^{o} angle such that flanges of one fruit fits into the 'V' groove of another. Pre-cooling to 4^{o}C by forced air is recommended to reduce the field heat and decay during storage. The recommended temperature for cold storage is 5-10^{o}C with 90-95% RH depending on cultivar and climate of producing area. A storage life of 10 weeks at 5^{o}C and 5 weeks at 10^{o}C has been reported. Being a succulent fruit shriveling is a problem which is reported to be controlled by waxing and modified atmosphere packaging. While sweet varieties are intended for fresh consumption, the tart types are processed into dehydrated slices and candied preserves, jam, jelly, pickles, juice, nectar and fermented beverages.

Dragon fruit (*Hylocereus undatus* Hans)

Dragon fruit, though native to Mexico and Central / South America, is being grown in Vietnam and neighboring countries for over a century. The dragon fruit is judged as mature when the outer skin colour turns bright red / pink. The flesh colour will be white or crimson or pale yellow depending on the variety. The fruit contains small black seeds resembling that of sesame interspersed in its flesh. Other indices of maturity include soluble solid content, acidity and days from flowering. Dragon fruit is non-climacteric and does not exhibit drastic changes in its colour or edible quality after harvest. Under ambient conditions it loses its quality due to moisture loss and fungal spoilage (*Fusarium* and *Aspergillus sp*). The optimum storage temperature recommended is 6-10°C. At 10°C yellow Dragon fruit was reported to have 14 days storage life and at a temperature less than 6°C chilling injury was reported. MAP coupled with storage at 10°C extended its storage life upto 35 days. No extensive use of Dragon fruit for processing is reported. However, as a fresh cut fruit it has great potential. It also holds promise for small scale processing into products like candy, sherbet, preserve, jam and jelly.

Durian (*Durio zibethinus* Murray)

Durian is known for its distinct smell and minute thorn covered husk. Being a minor fruit, it is cultivated on a limited scale in Thailand, Malaysia, Indonesia, the Philippines, and Vietnam. Maturity is judged based on the thickness of stalk, number of days from flowering, natural falling of some fruits to ground and spitting open of segments. Durian is a climacteric fruit exhibiting increase in ethylene evolution and respiration rate with maturity and ripening. The peel emits more ethylene than pulp. The optimum temperature for extended storage life is 15° C with 85-90% RH. At less than 14°C it exhibits chilling injury. Though CFB boxes are ideal for its packaging, bamboo baskets and plastic crates are also used. Durian is used for several value added products like ice cream, biscuits, milk shakes, cakes, soups, flavoured candies, jellies, etc. Durian ice cream is a popular dessert in Indonesia. It is used in several traditional food preparations like '*Sayur*' (fish soup) and sticky rice, curries with coconut milk and fermented beverage (called *Tempoyak*) in Indonesia, Thailand, Java, and Sumatra islands. Unripe fruit and seeds are cooked as vegetable in Thailand and seeds are boiled or roasted or fried and eaten in Malaysia.

Though not very popular, experimental reports suggests the possibility of making several processed products like juice, vacuum dried chips, fruit leather, spray dried and freeze dried powders. Minimal processing of Durian into segments or slices has great scope as the fruit is hard to peel and emits a strong odour (offensive) when kept in a room. Minimal processing facilitates its packaging and refrigeration with which the taste improves.

Fig (*Ficus carica* L.)

Fig (*Ficus carica* L.) native to China, is popular as a dry fruit in India. It is one of the highest plant sources of calcium and fiber. It is also reported to be rich in copper, manganese, magnesium, potassium, calcium and vitamin K. The fruit has laxative property and also contains compounds like gallic acid, chlorogenic acid, syringic acid, catechin, epicatechin and rutin having antioxidant properties. Fig is consumed fresh or dried, preserved, candied or canned. Fresh figs are very delicious, wholesome and nutritious and are also being used for making jam, jellies, pies, pudding, cakes, etc. Commercially dried fig is the most popular product.

Jamun (*Syzygium cumini* Skeels)

Jamun fruits are deep purple to violet in colour and is indigenous to India. It is very nutritious and abundant in phytochemicals (flavonoids). 100 g of fruits contain 19.7 g carbohydrate, 0.7 g protein, 1.0 g iron, 0.02 g calcium, 0.01 g phosphorus, 0.1 g fat and 0.9 g fibre. It is carminative, diuretic and used in blood purification, to treat diabetes, diarrhoea, eczema, and as an antidote for strychnine poisoning. Besides being a dessert fruit, it is also used to make beverages, squash, jam, jelly and wine. It is also used for making vinegar and pickle. Jamun seeds also have many therapeutic values. The seeds contain gallic acid and tannin and a trace of oxalic acid. In Goa and the Philippines, jamun is used for making wine (similar to Port), distilled liquors, brandy and vinegar. Jambolan vinegar, extensively made throughout India, is an attractive, clear purple, with a pleasant aroma and mild flavor.

Jack fruit (*Artocarpus heterophyllus* Lam)

Jack fruit is native to India and believed to be originated in western ghats of southern India. Fresh jack fruit is a good source of potassium (448 mg) , magnesium (29 mg), calcium (24 mg), phosphorus (21 mg), iron (0.23 mg) and zinc (0.13 mg). Fresh jack fruit has small amounts of vitamin-A, but good amount of flavonoid pigments such as *carotene-ß, xanthin, lutein and cryptoxanthin-ß*. Together, these compounds play vital roles in antioxidant and vision functions.

There are two types of jackfruit, one firm flesh type called 'varikka' and the other soft flesh type called 'Koozha' in Kerala. When the jack fruit is mature, it emits a hollow sound on tapping, spines become flattened, colour becomes pale and develops a strong aroma. The jack fruit is a climacteric fruit and shows a respiratory peak three days after harvest. The optimum temperature for long term cold storage (2-6 weeks) of jackfruit is 12-13°C. It can be stored for 4-5 days at ambient temperature. Below 12°C jack fruit exhibits chilling injury. Jackfruits are transported without any packaging. However, use of bamboo baskets or plastic crates are recommended. There are more than 50 different ways the jackfruit is used in India. Commercially important products are jackfruit chips, halva, canned payasam, chakka varatti, chakka pradhaman, cake, canned ripe bulbs in syrup, canned raw bulbs in brine, enzyme clarified juice, juice concentrate, beverages, jackfruit seed powder, etc. Unripe jack fruit is used as vegetable in several regions in India and is a delicacy on certain festive occasions. Jackfruit seed lectin has wide applications in pharmaceutical industry.

Karonda (*Carissa carandas* L.)

Karonda though originated in Java islands, is also grown in the sub-himalayan areas like Siwalik hills, Bihar, and West Bengal and western ghats region. Karonda is a sour and astringent fruit, very rich in iron and vitamin C. The harvest maturity of Karonda depends on the purpose for which it is used. If it is to be used for vegetable purpose it should be harvested when it is greenish white in color. For processing it should be harvested when white tinge disappears and is ripe with pink or dark purple colour.Wide variation is reported in the biochemical composition of the fruit, with total soluble solids ranging from 3 to 4.5%, ascorbic acid from 10.26 to 17.94 mg/100 g, reducing sugars from 0.93 to 2.4% and non-reducing sugars from 0.57 to 1.33%. Karonda is useful to treat anemia, stomach ache and is anthelmintic and antiscorbutic. Karonda has a couple of specific phytochemicals (mixture of sesquiterpenes) viz., carissone and carindone and a triterpenoid viz., carissin. Karonda cherry is an important processed product widely used in India (as a replacement for cherry) in bakery and confectionary industry. The fruits are boiled in a thick sugar syrup to remove the sourness and red colour is added to give the look of cherry. Mature fruits are used for making Karonda pickle / chutney and are sometimes used as source of pectin while making jam and jelly.

Kokum (*Garcinia indica* L.)

Garcinia indica L., commonly known as *kokum*, is a fruit tree that has culinary, pharmaceutical, and industrial uses. The extract/concentrate of this fruit is called *aagal* in Konkani and Marathi. It is ready to use for preparation of *sol kadhi* when mixed with coconut milk. The outer cover of fruit is dried in the sun to get *aamsul* or *kokam*. It is used as a slightly sour spice in recipes from Maharashtra that yields peculiar taste and dark red colour. The acidic sweet fruit is mainly used as souring agent for vegetable curry and dal. Sun drying is practiced for preservation. The fruits contain citric acid, acetic acid, malic acid, ascorbic acid, hydroxycitric acid and garcinol. Fresh fruits are cut in to halves and the fleshly portion containing the seed is removed. The rind which constitutes about 50 per cent of the fruit is repeatedly soaked in the juice of the pulp during sun drying. It makes excellent beverage with pleasant flavour. Kokum butter is a product of commerce obtained from seed. It is also used in soap and candle making and suitable for ointment and other pharmaceutical preparations. This fruit is known to reduce obesity and regulate blood cholesterol level.

Longan (*Dimocarpus longan* Lour)

Longan belongs to the family, Sapindaceae. Longan though is native to southern China, is less important to the Chinese as an edible fruit. The major components identified in longan fruit are gallic acid, corilagin (an ellagitannin) and ellagic acid. Antiobesity and hypolipidemic effects of polyphenol-rich longan flower water extract has been demonstrated in experimental trials.Although longan is mainly used for dessert purpose, it can be dried, frozen or canned. Preserved longans are considered by many as superior to preserved litchi, the flavour being more delicate. Some claim that the quality of longan improved with cooking. In China, the majority of longans produced are canned in syrup or dried. The dried longan product is black, leathery and smoky in flavor and is mainly used to prepare an infusion drink for refreshment. A liqueur is made by macerating the longan flesh in alcohol. The seeds, because of their saponin content, are used like soapberries *(Sapindus saponaria* L.) for shampooing the hair.

Mangosteen (*Garcinia mangostana*, Linn.)

Garcinia mangostana Linn. (GML) is cultivated in the tropical rainforest of Southeast Asian nations like Indonesia, Malaysia, Sri Lanka, Philippines, and Thailand. People in these countries use the pericarp (peel, rind, hull or ripe) of GML as a traditional medicine for the treatment of abdominal pain, diarrhea, dysentery, infected wound, suppuration, and chronic ulcer. GML is reported to have antioxidant, anti-tumoral, anti-allergic, anti-inflammatory, anti-bacterial, and anti-viral activities. The bark and young leaves are used to gargle for sore throat. It contains a crystalizable substance known as mangosteen. Mangosteen is mainly used as a fresh fruit. Aril of the seed is edible after being boiled in water. Mangosteen juice (solo) and blends is very popular product in the Philippines, Malaysia, Australia and South Africa. Mangosteen segments can also be canned in sugar syrup, though they lose their flavour . In the Philippines and Malaya it is used for making jam and a purplish jelly. The seeds are sometimes roasted and eaten.

Passion fruit (*Passiflora edulis* Degener)

Passion fruit is native to Brazil and Latin America through northern Paraguay. The yellow passion fruit (*Passiflora edulis* f. *flavicarpa* Degener), thrives well under humid tropical conditions and purple (*Passiflora edulis* Sims) prefer higher altitudes and subtropical climate. Passion fruit is a climacteric fruit exhibiting an ethylene production peak during ripening and responds well to exogenous application of ethylene. The shelf life of both yellow and purple passion fruit is limited (7 to 10 days) under ambient conditions and prolonged holding results in wilting, fungal decay and fermentation of pulp. Purple types maintain the quality better than yellow types and the colour break from green to yellow is an index of optimum maturity. The critical temperature for storage is 7-10^{o}C for yellow types and 3-5^{o}C for purple types with 90-95% RH. At these temperatures they can be stored upto 3-5 weeks. CFB boxes and plastic crates are ideal for transportation and storage. Though rich in nutrients, the passion fruit is highly acidic and pulp is embedded with large number of small seeds. Because of this the fruit pulp needs to be diluted and sweetened or blended with other fruit juices. It can also be used for flavouring yogurt, ice cream, sherbet or other desserts. Commercially important processed products are pasteurized juice, frozen juice / pulp and concentrate.

Phalsa (*Grewia subinaequalis* DC.)

Phalsa belongs to the family Tiliaceae where only one genus, *Grewia*, yields edible fruit. The only species of any importance is *G. subinaequalis* DC. (syns. *G. asiatica* Mast), long referred to in literature as *G. asiatica* L. Phalsa is the most used vernacular name in India where there are a number of synonyms. The plant is called *falsa* in Pakistan. The fruit is rich in anthocyanins called pelargonidin, which gives the fruit a deep red to pinkish / purplish colour, and is a potent antioxidant.

The fruits are eaten fresh as dessert, or made into syrup, and extensively employed in the manufacture of soft drinks. The fruit is used in making juice and squash. The shoots of the plants after pruning can be utilized for making baskets. Ropes can also be made from the bark after treating it, which yields fiber.

The fresh leaves are valued as fodder. The bark is used as a soap substitute in Burma. A mucilaginous extract of the bark is useful in clarifying sugar. The fruit is astringent and stomachic. When unripe, it alleviates inflammation and is administered in respiratory, cardiac and blood disorders, as well as fever. The leaves are applied on skin eruptions and they are known to have antibiotic properties.

Pummelo *(Citrus grandis* Osbeck*)*

It is the largest of citrus fruits with white, light yellow, pink or rose-red, juicy flesh with a sweet sour or spicy sweet taste. Pommelo fruit is an excellent source of vitamin A, B and C. The pomelo fruit is eaten fresh or processed into juice. The pummelo juice makes an excellent drink for breakfast. In the Philippines and southeast Asia it is used in curing swelling and ulcers. The fruit juice is taken as febrifuge.

Rambutan (*Nephelium lappaceum* L.)

The rambutan is native to Malaysia and commonly cultivated throughout the archipelago and southeast Asia. Though a close relative of the lychee and an equally desirable fruit, this member of the Sapindaceae is not well-known. In the India, it is generally called rambutan; and occasionally, *ramboostan.* Rambutan is a juicy fruit and it is very popular and tasty fruit in many countries.Rambutan mainly serve as fresh fruit or as dessert mixed with other fruits or used for canning or made into fruit syrup. The root have some medicinal value. Tannin present in it is used for dyes. Seed oil from the rambutan is used to manufacture candles and soap. Rambutan fruit is said to heal dysentery and diarrhea effectively. The leaves are also used to cure headaches. In Malaysia, rambutan fruit skin is used to prepare native medicines. Cultivated for its fresh fruit, it is also cooked for stewed fruit and jams. Young shoots are used to produce a green colored dye which is used along with turmeric for dyeing of silk. This fruit dye is one of the ingredients used to dye silk with a black color. The seeds are edible when roasted, and are bitter and said to be narcotic.

Tamarind (*Tamarindus indica* Linn)

Tamarind though native to Tropical Africa, is widely seen in India as avenue trees along the roads. Tamarind pulp is an important condiment as a sour ingredient in the Indian cookery. Pulp has an excellent keeping quality. The wood yields excellent charcoal and is used for making gunpowder. Starch is obtained from seeds and is used in the textile industry. Seeds can be fed to animal after roasting and removing the outer skin. Oil is obtained from seeds and is used in paints and varnishes. Leaves and flowers are also edible and is rich in medicinal properties. Fruits are considered as digestive, carminative and laxative. With the addition of water and sugar, tamarind yields a cool drink which is quite popular in Latin America. Due to its commercial value the most popular processed product of tamarind in India is tamarind paste followed by raw tamarind pickle (thokku). The major phytochemical compounds present are furanone, phenylacetaldehyde and tartaric acid. It is used to treat hyperacidity, leucorrhoea, ulcers and anaemia. The seed coat of tamarind has antioxidant and antimicrobial properties.

Development of value added products from non conventional fruits and vegetables grown in different regions of India

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India has vast resources of horticultural produce and is ranked second to China in vegetables and second to Brazil in fruits in terms of annual production. However, less than two percent of the produce is being subjected to processing and the value addition as such needs to be boosted to realize the full potential. There is also a need to lay emphasis on minor fruits and vegetables which otherwise are not well known in terms of commercial utilization. There are many regions in the country which are endowed with rich resources of fruits and vegetables. The North-East, Central Himalaya and Ladakh regions are prominent amongst them. Many of the fruits and vegetables available in these regions could not see the light of the day as they are locally marketed and value addition has not been adopted to enable the produce to be marketed in fresh or processed forms. In addition to these regions, areas such as Eastern Coast of India having unexploited fruit such as palmyra and the Western Ghats with a rich heritage of fruits and vegetables such as bread fruit could be surveyed and the produce could be subjected to value addition to realize the commercial potential.

Some of the major fruits and vegetables available in the above regions for commercial utility are listed in Table 1. Fruits such as carambola and heitup available in the North – Eastern sector are known for their nutritional value especially carambola which is also known as star fruit. Carambola is an exotic fruit, juicy, succulent and with attractive colour. The fruit is available in the rest of the country also in states of Karnataka, Andhra Pradesh, Uttar Pradesh, Uttarkhand, Himachal Pradesh etc. However, carambola available in the North-East is larger in size and fleshy with a high total soluble solid content making the fruit more amenable to value addition. Chau et al (2004) described the functional properties of carambola fibre with excellent water holding, swelling and cation exchange capacities. The fruit was subjected to value addition world wide to obtain juice concentrate (Wang et al, 1998), ready-to-serve beverage (Soyad, 1999) and fermented juice (Liu et al, 1998), and osmo-dehydrated fruits (Roopa et al., 2014).

Vegetables such as Dillenia are known to be rich sources of antioxidants and fibre. Jena et al. (2002) described the process for the preparation of antioxidant extract from *Dillenia indica*. On the other hand Heitup (*Meyna paniculata*) is relatively an unknown fruit. The fruit is crisp with a good texture in terms of mouth feel, sweet and as such a rich resource of natural antioxidant, fibre and minerals.

In the case of fruits and vegetables from Central Himalayas, items such as Ghingaroo, are excellent fruits, reddish–pink in colour and juice could be formulated in valuable products i.e. for squashes and RTS. Vegetables such as Lingaru, Colocasia. Meeta Karela and Gethi, it could be noted that except Colocasia, the other produce are only locally marketed and value addition to these produce had not taken place so far. Colocasia is a robust tuber vegetable and could be transported successfully to the planes for marketing purposes. Lingaru is an exotic spiral shaped leafy vegetable and the vegetable is well known in the Oriental countries as an exotic green vegetable which could be used in salads or as a selected vegetable preparation. Gethi, on the other hand, is an aerial tuber and seen in the local markets of Uttarkhand. The vegetable resembles potato to a greater extent with a firmer texture and rich resources of antioxidants. Gethi tubers could be ideal for French fries, chips and dehydrated products to add to the list of health foods which had gained increased popularity over the years. Produce such as Nagajalokia chillies which are available in the North-East are one of the hottest chillies in the world with pungency levels of more than 10,00,000 Scuvilline unit (SU). These chillies are ideal for registration geographical indicators (GIS) in terms of intellectual property rights and hold promise to contribute towards domestic and export markets in the form of value added product such as sauces.

The high altitude location of India such as Ladakh is well known for non-conventional fruits and vegetables such as apricot, sea buckthorn and Lepedium leaves. DFRL, Mysore has developed a number of value added products from apricot and sea buckthorn fruits for the benefit of local farming community and the food industry as such. Lepedium leaves are used extensively by the local population in their traditional dishes. The common practice is to subject the leaves for natural washing and leaching in the steams in the form of bundles for subsequent use in their culinary practices. The leaves are rich in vitamins such as carotenoids and ascorbic acid besides being rich source of minerals. The leaves could be subjected to value addition to obtain products such as chutney mixes for the benefit of consumers.

The Eastern coast of India has a rich source of palmyra trees (*Borussus flabellifer*). The trees could be seen in abundance all along the Eastern coast of India and the tree is mostly used for its wood, leaves and coir. However, the tree yields palm fruits in ripe and raw forms. Nikawela et al (1998) characterized the saponins. Enzymatic hydrolysis using naringinase was found to reduce bitterness to increase the scope of value addition with ripe palmyra fruit pulp (Ariyasena 2001). Heating of palmyra meal derived from palmyra shoot and flowers was also found to denature the tetra glucosides (Vindika – Sumudunie 2004 The raw kernels are whitish in colour with internal watery exudates, sweetish in taste and rich in electrolytes. These kernels could be preserved for their thirst quenching ability and soothing taste by minimal / multi preservation techniques. The ripe fruit gives pulp with good visco-elastic properties and it is a rich source of carotenoids, sugars and minerals. The local population makes jaggery out of the same and the pulp can be used for value addition to obtain tasty fruit bars, jams/jellies and RTS beverages. The Western Ghats of India are known for rich productivity of bread fruit which is popular fruit known for functional properties and also as a flour extender (Akubor et al., 2000). Ekpenyoung(1985) and Edet et al (1985) gave a comprehensive account of nutritional and functional aspects of bread fruit. The fruit looks like jack fruit and belongs to the genus of *Artocarpus* sp. which could be used to obtain convenience products such as curry mixes and deep fat fried chips. The Western Ghats are also known for health promoting wonder fruits such as Indian Noni (*Morinda citrifolia).* Noni extracts are widely marketed across the world and China is a major exporter of Noni juice/pulp. It is priced highly due to excellent health promoting functional attributes. Noni fruits posses plenty of functional principles and the foremost among them is proxeronine. The functionalities of Noni are multifold including remedies for cardiovascular dysfunctions, vascular contraction, diabetes, hyper cholesteremia, ageing etc. There is a need for developing value added products from Noni such as fruit juice blended beverages in tetra packs. Since, Noni extract as such do not have adequate sensory attributes to make its consumption on pleasant experience. The other produce of the Western Ghats include *Moringa indica* (Drumstick) in the form of pods and leaves which had been attributed with several functional properties and as such they are rich sources of iron, phosphorus and calcium besides a high ascorbic acid, fibre and protein contents.

There is growing demand for value added products from Moringa which is conveniently processed from such as soup powder and preserved leaf juice for the benefit of consumers.

Technology used for development of value added products from non conventional produce

Most of these fruits and vegetables are known locally and are subjected to localized farming methods or obtained from the forests in wild forms. There is a requirement of domesticating the wild varieties which are otherwise used by the tribal population. These varieties represent the vast genetic diversity and have resemblance with same of the well known fruits and vegetables. Domestication of these produce make it possible to add to the existing gene pool so that newer varieties of fruits and vegetables could be developed based on hybridization or biotechnological methods. The toxicological issues associated with the wild varieties are usually addressed by the parameter "Popular local use" which is a sort of certification to ensure food safety. In the present study, a number of non-conventional fruits and vegetables were subjected to value addition. The range of products include dehydrated product, hurdle technology / minimal processed products, jams, jellies, RTS beverages, Squashes, glazed products, pickles, convenience mixes and nutritional supplements. The products include potential health foods with emphasis on palate value and nourishment and also formulations with other nutritionally important ingredients to make wholesome products. Most of the products are of low calorie nature and rich in phyto-chemicals including minerals. There is a need to develop local entrepreneurship for these products to realize the commercial potential. The nodal laboratories involved in the collaborative project can establish extension services for generating entrepreneurship in the specific areas i.e. North East, Central Himalayas, Ladakh region, Western India and the Eastern Coast of India.

Table 1. Value added products from non-conventional fruits and vegetables

Commodities	Products
Carambola	Hurdle technology product Jams Ready-to-serve drink / squash Osmo-dehydrated products
Bread fruit	Deep fat fried product Minimally processed product Dehydrated product
Palmyra	Hurdle technology processing Minimally processed product Jams/spread Ready-to-serve drink Osmo-dehydrated products

Elephant apple	Osmo-dehydrated products Ready-to-serve drink Pickles
Gethi	Dehydrated product Deep fat fried products
Heitup	Osmodehydrated product
Lingaru	Dehydrated product
Noni	Beverages
Lepedium leaves	Dehydrated powder
Colocasia	Porridge
Noni	RTS beverage
Drumstick	Soup powder Beverage

The products showed an excellent shelf life varying from 6-9 months at ambient storage conditions depending on processing technique which has been periodically tested for physico-chemical, phyto-nutritional parameter. Most of the non-conventional produce studied showed excellent functional attributes and the produce are rich source of phyto-chemical such as natural antioxidants. These commodities can be used for development of various value added products for commercial exploitation.

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An impression on current developments in the technology, chemistry, and biological activities of underutilized fruits

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Cashew apple, the fruit of the cashew tree (*Anacardiumoccidentale* L) is a false fruit and is only a swollen fleshy peduncle while the fruit proper is the kidney-shaped nut attached to it. It possesses an exotic flavour with pleasing aroma. The average weight of the fruit is about 30 to 100 g depending upon variety. The cashew apple is highly nutritious and rich in vitamin 'C', and fiber that could help in prevention of hemorrhoids, varicose veins, hiatal hernias, and diverticulosis. Cashew fruit, according to Nadkarni'sMateriaMedica, is useful as ananaesthetic in leprosy and psomiasis and as ablister in warts, corns and ulcers. Tamarind (*Tamarindus Indica* Linn) is one of the common and most important trees of India. India is the main producer and consumer of tamarind in the world. It is estimated that India produces about 30,000 MT of fruits. Although, tamarind is grown for a long time, as it attained commercial significance only recently. It is used in the form of pulp as souring material in culinary preparations. The present domestic method of extracting the fruit pulp by soaking in water and squeezing out the juice is unhygienic, inconvenient and wasteful. Kokum tree *(Garcinia indica)* grows in the tropical rain forests of the Western ghats, including konkan, Coastal Karnataka coorg and Wynaad, and is reported to thrive on the lower slopes of Nilgiri Hills. It is often planted in the Southern districts of Maharashtra. It flowers in November-February and its fruits ripen in April-May. Kokum is mainly used to garnish and give an acid flavour to curries as well as in preparing cooling syrups in the West coast, especially in the konkan region of Maharashtra. For this, the outer rind of kokum fruits is dried and then soaked repeatedly in the juice of the pulp after which it is sun-dried. It is also used as a starting material for the production of edible natural colour.These crops are cultivated, traded, and consumed locally. These crops have many advantages like easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions. So, exploitation of underutilized horticultural crops can become a solution to the social problem of health and nutrition insecurity, poverty, and unemployment. The consumption of underutilized fruit crops can provide nutrition to the poor and needy tribals by meeting the nutrient requirements of vulnerable groups. As underutilized fruits, nuts, and vegetables are a rich of source of carbohydrates, fats, proteins, energy, vitamins-A, B1, B2, B3, B6, B9, B12, C, folic acid, and minerals-Ca, P, Fe, and dietary fiber. Also, the underutilized crops have the potential to give economic security to tribals by giving employment and by fetching good returns from their sale in raw form as well as value-added products.The present review focuses on the blending/value addition of under-utilized fruitsin appropriate proportions for the preparation of natural fruit based nutritive beverages.

Cashew Apple

Cashew is one of the important plantation crops introduced into India during the16th century. The potential of this crop in the international trade was first realizedby India in the early 1900s' through the export of cashew kernels. Since cashewwas considered as suitable for afforestation and soil conservation purpose, thecashew plantations raised till recently received very little attention. Further,cashew was always planted in the waste land and marginal lands with poorfertility status. Now India has largest area in cashew and it is also the largestproducer, consumer and exporter of cashew in the world. Cashew is mostlygrown in East Coast and West Coast of India and also in North-Eastern hillyregions to a limited extent. The present cashew area in the country is 8.55 lakhha. Production during 2011-12 was 5.73 lakh tones. Brazil and Vietnam are thecompetitors to India for cashew production and export.

Cashew apple, the fruit of the cashew tree (*Anacardiumoccidentale* L) is a false fruit and is only a swollen fleshy peduncle while the fruit proper is the kidney-shaped nut attached to it. The plant prefers deep, fertile, sandy soils but will grow well on moist soils except pure clays or soils that are otherwise impermeable, poorly drained or subject to periodic flooding. It grows well under a wide range of tropical and subtropical climates but is sensitive to low temperatures and freezing. The cashew apple is pear-shaped and it looks like an over ripened apple. Its color varies between different shades of red and yellow. There is a wide variation in weight and size of the apple and also in size of the fruits. The cashew apple has a fibrous flesh and is full of juice. When tender, the fruit is acidic and highly astringent, but when fully ripe it is sweet and slightly astringent. It possesses an exotic flavour with pleasing aroma. The average weight of the fruit is about 30 to 100 g depending upon variety.

The cashew apple is highly nutritious and rich in vitamin 'C', and fiber that could help in prevention of hemorrhoids, varicose veins, hiatal hernias, and diverticulosis. Cashew fruit, according to Nadkarni'sMateriaMedica, is useful as an anaesthetic in leprosy and psomiasis and as ablister in warts, corns and ulcers. The cashew apple contains 10.44 % of fermentable sugars and 261.5 mg/100 g. of Vitamin C, which is almost six times that of citrus fruits (40 mg/100g). Thus the fruit and the wine both have very good antiscorbutic properties. The liquor is also valued as a diuretic and has a healthy effect on the kidneys and advanced cases of cholera as well (S.N.Mahendru,). Various products can be made from cashew apples, such as fruit paste, candied fruit, canned fruit, jam and jelly, chutney, pickles, fruit juice, wine spirit and vinegar (Jain &Girdharilal 1962, Ohler, 1979, Lynannaz 1994). Literature is scant with regard to the pigments and also the nature of fibre in the fruits. The major problem in cashew apple utilization for product development is the presence of tannins which is responsible for the astringency, seasonal availability and short shelf life. However, tannins could be removed by precipitating with gelatin.

Carotenoids were determined by high-performance liquid chromatography (HPLC) and ascorbic acid (AA) by the official method of the Association of Official Analytical Chemists (AOAC) in cashew apple products found on the market of Campinas, (BrazilRaquel et al., 2003). The following products, concentrated juice, frozen pulp, nectar, ready-to-drink, and sweetened concentrated juice, were analyzed, showing AA contents from 13.7 to 121.7 mg/100 g and total carotenoid levels ranging from 8.2 to 197.8 mg/100 g. b-Carotene was the main carotenoid in the majority of the products, followed by a-carotene, b-cryptoxanthin and 9-cis- +13-cis-b-carotene in similar proportions. However, in 10 of the 60 samples analyzed, another carotenoidpattern was found with the presence of auroxanthin, 5,8-epoxycryptoxanthin, 5,8-epoxy-lutein, z-caroteneand two unidentified carotenoids. Cashew apple products were proved to be excellent sources of vitamin C,but not very good sources of carotenoids for the human diet.

Raquel et al., (2003) reported that, different varieties of cashew apple were collected in Brazil, three being from Piauı´ State (Northeast) and two from Sa˜o Paulo State (Southeast). In all the fruits, b-carotene (16.6–67.9 mg/100 g), b-cryptoxanthin (7.7–64.4 mg/100 g), a-carotene (5.9–51.9 mg/100 g) and 9-cis- + 13-cis-b-carotene (3.3–15.6 mg/100 g) were found.In general, the levels of carotenoids were higher in the red than in the yellow cashew apples, from both regions; for example, the levels of a- and b-carotene were about 1.8 and 1.3 times higher in the red than in the yellow fruits from the Southeast and Northeast, respectively. In contrast, ascorbic acid (AA) values were slightly higher in the yellow variety. Elongated red and yellow fruits also presented slightly higher AA contents than the rounded red ones. The total carotenoid levels of the rounded red fruits were 1.5 and 1.7 times lower than those found in the yellow and red varieties, respectively, all being from the Northeast region. Yellow fruits from the Northeast presented 1.7 times higher provitaminAlevels than those from the Southeast whereas, for the red variety, the values were similar. The yellow and red varieties from the Northeast showed non statistically higher AA levels than those from them Southeast.

The alcoholic fermentation of cashew apple juice has been investigated by Deborah S. Garrutia et al., (2006) and as an attempt to develop a novel alcoholic beverage, alternative to wine. The objective of this study was to determine the volatile compounds in this beverage and their role in the aroma. Compounds from the headspace were swept to a Porapak Q trap for 2 h by suction and eluted from the polymer with acetone, separated by HRGC and identified by GC-MS. Five experienced assessors evaluated the GC effluents in three replicates using Osme GC-olfactometry technique. Fermented, fruity and cashew were the beverage primary aroma descriptors. GC-MS and Osme analysis revealed that the esters methyl 3-methyl butyrate, ethyl 3-methyl butyrate, methyl butyrate, ethyl butyrate, trans-ethyl crotonate and methyl 3-methyl pentanoate were important to the sweet, fruity and cashew-like aroma of the beverage. The most unpleasant odor was due to 2-methyl butanoic acid, which was described as sweaty.

Edy Sousa de Britoetal., (2007) described about liquid chromatography, with diode array detection and electrospray ionization mass spectrometry (LC-DAD-ESI/MS), was used to identify and quantify flavonoids in cashew apple. One anthocyanin and thirteen glycosylated flavonols were detected in a methanol– water extract. Among them, the 3-O-galactoside, 3-O-glucoside, 3-O-rhamnoside, 3-O-xylopyranoside, 3-O-arabinopyranoside and 3-O-arabinofuranoside of quercetin and myricetin, as well as kaempferol 3-O-glucoside were identified by direct comparison with standards or positively identified flavonoids in cranberry. The anthocyanin was the 3-O-hexoside of methyl-cyanidin. Trace amounts of delphinidin and rhamnetin were detected in the hydrolyzed extract, suggesting their glycosides were present, but undetectable, in the original extract. The concentrations of the 14 flavonoids in the tested sample were determined. This is the first report of these flavonoids in cashew apple.

Ricardo P. Santos (2007) aimed to produce and characterize the incineration ashes of the primary residue derived from the cashew's juice extraction, the peduncle bagasse. Measurements showed that these ashes represent only 3% of the incinerated material. EDX analysis indicated the presence of the following elements: C, O, P, K, Mg, S, Na, Al and Si. X-ray diffraction and thermal analyses pointed KHCO3 (54.17%), K2SO4 (34.08%) and MgKPO4 Æ 6H2O (10.06%) as the most significant crystalline phases. These results indicate a possible use of this material as an imperishable source of potassium, sulfur, phosphor and magnesium in fertilizers and animal ration. Moreover, it may have many applications since its most abundant component is potassium bicarbonate, compound with several uses.

Ana AméliaMeloCavalcante et al., (2005),evaluated the inhibitory effects of CAJ/cajuina on AflatoxinB1(AFB1)–induced mutation, using the Salmonella/microsome assay with the experimental approaches of pre-, coand post-treatments. Both CAJ/cajuina suppress AFB1-induced mutagenesis in strain TA102 when applied in coand in post-treatment. Possible mechanisms for anti-mutagenicity in co-treatment are (a) interaction with S9 enzymes, (b) metabolization to non-mutagenic compounds of AFB1 or (c) inactivation of S9 potential. Total suppression of AFB1 mutagenicity was observed in co-treatment with both CAJ and cajuina. Post-treatmentanti-mutagenicity of both juices suggests a modulation of activity of error-prone DNA repair. CAJ/cajuina may beconsidered promising candidates for control of genotoxicity of AFB1 and may thus be considered as health foods with anti-carcinogenic potential. This promising characteristic warrants further evaluation with in vivo studies.

Leuconostcmesenteroides B-512F and L. mesenteroides B-742 were cultivated in clarified cashew apple juice to produce prebiotic oligosaccharides. Yeast extract (20 g/L); K2HPO4 (g/L) and sucrose (50 g/L) were added to the juice to promote the microbial growth and dextransucrase production. Initial pH was adjusted to 6.5 with H3PO4. Fermentations were carried out at 30 _C and 150 rpm for 24 h. The prebiotic effect of the fermented cashew apple juice, containing oligosaccharides, was evaluated through the Lactobacillus johnsonii B-2178 growth. L. johnsonii was incubated for 48 h using fermented cashew apple juice as substrate. Lactobacillus growth was compared to the microbial growth in non-fermented juice and in MRS broth. L. johnsonii growth in the fermented cashew apple juice was threefolds the observedgrowth in the non-fermented juice.

Ready process are available from CFTRI for commercial production of cashe apple candy, preservation of cashew apple and beverage dry mix. The freshly harvested cashew apple fruits were immersed in a solution containing NaCl and potassium metabisulphite for a period of 2-4 h, passed through a juice extractor and the extracted juice filtered. The required quantity of a clarifyingagent was added to the juice to precipitate the tannins. The flocculant precipitate of tannins settled down rapidly and the supernatant was siphoned off. The clarified juice was subjected to spray drying using a suitable carrier to obtain a free flowing powder. The free flowing powder was mixed with sweeteners and other additives to obtain cashew apple beverage dry mix. Cashew apple beverage dry mix contains 3.5% moisture and total soluble solids of 14-15% when reconstituted to an aqueous beverage.

The process consists dipping the freshly harvested cashew apple in a solution containing potassium metabisulphite 1000 ppm plus common salt 0.5 % for a period of 4 h transferring the cashew apple to a container with bottom drain and washing with water at least three times to remove the excess of sulphur-di-oxide, dipping the treated cashew apple in 0.5 % calcium hydroxide or 1% limewater solutions for a period of 1 h, softening the calcium hydroxide treated cashew apple by dipping in plain water containing 0.5 % citric acid at a temperature of 100°C for a period of 10 min, removing the excess water by draining out the cashew apple dipped in water and preserving the cashew apple obtained from above step in a brine solution having at least 10^0Brix.

The treated/ preserved cashew apples (400 kg) are soaked in sugar syrup (500 kg) of 30° Brix for 6 hrs. The syrup is drained off and the strength raised by 10° Brix by boiling, added back to the fruit and allowed to equilibrate for 24 hrs. The process of draining the syrup, raising the syrup strength by 10° Brix every time and adding back to the fruit are repeated every day till the syrup strength reached 60° Brix. At this stage, citric acid (0.5%) and flavors are added to the syrup to prevent crystallization of sugar and the process of raising the syrup strength is continued till it reached 75° Brix. The above preserve (900 kg) is transferred to a SS vessel and heated to 90° C and the free syrup drained out. The syrup-free pieces (370 kg) are coated with candied sugar to get fresh novel cashew apple flavoured candy (375 kg).

Tamarind

India is the main producer and consumer of tamarind in the world. It is estimated that India produces about 30,000 MT of fruits and exports tamarind products worth Rs. 50 crores per annum. The fruit pulp contains tartaric acid, reducing sugars, pectin and proteins, besides fibre and cellulosic material. The acid and sugar contents vary from sample to sample. Almost half of the tartaric acid is in a combined form, chiefly as potassium bitartate, and to a small extent as calcium tartarate. The tartaric acid is in dextrorotary form. About 2 per cent of other acids are also present, chiefly malic acid. Of the reducing sugars present, 70 per cent is glucose and 30 per cent fructose. Only a trace of sucrose is present. The crude pectin obtained by alcohol precipitation of acidified extracts is heavily contaminated with ballast materials like arabans and galactans. The hydrolysate analyses to 56.1 per cent galacturonic acid, 3.5 per cent galactose and 12.5 per cent arabinose. Powder pectin samples analyse to moisture 8, ash 3, calcium pectate 80, methoxyl 10 and uronic acid 56.2 per cent. The jelly grade is 180-200 in fresh samples. About 3 per cent crude protein is present in the pulp; 55 per cent of the total nitrogen is, however, present as non-protein nitrogen, and of this 70 per cent is free amino nitrogen. Proline and pipecolinic acid are the chief amino acids present.

The seeds form 35% of the whole fruit and 30 % of the seed is testae and 70% endosperm. The testa contains 40% water solubles, 80% of which is a mixture of tannin and colouring matter. The carbohydrates of seeds consist mainly of a polysaccharide composed of D-galactose, D-xylose and D-glucose in the ratio 1:2:3. The carbohydrates of seeds consist mainly of a polysaccharide and can be used as a substitute for starch and pectin, although it is structurally different from them.The composition of seed kernel is as follows; Proteins 17; fat 7; crude fibre 5.6, non-fibre carbohydrates 65; other components 5.4; and ash 2.8 per cent.The leaves are juicy and soft, with low ash content in spring and become dry and hard, with high ash content in the senescent stage in winter. Tartaric acid and malic acids are the main acids present(Phakruschaphan, 1982).Tender green fruits of tamarind are very acidic, and used to a limited extent to prepare tamarind '*tokku*'(a traditional food adjunct) & pickles, in south Indian states. Some of the draw backs of traditionally prepared '*tokku*' paste are Low shelf life of the prepared paste, Microbial spoilage of the base stock material, High salt content in the product and Quality variation

Hence the main utility of this process lies in providing a traditional condiment in a convenient and shelf stable form thereby avoiding kitchen drudgery and offering for industrial production in a hygienic way and with standard quality throughout the year. This products are a ready-to-use preparation that can find application in homes, restaurants, institutional catering and in industrially processed foods.

Value added products

Tamarind pulp and seeds are of commercial value and are exploited for food and industrial purposes. Pulp is an important acidulent in the Indian dietary. Apart from its use in this form it has potential for the preparation of a few value added products like Tamarind concentrate, Tamarind powder, Tamarind candy and Tamarind beverage. Ready process is available from CFTRI for commercial production of concentrate, powder and green tamarind based spiced paste and powder. There is a great potential for export of many of these products to the Middle East and Far Eastern countries. Demand is particularly for products like beverages and candies. Processes for these products can be developed.

Tamarind juice concentrate

Tamarind (*Tamarindus Indica* Linn) is one of the common and most important trees of India. Although tamarind is grown for a long time, it has attained commercial significance only recently. It is used in the form of pulp as souring material in culinary preparations. The present domestic method of extracting the fruit pulp by soaking in water and squeezing out the juice is unhygienic, inconvenient and wasteful. Potassium bitartrate being insoluble in water, half the acid present in the fruit pulp is left unextracted. Attempts at overcoming these difficulties have resulted in the development of a process for the production of a wholesome and convenient product namely tamarind juice concentrates. This is easy to dispense, since the jam like material is easily dispersible in water. The quality of the product does not deteriorate over a periods of one year storage. The know-how package covers processing and equipment detailed specification, packaging requirements as well as quality control procedures.

Green tamarind paste and powder

Green tamarind 'tokku' is a traditional food adjuvant and a seasonal delicacy prepared in Indian homes, especially in the southern states. It consists of a salt cured base stock of mature raw green tamarind, salt, turmeric powder and roasted fenugreek added in suitable proportions. Required quantities of the cured base material is periodically withdrawn, and ground into a paste adding water and selected spices and seasoning such as green chillies, mustard, cumin and garlic. This 'tokku' preparation has a shelf life of about 1-2 weeks only under ambient conditions. It is eaten with rice, chapathi etc… The present patent provides a method for preparing the 'tokku' like product in a ready to use, shelf-stable form, and a paste or a powder. The powder can be reconstituted with water to a paste or can be used as such also. The main utility of the process lies is providing this traditional condiment in a convenient and shelf-stable form thereby avoiding kitchen drudgery and potential for industrial production, a hygienic product of good quality throughout the year.

Tamarind powder

The cleaned pulp is dried in a suitable dryer at 70 -80^{0}C till the moisture reaches 6-8%. The dried pulp is mixed with known quantity of starch and anti-caking agent and then powdered in a hammer mill and passed through 16- 18 mesh sieve. The sieved material is cooled to room temperature and re-heated and passed through the same mesh sieve once again for obtaining a uniform powder. The sieved powder is packed in air- tight bottles as it is hygroscopic. The final product (powder) will have 12 to 18% tartaric acid and 5-8% moisture. The yield of the powder will be about 95%.

Tamarind paste

The commercial pulp of good quality is freed from seeds, fibrous and extraneous matter. The cleaned pulp is mixed with equal quantity of water and heated at 60-70^{0}C for one to two hours. The heated pulp is mixed well and subjected to coarse grinding in a wet grinder. The ground / pulverized pulp is made to pass through a stainless steel sieve (in a press-machine or manually) and the fibrous matter remaining on the sieve is discarded. The pure pulp (paste) coming through the sieve is collected separately and re-heated to reduce the moisture level. The re-heated pulp is mixed with a preservative and hot filled in air - tight bottles. The yield of the paste will be about 110% and it contains 10-11% tartaric acid on wet basis.

Kokum

Kokum tree *(Garcinia indica)* grows in the tropical rain forests of the Western ghats, including konkan, Coastal Karnataka coorg and Wynaad, and is reported to thrive on the lower slopes of Nilgiri Hills. It is often planted in the Southern districts of Maharashtra. It is unique food spice and medicinal plant. It is mostly grown in Konkan region of Maharashtra as a rain fed crop. It flowers in November-February and its fruits ripen in April-May. Kokum is mainly used to garnish and give an acid flavour to curries as well as in preparing cooling syrups in the West coast, especially in the konkan region of Maharashtra. The outer rind of Kokum fruit is used to prepare kokum Amsole (dried rind treated with salt and kokum fruit juice), which is used in culinary purpose, and it is used as substitute for tamarind in the preparation of curries. It is also used as a starting material for the production of edible natural colour.The juice extracted from the rind is used for syrup preparation and it is sold as a health drink. The Kokum syrup acts as anti-cholesterol and it is remedy for stomach upset. The seeds contain oil (33%), which is known as Kokum butter. Kokum butter is solid at ambient conditions. Kokum seeds are reported to contain a compound, which could turn liquids into solids. The Kokum butter is used in cosmetic preparations. Kokum rind contains Anthocynains pigments, Hydroxy Citric Acid (HCA) and Garcinol. The pigments can be used as a natural coloring in food preparations. HCA reduces fats in the body, and is being used in health care industry. The products from Kokum fruit are widely known as functional food. Functional foods are foods that provide health benefits beyond basic nutrition due to certain physiologically active components, which may or may not have been manipulated or modified to enhance their bioactivity. These foods may help prevent disease, reduce the risk of developing disease, or enhance health. In recent lifestyle the international demand for such products is very high.

Kokum processing

There is only one cycle of processing in a year. Processing is highly season dependent. The basic raw materials are available from April, May and to the first week of June. The processors purchase the raw material and processing operations such as Drying, treating, juice extraction of kokum takes place.

The primary processed products are stored in plastic drums. Subsequently as and when the demands increase, finish processing and packing is done and product is dispatched to the markets. Most of the operations are manual. During the off-season and in order to recover the fixed costs incurred, the units feel that it is essential to prepare products from the original stock of Kokum juice, rind and seeds. For example, Kokum juice can be used to prepare syrup, ready to serve beverages, and seed for Kokum butter. The Ghul, Amsole, Kokum Syrup, Kokum RTS, Kokum butter, Kokum Concentrate products are made from kokum fruit

Dried rind (Ghul)

Freshly harvested fruits are reddish green in colour and turns into full-red-purple colour in a day or two. The normal shelf-life of the fresh fruits is about 5 days. Hence sun drying is practiced for preservation. For sun drying, the fresh fruits are manually cut into halves and the fleshy portion containing the seeds is removed. The outer skin is sun dried for three days. The dried skin or rind is called as Ghul.

Treated rind (Amsole)

The rind which constitutes about 50-55% of whole fruit is repeatedly soaked in the juice of the pulp during the sun drying. About 6-8 days are required for complete drying. The product so dried, constitutes the unsalted Kokam of commerce. A salted variety, wherein common salt is used during soaking and drying of the rind is also marketed. Lonavalakokam, PakaliKokam, Khaneekokam and Khobakokam are some of the trade varieties.

Ripe kokum juice

Juice extraction: After destalking and washing of fruits, the seeds were removed from the fruits. Then the rind pieces along with juice from the fruit was passed through hand operated screw type juice extractor and the juice obtained was filtered through the four folds of muslin cloth and the clear juice obtained was used to prepare the R.T.S. squash and syrup. Salt is added to the juice to avoid fermentation and sorbet (concentrate juice) is made from it, which is packed in plastic drums. A process chart appears.

Kokum syrup

For preparation of syrup, the selection of fruits and extraction of juices were done. After extraction of juices, T.S.S. and acidity of different juices were noted and further required quantity of sugar and citric acid was added to raise the Brix and acidity of juice to 68 Brix and 1.5 per cent, respectively. After adding required quantity of sugar and citric acid, the product was boiled till all the ingredients get dissolved. Then the final product was immediately filled into the pre sterilized glass bottled and the filled bottles were immediately sealed with crown cork and pasteurized in boiled water for 30 minutes. Then the bottles were removed, cooled, labeled and were store at cool and dry place at ambient temperature.

Kokum butter, (Refined)

Kokum butter is obtained from the fruit of the Garcina indica tree grown in India. It has a triglyceride composition that is uniform and consists of up to 80% stearic-oleic-stearic (SOS) triglycerides. Kokum butter has excellent emollient properties and high oxidative stability, which assists emulsion integrity. It is a solid, stable hard butter, which melts on contact with skin. Prevents skin dryness and said to reduce the development of wrinkles. Reduces degeneration of skin cells and restores flexibility to the skin. It is ideal for lipsticks and balms; it‘s also a great addition to bar soaps and skin lotions.

Processing method of kokum butter

The butter is obtained by expeller pressing method. Expeller pressing is a chemical-free mechanical process that extracts oil from seeds and nuts. This method of oil extraction is an alternative to the hexane-extraction method used for many conventional oils. The temperature reached during pressing depends on the hardness of the nut or seed. The harder the nut or seed, the more pressure required to extract the oil, which in turn creates more friction and higher heat. There is no external heat applied during the expeller pressing.

Kokum concentrate

Kokum concentrate is a ready to use substitute in place of kokum fruit, which is used extensively in the Western Coast for culinary purposes. In the CFTRI process, the dried kokum fruits are cleaned to remove the seeds and extraneous matter and then cut into small bits in a shredder. It is then extracted with water in SS percolators. The extract is then concentrated in forced circulation evaporator to around 65° Brix. The concentrate is packed in suitable containers. This is a new product and the estimated future demand is about 1000 tonnes per annum.It is a granular or a free flowing powder, purple red in colour, made by mixing kokum concentrate with carrier like edible starch and subsequent drying.

Kokum contains the following phytonutrients: Anthocyanins (Cyanidin-3-sambubioside, Cyanidin-3-glucoside), Fatty Acids (palmitic, stearic, oleic, linoleic acid), Hydroxycitric acid (HCA), Garcinol, Anthocyanins are well known for their antioxidant, anti-inflammatory and anti-carcinogenic activity. Hydroxycitric acid (HCA) has gained much attention in recent years for its pivotal role in fat/lipid metabolism, with implications for use in weight loss.

Today's consumer constantly struggles to control weight gain which is generally brought about by over-eating, unhealthy food choices, stress and lack of exercise. When we consume a carbohydrate-rich diet, glucose is partially used and stored in the form of glycogen in liver and muscles. The excess glucose is converted to lipids and stored as fat throughout the body which causes weight gain. ATP-citrate lyase is an enzyme that cleaves citrate, produces oxaloacetate and acetyl-CoA (a key molecule used in fat storage). Watson et al., showed that HCA inhibits this crucial catalytic reaction, thus preventing glucose conversion to fat. In mice models, researchers Sullivan et al., have shown that HCA will suppress appetite and instigate a reduced caloric intake. Scientists have proposed that appetite suppression is initiated when HCA infiltrates the blood-brain barrier, and effects acetylcholine levels. Additional Benefits of

Kokum: Rao et al.,(1988) have also shown that HCA decreased cholesterol and triglyceride levels in an animal study. Kokum is known to decrease gastric acidity, prevent mucosal damage and has a plausible function as an anti-ulcer agent.

Future prospects

To take the advantages of kokum, tamarind and cashew apple, the value addition to these underutilized fruits through processing assumes an important activity, because fruits need to be processed before their consumption. In this context, these crops have attained the status of economic importance. The resultant of this activity will creates employment opportunities at rural area and on the other hand develops suitable products for earning the foreign exchange through the export of derivatives. The medicinal and antioxidant properties of these underutilized fruits also priced to be very high and much useful in cosmetic application. As a result of this many pharmaceutical industries have shown keen interest in kokum, tamarind and cashew apple and its derivatives. With this situation, India is the only country enjoying the monopoly with respect to kokum, cashew apple and tamarind production in the world.

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Quality measurement of agro and horti produces by electronic Means E-Nose, E-Vision and E-Tongue technology

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Centre for Development of Advanced Computing (C-DAC) is the premier R&D organization of the Department of Electronics and Information Technology (DeitY), Ministry of Communications & Information Technology (MCIT) for carrying out R&D in IT, Electronics and associated areas. C-DAC, Kolkata, is a constituent unit of C-DAC. It is a national Centre of Excellence in pioneering application oriented research, design and development in Electronics, Information Technology and associated areas. The technology development initiatives of the Centre are focused in the areas of Agri & Environmental Electronics, Knowledge & Perception Engineering, Image Processing, Face Recognition, Software Technologies, Health Informatics, Speech Processing, Information Security, Language Technology, Social Empowerment of Masses through IT, Digitization of Heritage assets, IT Systems & Services and related emerging areas.

In the area of Agri-Electronics, Electronic Nose-Tongue-Vision (ENTV) technology based applications being pursued at Kolkata. Journey of this research activity started with "Integrated Electronic nose and vision system for tea quality estimation", which has been developed and Transfer of Technology done. The Electronic Nose and Vision System (ENOVISION) & E-Tongue systems provide the industries, institutes a non-invasive method for objective assessment of tea quality, based on the new ENTV technology. After achieving success in Tea quality estimation, research activity has been envisaged on ENTV technology based solution for other food and agro produces, i.e. rice, silk, flower, spice, coffee etc. Discussion on ENTV technologies and its application in different areas, in details will be made subsequently.

Electronic Nose and its insight

An electronic nose uses an array of non-specific broadly tuned sensors to discriminate odours. The odours are analyzed by sensor array data with pattern recognition methods. A customized electronic nose set-up has been developed such that the same can be used in production floor of tea processing units for monitoring of volatile emission pattern during the fermentation process. The electronic nose consists of (a) sensor array, (b) micro-pump with programmable sequence control, (c) PC-based data acquisition and (d) olfaction software. An array of metal oxide semiconductor (MOS) sensors has been used for assessment of volatiles in the set-up. A series of experiments were carried out using a number of commercially available MOS sensors. From the response sensitivity of individual sensors, a set of eight gas sensors from Figaro, Japan (TGS-832, TGS-823, TGS-831, TGS-816, TGS-2600, TGS-2610, TGS-2611 and TGS-2620) has been selected

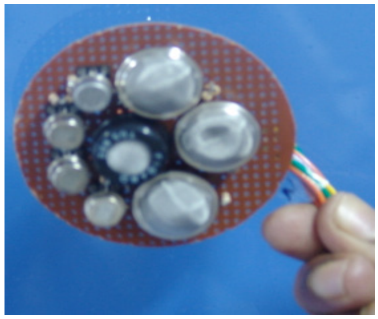

Fig. Sensor Array

Fig. Electronic Nose and Vision System

The outputs of the sensors are acquired in the PCthrough PCI Data Acquisition cards. The MOS sensorsare conductometric in nature, and their resistance decreaseswhen subjected to the odour vapour molecules. The changein resistance with respect to their original values (DR/R) isconverted into voltage and then taken to the PC throughanalog to digital converter cards for subsequent considerationin the computational models.

The experimental sniffing cycle consists of automatedsequence of internal operations: (i) headspace generation,(ii) sampling, (iii) purging and (iv) dormancy before thestart of the next sniffing cycle. Headspace generationensures adequate concentration of volatiles released bytea or other agri produces within the sample holder by blowing regulated flow ofair on the sample. During sampling, the sensor array isexposed to a constant flow of volatiles through pipelinesinside the electronic nose system. During purging operation,sensor heads are cleared with blow of fresh air so thatthe sensors go back to their baseline values. The programmabletime dormancy cycle is the suspended mode of theelectronic nose between two consecutive sniffing cycles.The PC-based data acquisition and automated operationof all these cycles are controlled by the speciallydesigned software, called olfaction software. The softwarehas got features like programmable sequence control,dynamic fermentation profile display, data logging, alarmannunciation, data archival, etc. The software has beendeveloped in LabVIEW_ of National Instruments.

The outputs of the sensors are acquired in the PC through PCI data acquisition cards. The MOS sensors are conductometric in nature, and their resistance decreases when subjected to the odour vapour molecules. The change in resistance with respect to their original values ($\Delta R/R$) is converted into voltage and then taken to the PC through analog to digital converter cards for subsequent analysis in the computational models.

Experimental conditions are as follows:

- » Heating Time= 65 sec
- » Amount of cardamom sample = 10 grams,
- » Headspace generation time = 30s,
- » Data Collection Time = 50s,
- » Purging time = 100s,
- » Airflow rate = 5 ml/s.

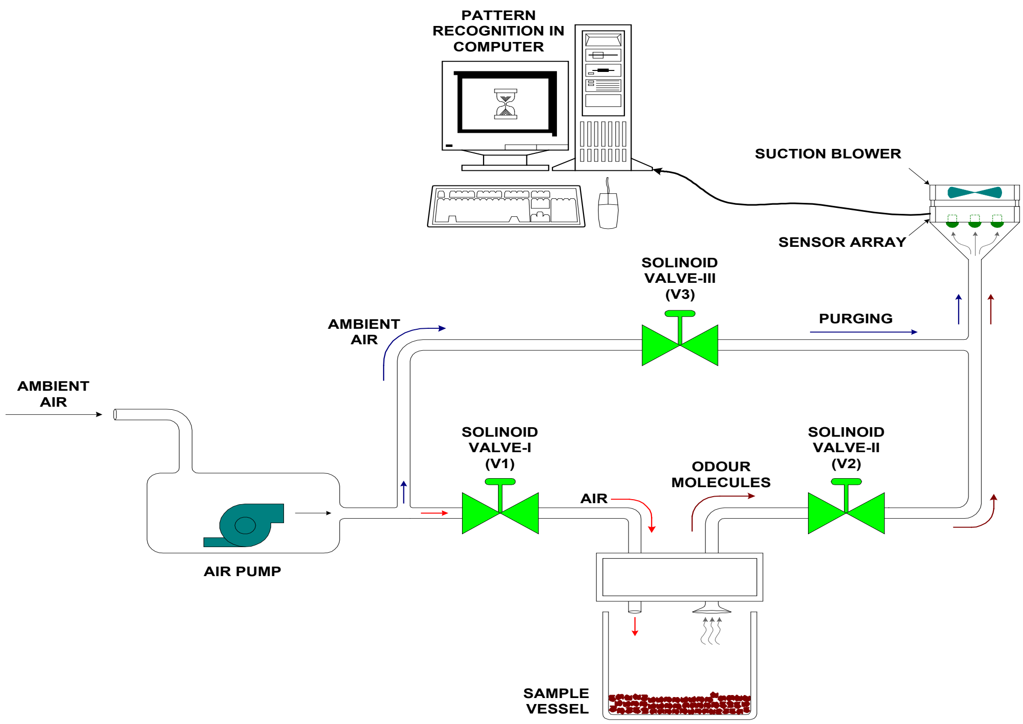

Fig. Customized electronic nose set-up.

Application of E-Nose

Monitoring of optimum fermentation time by E-Nose

Fermentation, which is primarily an oxidation process, is really initiated when the process of rolling begins and gains its momentum in a CTC machine. Reactions that proceed during fermentation are dependent on aeration, temperature and humidity.

Age-old empirical knowledge in the black tea processing inIndia has established the fact that odour emanation in the fermentationprocess travels through two defined peaks of intenseemission of volatiles with much reduced intensity of emissionduring intermediate spans over the fermentation time for blacktea. Such smell peaks are popularly termed as "First Nose" and"Second Nose" in Indian Tea Industry parlance. Experiencedfloor supervisors only can detect such distinct peaks of intensevolatile emission. As soon as the "Second Nose" is detected, thesupervisors call the end to the fermentation process. These socalled"First Nose" and "Second Nose" peaks are not only verysharp and prominent but also very much short-lived. It is quitepossible that the supervisors may not always be able to detectsuch short-lived bursts of odour peaks manually. Such age-oldprocess, though empirical, is being practiced by the Indian TeaIndustries from time immemorial. Such practices definitely arehighly subjective and non-reliable, and may lead to productionof inferior quality tea.

The prototype Electronic Nose may be used to monitor volatile emission pattern infermentation process over passage of time. Through prolonged experimentationwith various clones, fermentation processes and climatic variations, it has beenestablished that smell changes during the process may be reliably detectedrepeatedly by Electronic Nose. Even the smell peaks during so called "First Nose"and "Second Nose" may also be clearly detected with this new smart instrument.

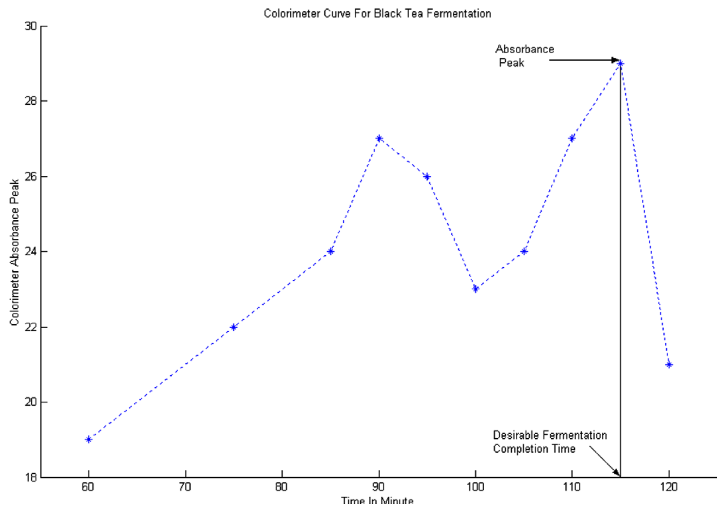

Fig. Fermentation Peaks

Quality evaluation of Finished Tea by E-Nose

Tea is an extensively consumed beverage worldwidewith an expanding market. The major quality attributes of teaare flavor, aroma, color, and strength. Out of these, flavor andaroma are the most important attributes. Human experts called"tea tasters" conventionally evaluate tea quality, and they usuallyassign scores to samples of tea that are under evaluation on a scaleof 1 to 10, depending on the flavor, the aroma, and the taste of thesample. The developed E-Nose for Tea system is capable to predict the Tea quality based on training. Where, first, the selection ofappropriate sensors was carried out based on sensitivity with themajor aroma-producing chemicals of black tea. Then, this sensorarray was exposed to black tea samples that were collected fromthe tea gardens in India, and the computational model has beendeveloped based on artificial neural network methods to correlatethe measurements with the tea taster's scores. With unknown tea samples, encouraging results have been obtained with a more than90% classification rate.

Rancidity detection of chips by E-Nose

French-fries are considered one of the most popular snack products in the world. Usually, they are made by deep-frying fresh potato slices in a vegetable oil bath. The reaction of lipid components of the vegetable oil with oxygen present in the air and heat is a major source of off-odours/flavours in food and, particularly, in French-fries. During the deep-frying process, vegetable oil is under temperature stress and this can induce onset of rancidity as a consequence of oxidative reactions of lipids present in the oil. This rancidity of French-fries ultimately cause the product less acceptable by the consumer. So, early detection of level of rancidity will help to determine Self life of French-fries. The present practice of quality estimation is done by GC, Titrimetric assays and Sensory method where different markers of rancidity such as volatiles or esters, aldehydes presence in the oil is qualitatively or quantitatively determined. This practice is laborious, time consuming and demands a skilled manpower. An Electronic nose sensor array has been made for Self life determination of French-fries. An experiment result has been depicted in PCA graph, where different rancid French fries made different clusters.

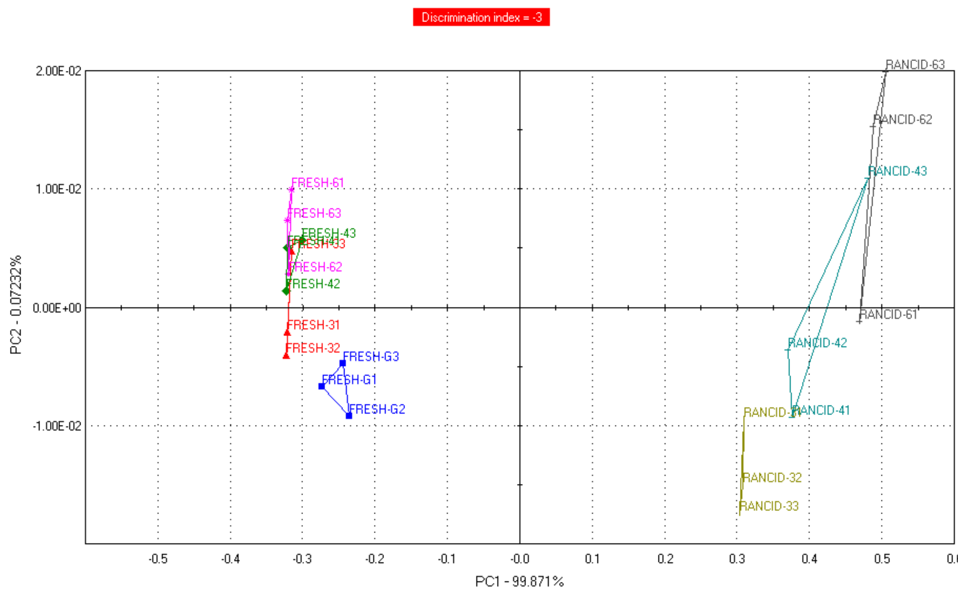

Fig. PCA analysis of French-fries with different rancid level

Some other Application

E-Nose technology has been deployed at some other application also, like, Prediction of oil yield % of cardamom, Soil fertility detection, quality evaluation of jasmine flower and concrete.

Electronic vision Technology

Vision is the most advanced human sense and images play the most important rolein human perception. "Digital Image Processing" is one of the emerging frontiers ofadvanced research and deals with the process of Digital Camera based imagecapturing, conditioning and measuring the captured images by advanced softcomputingalgorithm; so that important information and features may be extractedfrom the acquired images.

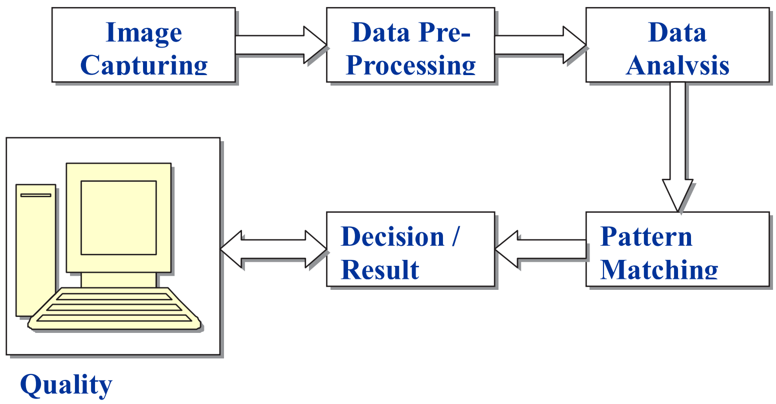

Fig. Fermentation colour profile

Some application of E-VISION developed by C-DAC, Kolkata

Fermentation

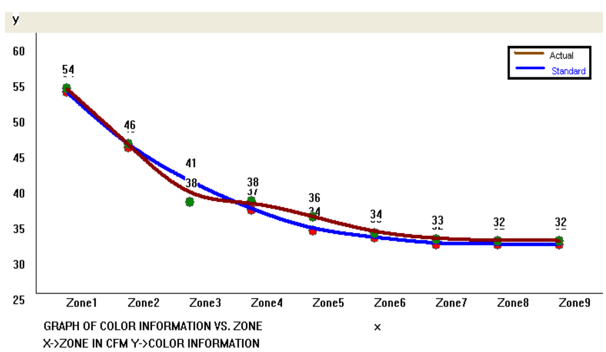

Fig. Software Screenshot

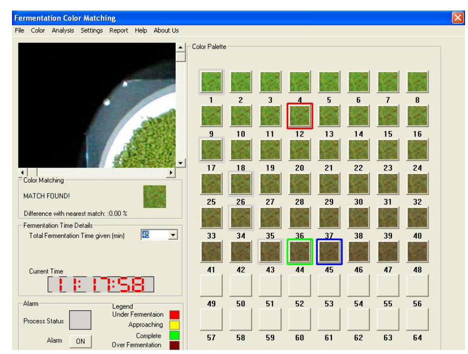

Fig. Fermentation colour profile

Determination of optimum point in fermentation process is crucial for quality in manufactured black tea. Fermentation is basically an oxidation process where various enzymatic reactions and chemical changes occur progressively, which leads to change in colour of the cut tealeaves from green to coppery-brown. Traditionally, the fermentation end point is determined by two physical parameters; namely: (a) observing the odor (apple type flavor) and simultaneously, (b) monitoring the leaf colour (coppery brown). There is a colorimetric test to determine the same fermentation end point.

An Image processing based Tea-FermVision system has been developed for appearance based fermentation process monitoring in tea using a suitable color matching algorithm backed-up with the soft computing technique. During training of the software, a color-palette /image database is required to be created with taking color images of the leaf with various stages of fermentation process. This is called a standard image database. During the actual fermentation process, any leaf image at any stage of the fermentation process can be compared against those of the standard database to determine an estimation of the remaining time for fermentation.

The software framework has been designed with enough flexibility and openness to enable those tea planters themselves may train the system with fermentation color data of their own garden. Additionally, user-friendly software has been designed to display dynamic color profile (with respect to time) for comparison against any previously stored profile. The framework enables data logging, audio-visual alarm annunciation, etc.

Tea Testing - Tea-Vision Software: An image processing based solution for Software for measurement of quality of finished tea based on appearance.

Since the beginning of the tea industry, experts have been traditionally measuring the quality of the processed tea by measuring grain size, appearance, and liquor color, infusion and flavor in a subjective manner (n a 1 to 10 scale) to determine the quality of manufactured black tea depending entirely on visual inspection method alone. Tea-Vision software captures the images of various tea samples for analyzing those samples using color matching/ soft computing technique to provide a color index value (like tea tasters' score) more precisely and reliably. It also finds a suitable match from the previously created image database. Monitoring will be done based on liquor color (with out milk), liquor color (with milk) and infusion. Color image is analyzed using HSI (Hue, Saturation & Intensity) model because human perception is closely matched with this classification system. A suitable color-matching algorithm with soft computing technique has been utilized to determine the nearest match from this image database. Ultimately this color indexing may also be correlated with the tea tastes' grading.

The image processing software has been developed with inbuilt flexibility and openness such that the tea tasters (or planters) themselves can train the system with their own grading. The system will estimate / predict the score/ color index value of the any unknown sample against this created matrices. The user friendly software has been developed to store the tea taster's results after embossing date-time stamping, tasting ID, pointer to the corresponding image in the image database for future reference.

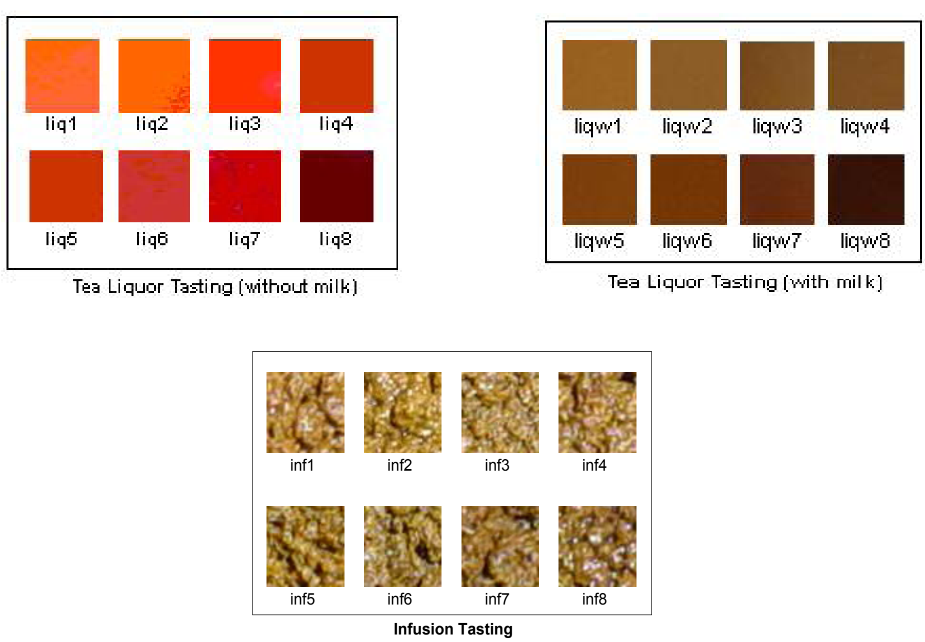

Fig. Some screen sot of Tea-Vision Software

Some other Application

Physical quality estimation of Basmati Rice and Non Basmati Rice is a major quality attributes for domestic market and export market. A E-Vision based system - 'ANNADARPAN' has been developed for Physical quality estimation of Rice, i.e. length, breadth, Area, Perimeter, L/B ration, elongation %, colour etc. Some other application, where research is ongoing are colour characterization of silk yarn, decease detection of reshom moth etc.

Fig. ANNADARPAN System with software screen shot

Electronic Tongue Technology

Taste buds are small structures on the upper surface of the tongue, soft palate,upper esophagus and epiglottis that provide information about the taste of foodbeing eaten. These structures are involved in detecting the five elements of tasteperception: salty, sour, bitter, sweet, and umami (or savory). Via small openings inthe tongue epithelium, called taste pores, parts of the food dissolved in salivacome into contact with taste receptors. These are located on top of the tastereceptor cells that constitute the taste buds. An Electronic Tongue is an instrument which comprises of electrochemical cell, sensor array and appropriate pattern recognition system, capable of recognizing simple or complex soluble non-volatile molecules which forms a taste of a sample. Electronic Tongue is an instrument that comprises of noble metal based sensorarray and pattern recognition model. It is capable of detecting the briskness of tealiquor and predicts briskness score as Tea Taster does in case of tea tasting.An Electronic Tongue system primarily consists of five functional blocks, viz., DataAcquisition System, Switching Circuits, Level Shifting and Amplification Circuit,Sensors and Electronic Test Cell and Intelligent Pattern Analysis and Recognition.The array of sensors is dipped in to the sample of tea liquor under test. Theresponse signals of sensor array are conditioned and processed through suitablecircuitry and fed to an intelligent pattern recognition engine for classification,analysis and declaration.

Application of E-Tongue

The developed Electronic Tongue system is based on Voltammetric technique. Inthis system, an array of six electrodes has been used. Gold, Platinum, Palladium,Iridium and Rhodium have been used as

Working Electrodes. Platinum andSilver/silver chloride electrodes have been used as Counter and Referenceelectrodes respectively. In the instrument, a specified voltage is applied betweenworking electrodes and counter electrode and the voltage equivalent of outputcurrent from working and reference electrode is collected through the dataacquisition card, where it is collected and stored for data analysis. Tea taste ia a major quality attributes of Tea. Tea testers are traditionally taste the tea and give a score between 1 – 10. Developed E-Tongue can be trained with the tea tester value and sample can be tested.

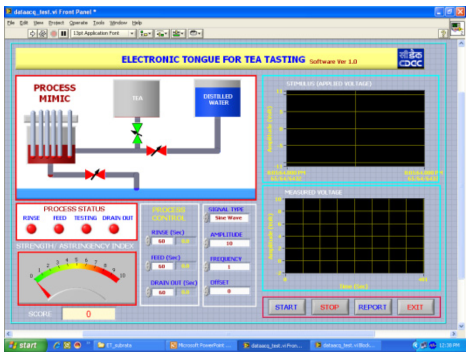

Fig. Software Screen shot of E-Tongue

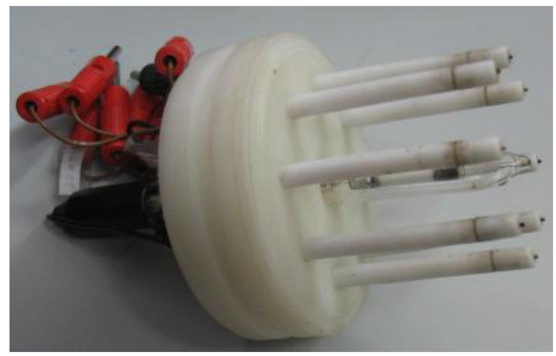

Fig. Sensor array of E-Tongue

Fig: E-Tongue system for Tea, developed by C-DAC, Kolkata

Some other Application

E-Tounge technology is deployed for other application also, i.e. detection of rare earth materials, detection of poly phenols content in tea leaf etc.

Quality estimation of Horticultural produces through Electronic means.

As per our understanding, Quality factors for fresh fruit and vegetables are broadly classified (Kader A.A., 1983) as: hygiene and quarantine factors(parasites larvae, pupae, natural toxicants, contaminants,spray residues, heavy metals etc.), cosmetic appearance(size, weight, volume, dimensions, shape, regularity, surfa-ce texture, smoothness, waxiness, gloss, colour, uniformity,intensity, spectral, physical defects, splits, cuts, dents,bruises), texture (firmness, hardness/softness, crispness,mealiness-grittiness, fibrousness toughness), and flavourfactors (sweetness, sourness, astringency, bitterness, aroma, off-flavours, off-odours) and nutritional (dietary fibre,cancer inhibitors, carbohydrates proteins, lipids, vitamins, minerals). From literature survey, we understood that, most the physical quality analysis is done manually, which is subjective, prone to human error and other analysis involves chemical assays, which is specific but time taking, expensive and expert manpower demanding process.

C-DAC developed ENTV technology may play an important role for determination of most of the mentioned quality attributes of horticultural produces.

Tree spices and functional foods

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There is no one definition of the term functional food, which is used in many contexts, including as technological advances, food marketing, and food regulatory norms. Indeed, the concept of functional food is complex and may refer to many possible aspects, including food obtained by any process, whose particular characteristic is that one or more of its components, whether or not that component is itself a nutrient, affects the target function of the organism in a specific and positive way, promoting a physiological or psychological effect beyond the merely nutritional. The positive effect of a functional food may include the maintenance of health or wellbeing, or a reduction in the risk of suffering a given illness. Aromatic herbs and spices conform to this definition in several ways, although the establishment of any function would involve identifying the bioactive components of these products to help specify their possible beneficial effects on health.

Functional food products have been defined as providing an added health benefit over and above the food product's traditional nutritional value . The main consumer motive for purchasing functional foods is the growing desire to use foods either to help prevent chronic illnesses such as cardiovascular disease, Alzheimer's disease and osteoporosis, or to optimize health, for example by increasing energy, boosting the immune system, generation of wellbeing etc. This need has led to one of the fastest growing food sectors, with a compound annual growth rate of 8.6% in the 10 years to 2012. The emergence of a new market segment called 'Health and Wellness' reached a global value of US$625 billion in 2012. This segment incorporates fortified/functional foods, but also including organic foods, "better for you" food and beverages (BFY), "naturally healthy" (NH) foods, products catering to food intolerance, vitamins and dietary supplements, traditional herbal products, slimming products and sports nutrition. Of this market, the functional foods part alone was valued at US$168 billion in a global market that is 2.5 times the size that of vitamins and dietary supplements.

The product development process for new functional food products has been described as complex, expensive and risky. The gray area where food and health markets merge has generated a need for new competencies for personnel and enterprises working in functional food product development (FFPD).

Spices and Health

Spices are an important part of human nutrition and have a place in all civilizations of the world. It is well documented in literature how spices impart flavor and reduce the need for salt and fatty condiments, improve digestion and provide the organism, the extra anti oxidant that prevent the appearance of physiological and metabolic alterations.

One of the changes secured in food industry is from the concept of 'adequate nutrition' to 'optimal nutrition' which includes potential of food to promote health, improve well being and reduce the risk of developing disease. That is how new terminologies like functional foods, designed or therapeutic foods, super foods or medicinal foods emerged.

The positive effect of a functional food may include the maintenance of health or well being or a reduction in the risk of suffering a given illness. Functional food may be obtained by modifying one or more of the ingredient or by eliminating the same.

Culinary herb and Spice

The leaves of a plant used in cooking are denominated as culinary herbs while any other part of the plant is known as a spice. Spices can be leaf(eg bay leaf), buds (clove), bark (cinnamon), root (ginger), berries (grain of black pepper), seeds (cumin) or even stigma of flower (saffron). Both spices and herbs can be used fresh, dried, whole, chopped or ground and due to their colour, aroma and / or flavor characteristisc are used in the preparation of foods and drinks. Spices and herbs contain proteins, fiber, sugars, essential oils, minerals, pigments besides bioactive compounds such as phenolic acids, sterols and cumarins. Many of the functional properties attributed to spices associate with presence, type and concentration of phenolic compounds although exact composition depend on several factors such as the plant part used, vegetative state, environmental conditions, harvesting techniques etc

Other compounds present in spices are the essential oils which due to their content in terpenes, monoterpenes and sesquiterpenes (as hydrocarbons, alcohols, ketones etc.)are responsible for many functional properties. These are composed of more than 70 components some of which may represent more than 85% of total content.

Phenolic Compounds

Phenolic compounds in any forms present in spices and herbs whether simple phenoles, flavons, flavanones, flavanols, anthocyanins etc are responsible for their functional properties. Properties of spices such as antioxidant, antibacterial, antiviral, anti-inflammatory capacities, cardio protective and anti carcinogenic effects and their ability to act as inhibitors of platelet aggregation are significant. Phenolic compounds contribute to colour and taste. Simplest phenols are liquid or solid with a low fusion point and high boiling point as they form hydrogen bonds. They are easily oxidized which is why they frequently appeared to be coloured.

Terpenes

These group of chemicals are the fundamental components of essential oils. They all result from the condensation of isoprenic units. Among their different form are monoterpenes, diterpenes and sesquiterpenes. They are extremely volatile and have been demonstrated to possess multiple functional properties including antioxidant, antimicrobial and antiviral capacities.

Antioxidant properties

Spices have shown their ability to slow down process of lipidic oxidation. This process is one of the principal causes of food spoilage and may occur during the storage of raw materials, processing or at the storage of final product. To avoid such spoilage food industry has resorted to synthetic antioxidant formulations, some of the most commonly used being butylated hydroxy toluene (BHT) butylated hydroxyl anisole(BHA) and propyl gallate. However because of their synthetic origin their safety and efficacy are frequently questioned. The result has been a growing interest in compounds of vegetable origin which show antioxidant potential.

Possible mechanism of antioxidant action by spices may be by scavenging free radicals, hydrogen donation, the chelating of metallic ions or the capacity to act as substrate of radicals such as superoxide or hydroxyl.

Free radicals, produced as a result of normal biochemical reactions in the body, are implicated in contributing to cancer, atherosclerosis, aging, immune suppression, inflammation, ischemic heart disease, diabetes, hair loss, and neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease. The human body possesses innate defense mechanisms to counter free radicals in the form of enzymes such as superoxide dismutase, catalase, and glutathione peroxidase. Vitamin C, vitamin E, selenium, b-carotene, lycopene, lutein and other carotenoids have been used as supplementary antioxidants.

Apart from these, plant secondary metabolites such as flavonoids and terpenoids play an important role in the defense against free radicals.

Plant parts of medicinal plants including spices (roots, leaves, branches/stems, barks, flowers, and fruits) are commonly rich in phenolic compounds, such as flavonoids, phenolic acids, stilbenes, tannins, coumarins, lignans and lignins. They have multiple biological effects including antioxidant activity. The antioxidant properties of phenolic acids and flavonoids are due to their redox properties, ability to chelate metals and quenching of singlet oxygen. Flavonoids, which are partly responsible for the pigmentation of flowers, fruits and leaves, are subdivided into flavanols,flavonols, flavones, flavanones and anthocyanins based on the saturation of the flavan ring and also their hydroxylation. They occur mostly as glycosylated derivatives, sometimes conjugated with sulphate or organic acids.

Role of Spices in health benefits

Spices are esoteric food adjuncts that have been used as flavoring and coloring agents and as preservatives for thousands of years. Much health benefit attributes of these common food adjuncts have been recognized in the past few decades by pioneering experimental research involving both animal studies and human trials. These studies documented digestive stimulant action, hypolipidemic effect, antidiabetic influence, antilithogenic property, antioxidant potential, anti-inflammatory property, antimutagenic, and anticarcinogenic potential of spices. Among these, the hypocholesterolemic and antioxidant properties of a few specific spices have far-reaching nutraceutical value. These beneficial physiological effects also have the potential of possible therapeutic application in a variety of disease conditions.

The spice trade, probably, is the most ancient trade practiced by man. The affluence generated by the spice trade was responsible for several historic voyages and discoveries of new lands. Today, the annual global spice trade is estimated to be in the order of $2000 million involving a quantity of 500,000 tons. India is the largest producer, consumer, and exporter of spices. India's annual spice exports amount to 2.3 lakh tons and of a value of Rs.16,000 million.

Spices are not only used individually, but also in the form of spice mixtures, known as 'curry powder," to suit different tastes and dishes. Although spices have never been considered to contribute anything to human nutrition, this group of food adjuncts has been used in human diets for centuries as flavor modifiers to make food more palatable. Some spices contain significant levels of vitamins and minerals, which cannot be ignored. A few spices are also rich sources of dietary fiber. The components of spices responsible for the quality attributes have been designated as "active principles" and in many instances, they are also responsible for the beneficial physiological effects of spices.

Extensive animal studies carried out to evaluate the safety aspects of spices have indicated that even at much higher dietary levels (up to 100 times the normal intake), red pepper, black pepper and turmeric have no adverse effects on growth, organ weights, Feed Efficiency Ratio, nitrogen balance, and blood constituents. In the past two to three decades, many more beneficial physiological effects of spices have been experimentally documented , which suggest that the use of these food adjuncts extend beyond taste and flavor. Among the health problems that effect mankind, diabetes, cardiovascular disease, and inflammatory disorders including arthritis, and cancer have received considerable attention. During recent years, spices and their active principles have been studied as possible ameliorative or preventive agents.

Antidiabetic Potential

Diet has been recognized as a corner stone in the management of diabetes mellitus. As part of the dietary treatment of diabetes, there has been a continuous search for novel antidiabetic drugs from plant sources. Spices, the natural and common food adjuncts, have also to be examined in this direction and their efficacy has been dealt with in detail. A considerable number of human experiments have also been carried out on these aspects, in addition to experimentally induced animal diabetic models. Major spices and their medicinal properties are listed in table.1

Table 1. Major spices and their medicinal properties

Medicinal property	Spices
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

Value added products from tree spices

A variety of products that can be made from tree spices as listed in Table 2.

Table 2. Value added products from major tree spices

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

Potential of Tree spices

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

Cinnamon powders from the bark of Cinnamomum species have long been used in Ayurvedic and traditional Chinese medicines as an antidiabetic . Within the past decade, several clinical trials evaluating the effects of cinnamon powder or cinnamon extract on symptoms of diabetes have been conducted with mixed outcomes. The form in which cinnamon is administered may be important since extracts (aqueous and/or organic solvent extraction) and powders (pulverized bark material) would provide different compositions of phytochemicals with different levels of bioavailability. A number of cinnamon phytochemicals, such as cinnamic acid, cinnamaldehyde and Proanthocyanidins (PACs) have demonstrated bioactivities in cellular pathways that lead to improved glucose balance in vivo. Cinnamon PACs have been reported to regulate expression of insulin signaling and glucose transport genes in adipocytes. Additionally, aqueous cinnamon extracts stimulated glucose uptake and glycogen synthesis in adipocytes A- and B-type. The incorporation of cinnamon powder into a rodent diet reversed high fat high-fructose impaired expression levels of insulin-signaling genes in the liver and muscle of rats.

Although cinnamon bark powder contains beneficial phytochemicals, cinnamon is commonly used in small quantities as a flavouring agent, where the dose of bioactives is unlikely to be measurably effective in humans. Conversely, large doses or chronic ingestion of cinnamon powder may also provide an increased dose of oil components that may cause adverse effects, such as inflammation and hyperkeratosis of the fore stomach . An aqueous extraction method reduces the exposure to cinnamon oil components as they are not efficiently extracted. The high content of water soluble bioactive polyphenols found in cinnamon bark can be similarly captured onto a protein rich soy flour matrix. The cinnamon polyphenol enhanced matrix would provide a protein rich dietary source of cinnamon bioactive phytochemicals. In a study by Cheng etal (2012) a phytochemically-enhanced functional food ingredient that captures water soluble polyphenols from aqueous cinnamon extract (CE) onto a protein rich matrix was developed. CE and cinnamon polyphenol-enriched defatted soy flour (CDSF) were effective in acutely lowering fasting blood glucose levels in diet induced obese hyperglycemic mice   at 300 and 600 mg/kg, respectively. Furthermore, CE decreased the gene expression of two major regulators of hepatic gluconeogenesis, phosphoenolpyruvate carboxykinase and glucose-6-phosphatase. The hypoglycemic and insulin-like effects of CE and CDSF may help to ameliorate type 2 diabetes conditions.

The incidence of cardiovascular diseases is increased two- to fourfold in people with type 2 diabetes . Although the causes of type 2 diabetes and cardiovascular diseases are multifactorial,diet definitely plays a role in the incidence and severity of these diseases. The dietary components beneficial in the prevention and treatment of these diseases have not been clearly defined, but it is postulated that spices may play a role. Spices such as cinnamon, cloves, bay leaves, and turmeric display insulin-enhancing activity in vitro . Botanical products can improve glucose metabolism and the overall condition of individuals with diabetes not only by hypoglycemic effects but also byimproving lipid metabolism, antioxidant status, and capillary function. A number of medicinal/culinary herbs have been reported to yield hypoglycemic effects in patients with diabetes.

Khan etal (2003) demonstrated that intake of 1, 3, or 6 g of cinnamon per day reduces serum glucose, triglyceride, LDL cholesterol, and total cholesterol in people with type 2 diabetes and suggest that the inclusion of cinnamon in the diet of people with type 2 diabetes will reduce risk factors associated with diabetes and cardiovascular diseases.

Studies also showed that Cinnamon extract improves fasting blood glucose and glycosylated hemoglobin level in patients with type 2 diabetes

Potential of Nutmeg and clove

Free radical and reactive oxygen species are responsible for lipid oxidation, which is the major chemical change involved in the deterioration of food during processing and storage. Antioxidants have been widely used as food additives to provide protection from oxidative degradation of foods and oils. The most extensively used synthetic antioxidants are propylgallate (PG), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and tert-butylhydroquinone (TBHQ), but there are some arguments about the safety and adverse effects of these substances when used as food additives. In fact, in recent years, researchers have focused on spicy and medicinal plants for extracting natural antioxidants, which play an important role in the food industry to combat food deterioration.

Studies have shown that Essential oil and oleoresins (ethanol, ethyl acetate, and iso-propyl alcohol) of *Myristica fragrans* were extracted by using Clevenger and Soxhlet apparatus, respectively. Gaschromatography-mass spectrometry analysis of essential oil showed the presence of 38 components representing about 99.6% of the total weight. Sabinene (29.4%) was found to be a major component along with beta pinene (10.6%), alpha pinene (10.1%), terpene-4-ol (9.6%),and several other minor components. Elemicin was the major component of all oleoresins. It has been observed that the essential oil and ethanol oleoresin showed better activity compared to other tested oleoresins and synthetic antioxidants, butylated hydroxyl anisole and butylated hydroxyl toluene. Furthermore, the activity of essential oil and oleoresin was measured for the inhibition of primary and secondary oxidation products in mustard oil by using peroxide, thiobarbituric acid, and p-anisidine values. In addition, these experiments were further supported by other complementary antioxidant assays, such as ferric thiocyanate method in a linoleic acid system, reducing power, chelating effect, and scavenging effects on 1,1_-diphenyl-2-picrylhydrazyl radical. Hence, the essential oil and ethanol oleoresin of *M. fragrans* could be considered as a natural food preservative.

Due to the role of free radicals in the etiology of chronic diseases including cardiovascular disease and cancer, the antioxidant properties of culinary spices, which are likely to be because of their high polyphenol content, have been the focus of some interest.Similar to free radical damage, chronic inflammation has been linked to the etiology of these conditions as well as neurological and metabolic disorders, and a growing number of culinary spices have been identified as possessing anti-inflammatory activity. Spices such as cinnamon, clove and nutmeg commonlyform part of a diverse group of cooked dishes, so the influence of cooking on the antioxidant and anti-inflammatory properties of these spices is of importance.The impact of cooking and digestion on the antioxidant capacity (AC), estimated total phenolic content (TPC) and anti-inflammatory activity (AA) of culinary spices wasdetermined to investigate their significance as dietary contributors to these properties. Extracts of uncooked (U), cooked (C) and cooked and digested in vitro, (D) cinnamon, clove and nutmeg were prepared and the TPC, AC and AA, specifically the inhibition of cyclo-oxygenase 2 (COX-2) and the amount of prostaglandin (PG) synthesized, were determined. Compared to their uncooked (U) counterparts, the following changes were statistically significant: the AC and TPC for (C) clove, and the TPC for (D) clove decreased, the TPC for (D) clove increased, the TPC for (C) nutmeg increased, and the

AC and TPC for (D) nutmeg increased, and the TPC for (C) and (D) nutmeg increased. All the spices achieved near 100 % inhibition of COX-2 which was associated with the inhibition of the amount of PG synthesized. Based on estimated levels of ingestion, cinnamon possesses a much higher AC than clove and nutmeg because it is typically used in larger quantities. For AA, (U, C and D) cinnamon and clove maintain near 100%inhibition of COX-2 but only the inhibitory potential of (D) nutmeg could be ascertained (70 %). Cooking and digestion alter the TPC and AC of these spices although the changes are not consistent between spices or across treatments.In contrast to AC, significant AA is likely to be present in these spices at amounts used in cooking

Encapsulation of polyphenols

Microencapsulation, developed approximately 60 years ago, is defined as a technology of packaging solids, liquids, or gaseous materials in miniature, sealed capsules that can release their contents at controlled rates under specific conditions . The packaged materials can be pure materials or a mixture, which are also called coated material, core material, actives, fill, internal phase or payload. On the other hand, the packaging materials are called coating material, capsule, membrane, carrier or shell, which can be made of sugars, gums, proteins, natural and modified polysaccharides, lipids and synthetic polymers

Microcapsules are small vesicles or particulates that may range from sub-micron to several millimeters in size. Many morphologies can be produced for encapsulation, but two major morphologies are more commonly seen: one is mononuclear capsules, which have a single core enveloped by a shell, while the other is aggregates, which have many crores embedded in a matrix. Their specific shapes in different system are influenced by the possess technologies, and by the core and wall materials from which the capsules are made.

Various techniques are used for encapsulation. In general, three steps are involved in the encapsulation of bioactive agents: (i) the formation of the wall around the material to be encapsulated; (ii) ensuring that undesired leakage does not occur; (iii) ensuring that undesired materials are kept out. The current encapsulation techniques include spray drying, spray cooling/chilling, extrusion, fluidized bed coating, co-acervation, liposome entrapment, inclusion complexation, centrifugal suspension separation, lyophilization, cocrystallization snd emulsion, etc

The main objective of encapsulation is to protect the core material from adverse environmental conditions, such as undesirable effects of light, moisture, and oxygen, thereby contributing to an increase in the shelf life of the product, and promoting a controlled liberation of the encapsulate. In the food industry, the microencapsulation process can be applied for a variety of reasons: (i) protection of the core material from degradation by reducing its reactivity to its outside environment; (ii) reduction of the evaporation or transfer rate of the core material to the outside environment; (iii) modification of the physical characteristics of the original material to allow easier handling; (iv) tailoring the release of the core material slowly over time, or at a particular time; (v) to mask an unwanted flavor or taste of the core material; (vi) dilution of the core material when only small amounts are required, while achieving uniform dispersion in the host material; (vii) to help separate the components of the mixture that would otherwise react with one another. Food ingredients of acidulants, flavoring agents, sweeteners, colorants, lipids, vitamins and minerals, enzymes and microorganism, are encapsulated using different technologies.

Recently, research and applications of polyphenols have been areas of great interest in the functional foods, nutraceutical and pharmaceutical industries. Polyphenols constitute one of the most numerous and ubiquitous group of plant metabolites, and are an integral part of both human and animal diets which possess a high spectrum of biological activities, including antioxidant, anti-inflammatory, antibacterial, and antiviral functions. A large body of preclinical research and epidemiological data suggest that plant polyphenols can slow the progression of certain cancers, reduce the risk of cardiovascular disease, neurodegenerative disease, diabetes, or osteoporosis, suggesting that plant polyphenols might act as potential chemopreventive and anti-cancer agents in humans.

Unfortunately, the concentrations of polyphenols that appear effective *in vitro* are often of an order of magnitude higher than the levels measured *in vivo*. The effectiveness of nutraceutical products in preventing disease depends on preserving the bioavailability of the active ingredient. This is a big challenge, as only a small proportion of the molecules remain available following oral administration, due to insufficient gastric residence time, low permeability and/or solubility with in the gut, as well as their instability under conditions encountered in food processing and storage, or in the gastrointestinal tract, all of which limit the activity and potential health benefits of the nutraceutical components, including polyphenols. The delivery of these compounds therefore requires product formulations and manufactures to provide protective mechanism that can maintain the active molecular form until the time of consumption, and deliver this form to the physiological target within the organism. Another unfortunate traits of polypheonls is their potential unpleasant taste, such as astringency, which needs to be masked before incorporation into food products.

Conclusion

Functional foods, being one of the major food categories of the global health and wellness market, are becoming a major focus of new product development (NPD) in the food industry. Functional food product development (FFPD) is a complex process with success factor that are somewhat different from those of traditional new food product development. Greater focus on a product- oriented NPD portfolio and diverse multiple external partners have been suggested as key factors for accelerating the progress of FFPD. Tree spices cinnamon, nutmeg and clove possess great potential in the functional food sector.

Approaches for processing and flavour quality in products of underutilised fruits

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There are a number of semi-tropical and tropical fruits both with utilized and underutilized value addition potential including juice, puree or pulp in India. Processing technology and flavour quality in fresh and value added products including juice products from the less-known fruits such as karonda and passion fruit, which is an area of potential interest.Most other fruits are strictly tropical as their commercial production is severely limited by near freezing temperatures and actual freezes are devastating. Even tropical highlands may not be suitable, barring protective climates (Popenoe, 1920; Martin, *et al.,* 1987; Mortonnes, 1987).Karonda, passion fruit, etc. and a host of other fruit known and consumed only locally and sporadically. When prepared and stabilized in liquid/solid form these exotics can provide additional value and diversity to juices and value added products. They possess nutraceutical/phytochemical, nutritional, sensory and other desirable quality attributes as yet under exploited. Compared to the shelves of a health food store, these are with many food and dietary supplement value awaiting discovery. Fruit products such as juices, puree etc. and passion fruit juice are commercially important. Karonda and its value added products have bright commercial potential. While under-utilised fruits such as Karonda and passion fruit are:

» The fruits not available in sufficient quantity to justify industrial processing in India (except some small isolated processors).
» Less well known and/or many species/cultivars exist that selections have yet to be developed having commercial potential,
» Strong, whole fresh fruit demands preclude a co-product, except locally,
» Highly dispersed production makes logistics & central processing unviable.

Passion fruit

One of the more easily processed fruits, passion fruit (P*assifloraedulis* and *flavicarpa*) is more readily consumed as the juiced flesh than in the whole seed-containing pulp form. Yellow (edulis) and purple (flavicarpa) cultivars are popular, although many underutilised members of the *Passiflora* genus exist and are popular in tropical regions (Nagy, *et al.*, 1990). Although morphologically similar, the yellow is more acidic and with a pH of less than 3.0, generally requires dilution and sweetening for consumption. Parallel commercialization in Hawaii and Australia has resulted in fruit processing lines that efficiently separate the gelatinous pulp from the seed and rind. In Hawaii this is accomplished by a centrifugal extractor where the pulp and some seeds of mechanically sliced fruit pass through holes in the spinning centrifuge. The Australian system lightly crushes the whole fruit between rotating disks popping the placenta away from the rind. More recently an Italian compression roller system has been developed industrially (Somoygi *et al.,* 1996). In all cases a finisher with a 0.8 to 0.3-mm screen separates seeds from the juice. Other systems employing a vacuum to remove the pulpy interior of halved fruit or an oversized pitting device have been mentioned (Jagtiani, *et al.,* 1988).

Single strength yellow passion fruit juice at ~17ºBrix and 2.8 pH is too strong for direct consumption. The nectar base, consisting of 55 to 60 parts sugar to 100 parts juice, is best preserved by freezing and reconstituted 1:3 or 4 with water for consumption. The purple cultivar and newer introductions are less acid and require correspondingly less sugar and dilution as nectar bases. Where freezing is not practical, rapid pasteurization or aseptic processing produces acceptable but flavour-diminished nectar.Passion fruit juice is unique in containing from 0.5 to over 3 percent starch, resulting in an increase in viscosity upon pasteurization or concentration as the starch gels, unless pretreated with enzyme (amylase) or separated by unit operation such as centrifugation. The delicate flavour is diminished by pasteurization and even aseptic processing or gentle concentration systems cannot approach the fresh or frozen product in flavour. Despite the heat labile flavour, passion fruit is a major component in many processed tropical fruit beverage blends and popular with those unaware of the exquisite flavour of analogous unheated (fresh or frozen) products. Acceptable passion fruit concentrate to greater than 60ºBrix (200Litre drums) can be produced with attention to low temperature or short residence time evaporators - centrifugal or falling film evaporators. Essence recovery and add-back approximate (but do not match) the original flavour. The concentrate, packed in 200L barrels and frozen, can be held at -20ºC and used in tropical juice/beverage blends.Although the rind is high in quality pectin and seeds are a source of protein and oil, no major co-product industry has developed. Despite the extensive research and industrial developments with passion fruit, there is much to be done. Probably the diffused, mixed cultivar and comparatively small-scale cultivation has hampered more widespread investigations. And many other *Passiflora* genus merit development.

Extraction of natural flavours from fruits

The fragile, delicate flavours of tropical fruits such as passionfruit, karonda, mango, banana and guava are lost or damaged in the course of conventional processing. This is particularly true of the valuable aroma “top-notes”. Spinning Cone Column (SCC) is a reported innovation can be designed to perform pasteurisation, de-aeration and aroma recovery simultaneously on many fruit juices and purees. The fruit juice or puree can be processed as soon as it leaves the finisher meaning that the aroma recovered is absolutely true to the fresh fruit.

The SCC can readily handle thick, viscous purees which would be impossible to process in any other aroma recovery system. The ability of the SCC to process slurries makes it possible to recover entirely natural essences from passionfruit, karonda, strawberry, tropical fruit, tomato and other materials where capturing the “top-note” is vital to maintain a true flavour profile. With the importance of FTNF (from the named fruit) flavours growing in many parts of the world, the SCC ensures the ability to collect the best natural flavours for addition to food products so that flavour regulations can be complied with.The high mass-transfer efficiency of the Spinning Cone Column, combined with its low thermal impact, make it an ideal system for capturing premium quality fruit essences. In fact, the flavours recovered using the

SCC are so true to the raw material, some flavour houses use SCC aromas as templates for synthetic or nature-identical flavours.All the major polar and apolar aroma and flavours from fruit can be recovered using the SCC, including: Passion Fruit, Karonda, Banana, Pineapple, Blueberry, Cantaloupe, Melon, Guava, Kiwi, Mango, Papaya, Peach, Apple, Pear, Raspberry, Strawberry, Watermelon etc.Benefits of the SCC for the recovery of and concentration of aroma components in fruit juice and purees include:

- Fast and efficient recovery of sensitive aroma compounds
- Concentration of the essence components to a high fold
- No damage to the natural essences or colour
- Can be integrated with the Centritherm evaporator to produce premium flavour fruit concentrates
- Can be made into a modular system to allow for capacity increases
- Easy operation and cleaning with built-in CIP

The possible stages for flavour loss

Conventional fruit processing destroys aroma and flavour at various stages in production. These stages include:

1. Extraction. The separation of juice and solids normally involves milling the raw material followed by pressing or centrifuging. Substantial flavour is lost as it is left behind in the waste solid material.
2. Enzyme treatment. Enzymes are an important part of fruit and vegetable processing, increasing yields and reducing processing costs. Unfortunately, the same process that breaks down the plant tissue can often destroy the flavour compounds.
3. Heat treatment. Pasteurisation substantially increases the shelf life of juice or puree. However, the high temperatures utilised can cause degradation or loss of the delicate volatile favour compounds.
4. Concentration. Loss or destruction of most of the volatile aroma/flavour compounds occurs during thermal evaporation.
5. Drying, Dehydration, Spray Drying. What flavour remains can often be damaged further.
6. The application of the SCC (Spinning Cone Column) during the critical stages of processing enables an entirely new standard for products “from concentrate” as well as a completely new range of high-quality natural fruit and vegetable flavours. Some examples are below.

Essence Concentration

The performance of conventional aroma recovery systems on some fruits and extracts allows the production of essences at approximately 150 fold. Reflux and long thermal exposures are normally required to reach this level.The SCC can produce up to 150 fold essence with a single pass of approximately up to 25 seconds residence time. Moreover, if this recovered essence is passed through the SCC a second time, an essence of around 1,500 fold or more may be produced. This high strength essence has all of the original top-notes intact.

Aroma Recovery from Waste Streams

The cheapest, most abundant source of excellent natural flavour in the world is the discarded portion of fruits and vegetables. The SCC has been used to extract value from these streams by recovering the natural flavour in a concentrated liquid form. Examples include passion fruit pomace, karondapomace waste, apple or berry pomace, crushed cherry stones, citrus peel and "tops and tails" from onion processing.

Superior fruit flavour/concentrates

Integration of the SCC in a typical concentrate process has proven its ability in multiple locations to produce fruit and vegetable concentrates which are superior to traditional products. This configuration is particularly advantageous when solids are present and/or the end product is a paste.

Aseptic packing

Growing in use is the SCC's integration in an aseptic process, avoiding the previously inevitable loss of flavour during heat treatment and subsequent storage. The SCC's clear flavour condensate resulting from this application is easily cold-sterilised before it is dosed back aseptically at the filling stage.

Spinning Cone Column

Spinning Cone Column (SCC) is a highly efficient counter-current liquid-gas contact device. It is a distillation or stripping column belonging to the same family of mass transfer devices as packed, plate and bubble-capcolumns. The SCC is unique in its use of gentle mechanical forces to enhance inter-phase contact. This allows efficient and rapid separation of volatile compounds from their host material. The unique design of the SCC enables it to process clear liquids, viscous products or slurries containing high levels of suspended solids.The Spinning Cone Column is widely used as an aroma recovery or flavour management device. This may find application in karonda / passion fruit.

Applications in the Food and Beverage industry include as outlined below:

- Aroma recovery during production of fruit and vegetable purees and juices.
- Aroma recovery during heat sensitive juices/beverages eg. soluble tea/coffee production.
- Simultaneous flavour and soluble solids extraction from coffee and tea slurries.
- Dealcoholisation and alcohol management in wine, beer and other nonalcoholic / alcoholic beverages.
- Deodourisation of cream and flavour management of dairy products.
- De-oiling of NFC citrus juice.
- Essential oil extraction from botanicals, herbs and spices.

Working of the SCC

Spinning Cone Column is a distillation or stripping column in which steam removes, under vacuum, volatile compounds from liquids or slurries.The column itself is a vertical, stainless-steel vessel with a central rotating shaft. It contains a stack of alternate rotating and stationary cones, the rotating cones attached to the shaft, the stationary cones fixed to the wall of the column. A cross section diagram of a single cone set is shown in Figure below.The feed material, from which the volatile compounds are to be removed, is fed into the top of the column. This material, either liquid or slurry, flows as a thin film down the upper surface of the first stationary cone. It then drains through the outlet of the stationary cone on to the base of the spinning cone immediately below. Centrifugal force, generated by the rotation of the cone, causes the liquid to flow upwards and outwards across the upper surface of the spinning cone, again as a thin film.This film breaks up as it is thrown from the lip of the spinning cone; the liquid is then deflected downwards on to the next stationary cone, and the cycle is repeated. In this manner, the liquid works its way, cone by cone, from top to bottom of the column.At the same time as liquid is flowing down the column, stripping steam is introduced into the base of the column. The vapour flows upwards, across the surfaces of the volatile-rich liquid films, separating and removing the volatile compounds from the liquid. Fins on the undersides of the rotating cones promote turbulence in the vapour stream, increasing mass transfer efficiencies.The vapour flows out of the top of the column and passes through a condensing system which captures the volatiles in a concentrated form. The remaining liquid or slurry is pumped out of the bottom of the column.

Passion fruit

There are more than 500 different varieties of passion fruit, of which 50 are edible and only two are normally considered of major commercial significance.Grown mainly in Ecuador, the yellow passion fruit provides the highest yield per hectare and is the main variety used for producing juice and concentrate. The aroma and taste of passion fruit are so intense that it is usually considered too strong to be used in pure passion fruit juices.However, these unique qualities make passion fruit juice an ideal ingredient in other fruit drinks, nectars and tropical juice blends.In juices, passion fruit is the only ingredient that simply cannot be replaced with anything else. High-quality passion fruit juice concentrate therefore has an exceptionally high market value.The intense flavour and aroma of passion fruit are, however, extremely delicate. Processing therefore has to be rapid and meticulously controlled, as well as involving a minimum of thermal stress. This requires equipment of an exceptional standard.Select machinery manufacturer are by far the world's major supplier of systems and equipment for processing passion fruit into juice of export quality. We are also pioneers in applying high-efficiency technologies in processing extremely delicate and aroma-sinsitive juices such as passion fruit juice.These include complete ranges of heat exchangers, disc stack centrifuges, decanter centrifuges, evaporators, clarifiers, and equipment for both aroma recovery and deaeration.

The juice has a pH 2.6-3.0 and unusually high starch content. There are approximately 25-35 fruits to the kilo. The bigger fruits (more than 30g) are more suitable for processing as they have more juice and less rind. There are two important commercial varieties, purple passion fruit (*Passifloraedulis*), and yellow passion fruit, (*Passifloraedulis forma flavicarpa*), the latter has larger fruits, a more acidic juice, and a less preferred flavour. The fruits are most suitable for processing when all greenness has disappeared and the outer skin has a smooth or slightly crinkled surface. The fresh whole fruit can only be stored for a few days at ambient temperature before it deteriorates. At 6.5°C they can be stored for 3-4 weeks before any major deterioration. The pulp can be stored for long periods in bulk with 1 000-1 500ppm of sulphur dioxide or benzoic acid or a mixture of both, but there is a reduction in the quality of the flavour. During heat preservation the main problem to overcome is the loss of the extremely heat sensitive flavour, which is susceptible to quick oxidation. The seeds are not suitable for stock feeding due to their very high crude fibre content. However, they are of use in the manufacture of soap, paint, varnish and cooking oils after refining. The skin of passion fruit is a good source of pectin and makes good manure. It can also be used to make artificial pears in sugar product. As reported by Owen, in Kenya passion fruit is emerging as new horticultural industry. The marketing of any new product in Europe faces intense competition from similar established products and a lot of time and money may have to be spent before the products can be considered successfully launched. Passion fruit juice, fortunately, has several advantages. It is obtained from a fresh fruit and requires no chemical additives since the flavour and colour is naturally strong. The flavour is also unique and versatile in its application. The juice can be used on its own, as a cordial drink, as a carbonated drink or as flavouring for sweets and ice cream. It can also be blended with other fruit drinks to bring out their flavour. This is a very useful way in which to introduce the flavour to the public, since passion fruit juice can be consumed with a juice already familiar to consumers.The initial advertising and promotion in Europe should obviously be aimed at familiarising the public with the new flavour of passion fruit. However, before a firm considers launching a new product requiring a large advertising campaign, they must be assured of a continuous supply of the new material. Passion fruit production in Kenya has, unfortunately, been liable to large fluctuations in supply and the production problems must obviously be solved before large-scale marketing can take place. In addition to these problems, the technical ones of processing the juice and converting it into a saleable product are also proving to be difficult to solve. Passion fruit juice extraction does not follow the normal pattern of other juice processes. Retaining the full flavour and preventing sedimentation are two of the most difficult problems. Fortunately, a Swiss firm which is leading developments in this field, is mounting a major research programme aimed at solving some of the technical problems related to the processing of passion fruit.

Table Attributes of commercially available passion fruit pulp and concentrate

Product Name	Brix	Acidity	pH	Color	Flavour
Passion Fruit Juice Concentrate	50±1	6.1-10.2	1.6-4.0	Brown	Characteristic
Passion Fruit Pulp	15.0±1	2.24-2.94%	1.8-3.5	Yellow	Characteristic

Karonda

Carissa Carandas Linn. (Karaunda) is a widely used medicinal plant by tribals throughout India and popular in various indigenous system of medicine like Ayurveda, Unani and Homoeopathy. All parts of the plant are used in traditional medicine. Traditionally the plant has been used in the treatment of scabies, intestinal worms, pruritus, biliousness and also used asantiscorbutic, anthelmintic. The notable biological activities reported are analgesic, anti-inflammatory, anti-pyretic, cardiotonic and histamine releasing. The plant is also an alternative source of oil, hydrocarbon and phytochemicals. Medicinal plants are a major source of biodynamic compounds of therapeutic values and are basis of many traditional medicines throughout the world for thousands of years.

Bio-chemical constituents

The roots of C.congesta have Volatile principles including 2-acetyl phenol, Lignan ,carinol from root of C.congestasesquiterpenes , namely carissone and carindone. The leaves were reported to have triterpenoid constitutes well as tannins, and a new isomer of urosolic acid namely carissic acid was also found. Fruits of this plant were reported to contain a mixture of volatile constituents including 2-phenly ethanol, linalool, β-caryophylline, isoamyl alcohol, benzyl acetate and a novel triterpenic alcohol, carissol. Enzymatic mild hydrolysis of polar glycoside from the plant yielded oderoside H, digitoxigenin and the sugars D-glucose and Ddigitalose. Moreover, C.congesta contains crude protein 13%, polyphenols7.8%, fixed oil 5.3 % hydrocarbons 58 % and free acid 31.4 %. Higher gross hest values of this species indicate that it can be used as fuel source. Essential oil from *C.congesta* was found to contain coumarin .It has been reported that fresh leaves of C.*congesta*contain four pentacyclictriterpenoids including one new constituent carissin and two hitherto unreported compounds.

In conclusion there exists enormous potential for karonda and passion fruit cultivation, conservation, value added processing into products, utilization and marketing, with and without processing considering their phyto-nutracutical aspects and health benefits along with socio-economic development and environment preservation. This calls for focused networking of various stake holders from growers, academia, research, industry and government for tapping the potential of underutilised fruits such as karonda and passion fruit in India.

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Post harvest and value addition of underutilized fruit – Model approach

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At present, the homestead-based indigenous fruit crops are grown only in marginal areas, wastelands and backyards, mostly as neglected crops, and not at all considered as a commercial horticultural crop by farmers, anywhere in India. The commercial potential of value addition of indigenous fruits and vegetables has to be popularized among rural farmers. The development of rural processing industry for homestead-based fruit crops can revolutionize the productivity, income and employment generation potential of homestead based cropping systems. Processing of indigenous fruits like jackfruit, mango and banana for preparation of derivative products seems to be a promising area since they can be pulped, juiced or concentrated, canned, sliced and dried. The cultivation of minor fruits on commercial scale is still in infancy in India. Though we are bestowed with the ideal agro- climate and geographical situations suitable for commercializing fruit production even at homestead level, we have never taken care to develop this area as a major enterprise for achieving self-sufficiency, food security and generating income for the nation. The post harvest infrastructure and collection and distribution systems have to be strengthened under cluster approach/fruit-village concept for minor fruits. We have excellent models like the ARS, Anakkayam, and RARS, Ambalavayal of the Kerala Agricultural University that have developed and demonstrated the technologies for total value addition of fruits and vegetables. It is high time that the export oriented value addition (total value addition) of underutilized and homestead-based minor fruits are explored and fully tapped through concerted efforts.

Introduction

The basic "right for food" of the ever-enhancing population is the greatest challenge to be addressed by the "agriculture technology" world over. However, agriculture is becoming a less lucrative enterprise due to the small holdings, insufficient labour strength, high cost of inputs like manures, fertilizers and pesticides, non availability of quality planting materials, pests and diseases and low productivity. Sustainable agriculture backed by green technologies in an integrated farming system has been considered as a promising and potential pathway to solve this issue. It is high time that innovative technologies which can reduce costs while increasing returns be applied to agricultural lands and homesteads to sustain and support the farming community. In this context, hi-tech farming, especially for underexploited and exotic fruit crops and their sensible utilization becomes a promising solution if applied logically.

India has one of the world's largest agricultural research networks, churning out a good deal of new technology. However the majority of farmers still practice traditional farming, for want of adequate transfer of the new technology to the fields. A recent National Sample Survey report on farmers revealed that over 60 per cent of them lack access to new technology. In reality, a sizable chunk of others too, do not get to know all that is new and useful for them. It is well said that "unless and until demonstrable impacts are shown to the farmers the young generation will not take up farming as a profession". An integrated approach for combining training and demonstration of viable technologies with entrepreneurship development is essential for attracting rural youth and women towards agriculture and allied activities, especially to promote agriculture as a means of sustenance. The technology should be acceptable in terms of economy and social situations.

Ensuring sustainable agricultural development and livelihood security of farming community are the prime role of any research, developmental or extension activities in the field of agriculture. This task can be accomplished only through a multi-faceted realistic approach which should be backed with technology, infrastructure and agricultural education. Setting up hi-tech farming units of fruits and vegetables and high density model orchards with an equal emphasis on enhanced income generation through value addition and organized marketing will help us to demonstrate the cost effectiveness and production potential of advanced agricultural technologies in cultivation of fruits like mango, jackfruit, banana, litchi, avocado, rambootan, oranges, grapefruit and citrus, chikkoo (sapota), papaya, strawberry, passion fruit etc.

The Present Scenario

The potential

At present, the homestead-based indigenous fruit crops are grown only in marginal areas, wastelands and backyards, mostly as neglected crops, and not at all considered as a commercial horticultural crop by farmers, anywhere in India. The commercial potential of value addition of indigenous fruits and vegetables has to be popularized among rural farmers. The development of rural processing industry for homestead-based fruit crops can revolutionize the productivity, income and employment generation potential of homestead based cropping systems. If put in more efforts to ensure that the indigenous fruit crops provide security to small farmers and discourage them from wasting/selling fruits out of frustration, it is possible to transform fruit processing into a lucrative agri-business. For this, it is essential to have organized marketing and reliable supply chain that will ensure a fair price for indigenous fruits like jackfruit, mango and minor fruits.

For instance if we consider the major fruit crop, banana, due to mishandling of produce, about 25-40% of banana is being wasted and only 2% is processed into value added products, the remaining being used in the raw form. This leads to price imbalance and large price variations both spatial and temporal, which disheartens farmers. In order to sustain production and growth potential, it is essential to produce value added products based on indigenous fruits so that farmers get an assured price for their produce all the time. Low volume export of banana and other indigenous fruits is due to non-ideal post harvest practices, transport procedures, lack of proper storage facilities, outdated handling practices etc. At present not much of product diversification is done as only few industries are utilizing the fruits for value addition. Processing of indigenous fruits like jackfruit, mango and banana for preparation of derivative products seems to be a promising area since they can be pulped, juiced or concentrated, canned, sliced and dried.

Major issues

The major limiting factors in the development of commercial fruit production and value addition activities are the lack of;

- Scientific support
- Infrastructural support
- Technology support
- Technology transfer

The facts about underexploited/minor fruits

Minor fruits are the most underutilized crops mainly grown in marginal/sub-marginal lands and homesteads. The cultivation of minor fruits on commercial scale is still in infancy in India. Though we are bestowed with the ideal agro- climate and geographical situations suitable for commercializing fruit production even at homestead level, we have never taken care to develop this area as a major enterprise for achieving self-sufficiency, food security and generating income for the nation. Obviously they are not considered as commercial crops and do not have a market too. There is no set pattern of pricing, weight and measure or grading for these produce. The major characteristics of minor fruits can be summarized as;

- The most neglected crops
- Profusely bearing even under "no management"
- Rich in many minerals and vitamins
- Most ideal as intercrops in family farming/homestead farming systems
- More than 50% wasted/unutilized
- Less than 5% is utilized for value addition at present
- Most ideal for commercial cultivation/export oriented production under hi-tech mode, especially in high ranges

The major constraints in the commercial production of minor fruits are

- Non-availability of statistical data on minor fruits in general and marketing in particular.
- Absence of quality product due to non-availability of quality seeds/planting materials.
- Lack of awareness of both buyers and sellers about nutritional and economic value.
- Non-availability of processing, packaging, storage facilities leading to wastage.
- Absence of scientific resources for testing, valuation and post-harvest management.
- Negligible existence of the marketing network and infrastructure facility.
- Very low level of marketing functions due to financial constraints and market risk.
- Government as well as private sector yet to take major role to promote marketing.

Strategies for fruits production and utilization

There is an immediate need for research on improvement and commercial production of fruits under precision mode, especially in the high ranges.

» Introduction and evaluation of new crops/varieties

» Perfection of technologies including hi-tech production

» Demonstration, and expansion

» Post-harvest management and utilization - value addition

The post harvest infrastructure and collection and distribution systems have to be strengthened under cluster approach/fruit-village concept for minor fruits. We have excellent models like the ARS, Anakkayam, and RARS, Ambalavayal of the Kerala Agricultural University that have developed and demonstrated the technologies for total value addition of fruits and vegetables. We have developed technologies to make more than Rs. 5000/- from a single banana plant, Rs. 500/- from a single jack fruit, Rs. 300/- from one kg green country mango, and Rs. 250/- from one kg nutmeg fruit rind through value addition of unutilized parts. Likewise, the following table depicts the potential of commercializing minor fruits through value addition, especially in the rural sector, as compiled from our experience;

Table I. Underutilized Minor/unexploited fruits crops with commercial potential in Kerala

	Crop	*Scientific name*	*Possible potential processed products*
1	Litchi	*Litchi chinensis Sonner.*	*Jam, squash, preserve in sugar, honey & jaggery, RTS*
2	Mangosteen	*Garcinia mangostana*	*Jam, squash, RTS*
3	Straw berry	*Fragaria vesca*	*Jam, squash, preserve in sugar*
4	Passion fruit	*Passiflora edulis Sims*	*Squash, fruit peel jelly, jam*
5	Bilimbi	*Averrhoa bilimbi*	*Pickles, squash,preserve in brine*
6	Carambola	*Averrhoa carambola*	*Pickles, squash*
7	Karonda	*Carissa caranda*	*Preserve in sugar*
8	Loquat	*Eriobotrya japonica*	
9	Phalsa	*Grewia asiatica*	
10	West Indian Cherry	*Malphigia punicifolia*	*Fruit jam, squash, preserve in sugar*
11	Annona	*Annona squamosa*	*Squash, jam, RTS*
12	Annona	*A.reticulata*	*Squash, jam, RTS*
13	Annona	*A.cherimoya*	*Squash, jam, RTS*
14	Lemon	*Citrus limon*	*Pickles, squash, preserve in brine*
15	Rambutan	*Nephelium lappaceum*	*Squash, jam, RTS, toffee*
16	Durian	*Durio zebethinus*	*Fresh fruit, squash, jam*
17	Avocado	*Persea americana*	*Fruit jam, squash, choco-spread*

18	Fig	*Ficus carica*	*Pickles, dry fruit*
19	Persimmon	*Diospyros kaki*	
20	Kiwi	*Actinidia delicious*	
21	Apricot	*Prunus americana*	
22	Bread fruit	*Artocarpus incise*	*Dry flakes*
23	Egg fruit	*Pouteria campechiana*	*Fruit jam, squash*
24	Jackfruit	*Artocarpus heterophyllus*	Fruit jam, squash, laddu, mixture, jelly, pappad, preserve, spread, cookies, biscuit, toffee, chips, halwa, sandwitch, cutlet, nectar, Dried Jack coat Flakes, Dried Jack flakes, jack fruit rind pickles, jackfruit seed chutney powder, Sip - up
25	Pummelo	*Citrus grandis*	Squash, pickles
26	Malayan apple	*Syzygium malaccense*	Preserve
27	Garcinia	*Garcinia gummi-gatta*	Pickles, dried garcinia
28	Surinam cherry	*Eugenia uniflora*	Jam, squash, preserve in sugar
29	Papaya	*Carica papaya*	Papaya candy, halwa, toffee, peel Jelly

Obviously, there is enormous potential for ensured high income from underutilized fruit crops like Jackfruit through total value addition and product diversification. The products include those from tender as well as ripe jackfruits. In the rural sector there exists scope for production of value added products from fruits as well as psuedostem and rhizome of banana, tasty products from tender, mature and ripe mangoes, tomatoes, rind and flesh of cucumber, pumpkin and ash gourd. It is high time that the export oriented value addition (total value addition) of underutilized and homestead-based minor fruits are explored and fully tapped through concerted efforts.

Ironically, it is a matter of concern that India looses 25 to 50% of the fruits and vegetables, 10 to 30% of the grains and oil seeds in the post harvest chain. These losses translate to a whopping monetary loss worth Rs. 60,000 crores per year. Preserving and value adding these wastages will help to enhance the income levels of farmers, traders and the country as a whole. Wide and untapped scopes exist for the farmers, entrepreneurs and unemployed youths to improve their economic status by investing into food processing sectors. Due to the lack of technical knowledge on processing, preservation and value addition of the agricultural produce no new ventures in food processing sector come in. Food processing and value addition are promising commercial business prospects at cottage levels and for village youth and women self help groups.

Value Addition Of Fruits And Vegetables

The variety of products that can be derived from fruits and vegetablescan be classified according to the preservation techniques as listed below;.

» Jams, jellies and marmalades
» Pickles
» Dried fruit (pineapple, banana and etc)
» Fried snacks (banana)
» Juices
» Squashes
» Halwa
» Jack Fruit Papad
» Toffees and Candy

Jams, Jellies and Marmalades

Jam is made using pulp from a single fruit or from a mixture of fruits. The combination of high acidity (pH around 3.0) and high sugar content (68-72%), prevents mould growth even after opening the jar. Jellies are crystal-clear jams that are made using filtered juice instead of fruit pulp and marmalades are produced from clear citrus juices (lime, grapefruit, lemon or orange) that have fine shreds of peel suspended in the gel. Ginger may also be used alone or mixed with the citrus fruits.

Jam

Jam is a product made by boiling fruit pulp with sufficient sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. Pappaya, Pineapple, banana, Mango, Jack fruit and other seasonal fruits are mainly used in jam processing. It can be made from one or from more than one fruit.

Jelly

A jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin containing fruit extract, free from pulp after the addition of sugar and acid. Guava, plum, papaya, jack fruit rind and etc are generally used for jelly preparation.

Marmalade

This is fruit jelly or jam in which slices of the fruit or its peel are suspended. After pectin extraction similar to the method followed in jelly preparation, for 1kg pectin extract, 750g of sugar, 62g of shredded peel is added. Shredded peel boiled for 10 to 15 mins in several change of water for softening and removing the bitterness.

Fruit Bar

Fruit bar is a concentrated fruit product with good nutritive value. It isclassified as a confectionary product with longer shelf life. Fruit bars are considered to be hygienic as they are produced mechanically.

They are attractively packed and consumed readily. The fruit pulp and sugar is taken in the ratio 1:2.

Preserve

A mature fruit/vegetable or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as a preserve. Litchi, strawberry, karonda, cashew apple, banana Pseudo stem, pineapple, cherry, papaya etc., can be used for making preserves.

Candied Fruits / Vegetables

A fruit/vegetable impregnated with cane sugar or glucose syrup, and subsequently drained free of syrup and dried, is known as candied fruit/vegetable.

The preserve and candy can be prepared using 1kg of fruit, 1litre of water and 1kg of sugar. A little quantity of acid (citric or tartaric) is added during the preparation to prevent crystallisation of sugar.

Crystallized Fruits

Candied fruits/vegetables when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from dense syrup are called crystallized fruits.

Fruit Toffee

Pulpy fruits like rambutan, mango, guava, papaya etc can be used for making toffee. It is prepared using 1kg fruit pulp, 700g sugar, 100g glucose, 150 g skimmed milk powder and appropriate amount of ghee, essence and colour

Pickles and Salted Vegetables

There are a wide variety of pickles processed from different fruits and vegetables.

Different types include:

7. *Spicy pickle*: It is made by submerging vegetables in a dilute brine (2-5% salt). Naturally occurring bacteria grow over 1-2 weeks to produce lactic acid, which then prevents the growth of food poisoning bacteria and other spoilage micro-organisms. The produce are then mixed with spices including chili powder, turmeric powder and etc as per the requirement
8. *'Salt stock' pickle* is produced using a more concentrated brine (up to 16% salt), and is preserved by the salt. Fruits and vegetables can be preserved in this way to spread production throughout the year.
9. *Vinegar Pickle*: Vegetables may be packed in vinegar (acetic acid), salt and sometimes added sugar to produce a variety of pickled products that have a different flavour and texture to fermented pickles. They are usually pasteurized by heating.

Squash/ Syrup From Fruits

This is a type of fruit beverage containing at least 25% fruit juice or pulp and 40 to 50 per cent total soluble solids. It also contains 1 % acid.

Dried Flakes

Fruits/vegetable can be dried whole, in halves, or as slices. Alternatively they can be chopped after drying. The residual moisture content can vary from small (3 – 8%) to substantial (16 – 18%), depending on the type of fruit.

The initial temperature of the dehydrator is usually 43°C which is gradually increased to 60-66°C in case of vegetable and 66-71°C in case of fruits

Halwa

Halwa can be prepared from pulp of fruit including papaya, pineapple, banana, jack fruit*etc.*

Jack Fruit Pappad

Jack fruit pappad can be made from the immature jack fruit. Add required amount of spices including flaked chili, pepper for better taste.

The model approach

Rural processing industry has to be strengthened specifically for value addition of homestead grown minor fruits by establishing fruit & vegetable processing units. It is most essential to commercialize value addition/secondary agriculture through participatory homestead-based production making each homestead a steady source of income. The capacity building process has to be given due emphasis to promote the fruit and vegetable processing sector. We have success stories from the KAU Research stations at Anakkayam and Ambalavayal wherein the training programmes to the unemployed rural women and tribal youth conducted at these research stations have helped them to acquire the necessary skills for value addition of fruits and vegetables. On successful completion of the training, the beneficiaries were encouraged to form SHGs and participate in the production programmes on a profit-sharing mode. This also helped the research station to scale up the production and provide them employment throughout the year. This not only ensure additional income to each homestead from the existing unutilized/ underutilized homestead based fruit crops but also encourage local, small and marginal farmers to care jackfruit and other neglected fruits like carambola, bilumbi, passion fruit, papaya etc. for better prospects.

Approved self help groups, farmer organizations and cooperatives has to take a lead role in this process by setting up producer's companies or cooperative marketing societies run by farmer groups. The regular and sufficient supply of raw materials for the processing unit/s will have to be ensured by procuring the raw materials from homesteads and farmers at reasonable prices under the fruit village in participatory mode. In this participatory mode, the farmers can sell their raw fruits to the groups/ societies at reasonable prices or the farmers can also get their fruits processed from the unit on payment of service charges and sell them in the rural markets.

Dehydrated processed products from under - utilized fruits work done at IIHR

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Under-utilized fruits have special significance as source of food due to their nutritional and medicinal properties. Several fruits such viz. *anola*, jackfruit, kokum, karonda, Malayan apple, Cherry are grown in different parts of India. Some of the fruits such as *aonla*, kokum, karonda are not suitable for direct consumption, while fruits such as jackfruit is highly inconvenient for use by the consumers. Research on value addition to under utilized fruits were carried out at IIHR Bangalore. Osmoticlly dehydrated products from aonla and Jack fruit as well as *aonla* segments infused with kokum juice using combination processing have been developed. Research was carried out with respect to varietal, suitability, process optimization and storage quality evaluation Products were found highly acceptable and technology for osmotically dehydrated slices from *aonla* and Jack fruit have been commercialized. Kokum being a good source of athocyanin with its other medicinal significance, had proved to be a very good source for infusion. Preliminary experiments on value addition of karonda and Malayan apple by infusion of Kokum juice has resulted in very good dehydrated products from these highly perishable fruits. Further studies on process optimization of karonda and Malayan apple and Barbarode Cherry will be taken up near future.

V-2

Health benefits and nutrition facts of passion fruit (*Passiflora edulis*)

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Passion fruit belongs to the family passifloraceae which contains antioxidants, minerals, vitamins and fiber. 100 g fruit contains about 97 calories. The fruit is a very good source of dietary fiber. 100 g fruit pulp contains 10.4 g or 27% of fiber. Good fiber in the diet helps to remove cholesterol from the body. In addition dietary insoluble fiber by acting as a bulk laxative helps protect the colon mucous membrane by decreasing exposure time to toxic substances in the colon as well as binding to cancer-causing chemicals in the colon. Passion fruit is good source of vitamin C providing about 30 mg per 100 g of edible portion. Vitamin-C (ascorbic

acid) is a powerful water soluble anti-oxidant which helps the body to develop resistance against flu-like infectious agents and scavenge harmful, pro-inflammatory free radicals. The fruit contains very good levels of vitamin-A which is nearly about 1274 IU per 100 g) and flavonoid antioxidants such as β-carotene and cryptoxanthin-β. Current research studies suggest that these compounds have antioxidant properties and along with vitamin A are essential for good eye-sight. Vitamin A is also required for maintaining healthy mucus membranes and skin which also helps to protect from lung and oral cavity cancers. Fresh fruit is very rich in potassium which is an important component of cells and body fluids and helps to regulate heart rate and blood pressure. Fruit contains 348 mg of potassium per 100 g of edible portion. Furthermore, passion fruit is a very good source of minerals. Iron, copper, magnesium and phosphorus are present in adequate amounts in the fruit.

V-3

Studies on preparation of functional beverages from karonda (*Carissa carandas*)

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An investigation was carried out to develop a technology for preparation of functional beverage from karonda juice and to study changes in composition and quality of beverage during storage. The RTS beverage prepared with selected level of ingredients was preserved by various treatments at refrigerated (7±1 °C) and ambient temperatures. Based on sensory properties a fresh RTS beverage containing juice 10 per cent, TSS 10° Brix and acidity 0.30 per cent was found to be the best giving highest score over other combinations studied. During the storage of RTS beverage, the total soluble solids, acidity, reducing sugars and total sugars contents increased while ascorbic acid and anthocyanin contents decreased. The beverage when stored at refrigerated temperature, exhibited better quality than that stored at room temperature.

V-4

The nutrient profile of important *garcinia* species of India.

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Garcinia is a tropical evergreen tree species belonging to the genus Clusiaceae, and are featured by acidous fruits and copious exudates from puncture sites. In India, they are habited in Western Ghats and N.E Himalayas, and the present study compares the nutritional aspects of the major *Garcinia* species of those ecosystems.Organic acids were found to be the predominant compounds present in the fruits

(upto 30%). The presence of organic acids renders them to use as spice and medicinal crop. Hydroxycitric acid (HCA) and malic acid were found to be the major organic acids. HCA is considered to be a potent natural anti-obesity compound, *Garcinia* being its most abundant source. Though carbohydrates (avg. 5%) were the next abundant, the sugar content (0.7%) was very less compared to other major tropical fruits. *G. mangostana* had a higher reducing sugar (1.5%) content and lowest acid content (4.3%), making it palatable among other *Garcinia* species. *Garcinia* have a mineral and vitamin contents similar to the major consumed fruits like apple, grapes, peaches or banana. However, they are devoid of fat soluble vitamins like A, D, E and K. Vitamin C was the major vitamin present (~40mg/100g). Potassium (40mg/100g) and Magnesium (33 mg/100g) were the major minerals. Magnesium, phosphorus and iron contents were higher proportion in Garcinia than of commonly consumed fruits.Fruits contained flavonoids (2-3%) and xanthones (1.3-2%) as major secondary metabolites.

Butters from *Garcinia* seed kernels were solid at room temperature and had pleasant appearance and aroma. Chemical properties of *Garcinia*-butter were similar to that of major cooking oils such as peanut oil, sesame oil and sunflower oil. Even though the physical properties such as melting point (40°C), flash point were similar to that of Ghee and hydrogenated fats, the relatively high unsaturated fatty acid (43-57%) composition makes *Garcinia*-butter healthier than them. Iodine value (37-51) and saponification value (187-200) are in range with that of commonly used oils like olive oil, sunflower oil and sesame oil.*Garcinia* exudates were resinous-gum type, having both phenolic resins (60%) and sugars (as gum). The resin has about 40% xanthones content; these groups of molecules are found to possess numerous pharmacological activities including anticancer, anti-bacterial and anti-inflammatory activities.

V-5

Nutritional status of *sohiong* (*Prunus nepalensis* Ser.) fruit in NEH Region, India

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Prunus nepalensis belongs to the family Rosaceae and is an important indigenous underutilized fruit of the tribal population in Khasi and Jaintia Hills, India. The ripe fruit is consumed either as fresh or processed into juice or wine. The present study was carried out in the two types (big and small fruits) of Sohiong (*Prunus nepalensis* Ser) fruits to determine the physical characteristics and nutritional contents in the Division of Horticulture, ICAR Research Complex for NEH Region, Umiam, Meghalaya. Result indicated that the big fruit size type had higher values for various physic-chemical characters except for pulp recovery (74.71 %), pulp to stone ratio (2.95) and dry recovery (34.72 %), TSS (20.15%), β-carotene (2.76 mg/100g), anthocyanin (358.86 mg/100g) and fibre (2.5%). Similarly, the mineral contents of big -sized fruits were comparatively higher than the small fruit type except for potassium and ash content

(1.51%). The survey indicated that the availability of sohiong fruit is from second week August to first week November. The rate of fruit per kilogram was highest during the lean season (Rs. 110/ kg). It is concluded that sohiong fruits showed promising nutritional values for both the fruit types.

V-6

Physical and bio-chemical profiling of s*ohshang* (*Elaeagnus latifolia* Linn) fruit in the Northeastern Hills Region, India

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Sohshang (*Elaeagnus* latifolia L.), a locally known and popular underutilized fruit crops in Khasi hills, Meghalaya, NEH region, India. It belongs to family Elaeagnaceae. However, it is also found quite common in Sibsagar (Dikho valley of Assam), Naga hills (Nagaland), Khasi and Jaintia hills of Meghalaya, Dirang and Tawang area of Arunachal Pradesh up to an elevation of 2500 m asl. Studies was conducted to determine the physical and bio-chemical status of the fruits of *sohshang* in the Division of Horticulture, ICAR Research Complex for NEH Region, Umiam, Meghalaya. Result showed that the fruit weight was 16.92 g, fruit length (40.15 mm), fruit diameter (26.51 mm), TSS (11.5%), acidity (2.69-2.82%), ascorbic acid (15.7-19.4 mg/100 ml juice), total sugar (6.06%), β Carotene (1.12 μg/100 g), anthocyanin (16.33 mg/100 g), fibre content (5.54%), ash (0.61%), antioxidants (10.17 μ mol trolox/g), total nitrogen (1022 mg/100g), total phosphorus (95 mg/100 g), total potassium (487 mg/100 g), total sulphur (712.5 mg/100 g), iron (16.82 mg/100 g), copper (1.91 mg/100 g), zinc (4.94 mg/100 g) and manganese (4.52 mg/100 g). Therefore, it can be concluded that the fruit is very rich source of vitamins and minerals and other bioactive compounds which is one of the nutritional supplementation for the populace of the region.

V-7

Influence of *aloe vera* gel coating of jamun fruits on quality parameters under cold storage

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Jamun is an evergreen tropical minor and seasonal fruit crop. It bears in summer months of May-June. It is a non-climacteric fruit having a very short shelf-life of 2-3 days limiting its use in fresh form. The reasons for the short shelf-life of the fruits are physico-chemical and physiological changes leading to the loss of sensory attributes and loss of water through transpiration, weight loss and mechanical damage caused during harvesting and handling, microbial activity leading decay of fruits. Hence, it was attempted to increase storage life through coating of aloe vera gel. Jamun fruits were harvested and washed with $NaHCl_3$ at 0.5ml per litre, surface air dried jamun fruits were treated with 10 and 15 per cent aloe vera gel, keeping untreated fruits as control and they were stored at 13°C and 85 per cent RH for 15 days. The physico-chemical parameters *viz*., physiological loss in weight (PLW), firmness (N), TSS (^{0}B), and titratable acidity (%) were recorded at 3 days interval upto 15 days. Fruits treated with aloe vera gel at 15 per cent maintained lower PLW and higher firmness up to 15th day of storage. Total soluble solids increased from 6th to 15th day of storage. Fruits treated with 10 per cent aloe vera gel recorded lower TSS and higher TA indicating the delayed biochemical changes whereas, untreated fruits recorded progressive and sharp increase in TSS throughout the storage period. In conclusion, jamun fruits coated with aloe gel retarded the quality changes under cold storage.

V-8

Post-harvest management and value addition in amla (*Emblica officinalis*)

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Amla (*Emlicaofficinalis)* king of arid fruits commonly known as "Indian gooseberry". It is a small sized sub-tropical fruit grown in North India. It is considered as wonder fruit for health because of its great qualities. Post-harvest losses are the major constraints which discourage farmers to go for amla

cultivation. The extension of shelf life may be possible by checking the rate of transpiration, and by checking microbial infection.However, amla fruit is highly perishable and has a short shelf life of 5-6 days.Different Chemicals Waxol, Ca (NO3)2, CCC.Carbendazim, GA3, borax, kinetin and packaging materials like nylon net, perforated PF bags, ventilated CFBboxes, gunny bags, wooden crates etc. can be used for prolong the storage life of fruit. Refrigerated storage also helps in enhancing the storage life of fruit. There are so many products like amla squash, candy, jam, juice and chutney prepared from fruit. These products in diet help in improving the nutritional value. In order to have good income from amla, it must be sold immediately in the market. Fruit is sensitive to bruises, browning, desiccation and various post-harvest diseases. Plant growth regulators, certain chemicals and fungicides play a great part in increasing the storage life (Dhumal*et al.,*2008). Processing into value added product will not only reduces the post-harvest losses but also provides higher returns to the growers.

V-9

Effect of pre-harvest spraying of chemicals for the management of fruit rot in ber

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Ber fruits at berry and marble stage are infected with *Colletotrichum* and *Alternaria* pathogen. An experiment was conducted from 2009 to 2011 at Regional Research Station, Aruppukottai with eight treatments (Mancozeb (0.2%), Carbendazim (0.1%), Captan (0.2%), Bitox (0.4%), Benomyl (0.1%), Thiophanate methyl (0.1%), Copper oxy chloride (0.3%)) replicated thrice in randomized block design. Two sprays were given vide one at immediately after the appearance of fruit rot caused by *Colletotrichum* (pea fruit stage) and another at marble fruit stage against *Alternaria* fruit rot. The pre-harvest spraying (15 days before harvest) of 0.3 per cent copper oxy chloride at pea fruit stage was found effective against fruit rot caused by *Colletotrichum* which recorded 4.0 PDI followed by 0.1 per cent spray with Thiophanate Methyl (5.7 PDI) and the treatment of control recorded 50 per cent incidence. The pre harvest spray of 0.2 per cent spray of Mancozeb at marble fruit stage was found effective against fruit rot caused by *Alternaria* which recorded 3.8 PDI compared to control which recorded 37.6 PDI.

V-10

Medicinal value of myrobalan (*Phyllanthus emblica*)

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According to Hindu myths, Amla (Myrobalan) is said to have originated from the drops of Amrit which spilled on earth accidentally and hence also this religious belief makes claims that it almost cures every disease. In support of this, fruits of myrobalanare reputed to contain high amounts of ascorbic acid (445 mg/100g) and antioxidant strength due to high density of ellagitannins, such as emblicanin A, emblicanin B, punigluconin and pedunculagin in fruits. The preparations of leaves, bark or fruit have shown potential efficacy against laboratory models of diseases likeinflammation, cancer, age-related renal disease and diabetes. A human pilot study also demonstrated a reduction of blood cholesterol levels in both normal and hyper-cholesterolemic men with treatment. Roots are used to treat hypertension, epigastric pain, enteritis, and tuberculosis. Leaves used externally for oedema and eczema and were also found to be having anti-inflammatory and antipyretic activity and hence being used in traditional medicine by rural populations in Asia. As per ayurveda, Amla is used to revitalising potency and the digestive system, rejuvenating longevity, treat constipation , reduce fever, purify the blood, reduce cough, alleviate asthma, strengthen the heart, benefit the eyes, stimulate hair growth, enliven the body, and enhance intellect.

V-11

Butterfruit: A potential candidate for utilization in convenient dairy mixes

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Due to the expanding market of dairy companies, there has been a merging of dairy product and fruit beverage markets, with the introduction of hybrid dairy products, such as 'juiceceuticals', offering health, flavour and convenience. Instant dairy mixes like lassi powder, dry ice cream mix and milk powders do not contain phytonutrients. There is a great scope for developing freeze dried and spray dried dairy mixes fortified with phytonutrients derived from fruit juice/ pulp. Freeze drying and animal products Technology Division of Defence Food Research Laboratory has initiated research activities in this area. Freeze dried fruit lassi powders have received good feedback w.r.t their organoleptic quality and ease of reconstitution from the target group of Armed forces deployed in extreme enviromments. Whey protein enriched grape juice powder and whey –fruit beverage mixes are other products which combine the health benefits of dairy and fruit components.

Avocados are an ancient fruit. Over 14,000 years ago, mega fauna roaming Central and South America dined on avocados as a delicacy. The glyptodonts, or, massive armadillos, used to devour avocados whole and spread the seed throughout the region. Although avocados have existed for centuries, the Hass avocado—the bumpy-skinned variant accounting for most of the avocados sold worldwide—has its origins in California during the early 1900s. Rudolph Hass convinced his children not to destroy a bizarre tree found in his neighborhood. By 1935, the small sapling grew magnificent fruits that he later patented them as the Hass avocado. India does not grow many butterfruits, and only a handful of sub tropical southern states grow them commercially. Regions producing the fruit include the hill slopes of Tamil Nadu, Kerala, and Coorg regions of Karnataka. The only state successfully growing avocados in the north is the eastern Himalayan state of Sikkim, where they grow at elevations between 800 to 1600 meters. The avocado industry is fragmented and not well organized; however, as of 2013, a few organizations have formed to support avocado farmers and develop marketing campaigns. The South's main avocado season is July through August, with a few trickling in during September. Fruits grown in Sikkim arrive in September and last through October.

Butter fruit (Avocado) provides about 20 essential nutrients. It mainly contains mono unsaturated fats like oleic and palmitoleic acids and also omega-6 poly unsaturated linoleic acid. Fat provides about 75% of the calories. It has more potassium than bananas, is rich in B complex and vitamins A, E and K. The fiber content is high with 75% insoluble and 25% soluble fiber. The insoluble fiber cleans the bowels and prevents constipation. The soluble fiber keep one full and prevents over eating, delays hunger. It is extremely rich in iron, copper, magnesium, manganese and potassium. Along with high tannin content it is extremely rich in many polyphenolic antioxidants like lutein, zeaxanthin, carotenes and cryptoxanthin. Avocado has a nutrient boosting effect. In effect this means that it enables the body to absorb more of alpha and beta carotene and lutein if the fruit is eaten with food. Avocado provides an excellent and wide ranging anti inflammatory action beneficial for arthritis sufferers. *T*he low carbohydrate content and sugar, a low glycemic Index as well as fairly high dietary fiber content makes this possible. Though avocado is high in fat, 2/3rd of this is the heart healthy mono unsaturated fat which controls overeating as it suppresses appetite. Avocado also lowers cholesterol thus aiding weight loss especially from the belly. The high potassium content also prevents fluid retention and reducing body fat and also converting the consumed food into energy and encouraging muscle growth. The L-carnitine amino acid's primary function is to metabolize body fat. Thus it promotes fat loss and weight loss. The high fiber content needs more calories to digest and also keeps one fuller longer, thus further aiding weight loss. 1/2 an Avocado has 160 calories,15 gms of heart healthy unsaturated fat but only 2 gms of saturated fat . 1 whole fruit meets 1/3 Daily Requirement of Vit C, more than 1/2 daily requirement of Vit K.

The preservation of this seasonal fruit which is a treasure chest of many significant phytonutrients and protective antioxidants is a challenge to the food technologists. Such technologies will also be a boon to the farmers who may not get a profit from the fresh produce due to the seasonal variations in its production and difficulties in providing ripe fruit supplies throughout the year.Hence the Laboratory located in Mysore is embarking on new technologies to preserve the fruit in shelf stable form through development of instant dairy mixes .These include spray dried and freeze dried beverage mixes like lassi powder, milk shake and dry ice-cream mix. The inactivation of enzymes before heat processing is a special requirement to avoid some bitterness in the final product Preliminary trials carried out in the laboratory have yielded satisfactory results with regard to powder colour, flavour and overall acceptability.This will open the doors of technology to greater possibilities and prospects for utilisation of butterfruit produced in different parts of Karnataka and take this wonder fruit with its valuable nutrients to the High altitudes and extreme areas where the Indian troops are deployed.

V-12

Effect of postharvest calcium chloride dip treatment on quality and shelf life of jamun fruits under cold storage

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Jamun (*Syzygium cumini* Skeels) fruits are highly seasonal (May to June) and having delicate taste but very short shelf life limits their usage. Hence, it was attempted to increase storage life through postharvest treatment with calcium chloride. Matured ripened jamun fruits were harvested and washed with $NaHCl_3$ at 0.5 ml per liter of water then surface air dried and treated with 1 and 2 per cent $CaCl_2$ and untreated fruits served as control. The fruits were stored at $13\underline{+}1^0$C and 85 per cent RH for 15 days. The physico-chemical parameters *viz*., physiological loss in weight (PLW), firmness (N), respiration rate ($mlCO_2$/Kg/h), TSS (^{0}B), and titratable acidity (%) were recorded. Fruits treated with $CaCl_2$ at 1 and 2 per cent recorded slower decrease in PLW as compared to control. Higher firmness was maintained in 2 per cent $CaCl_2$ treated fruits till 15th day whereas, untreated fruits showed rapid reduction in firmness at 8th day of storage. Untreated jamun fruits recorded respiratory peak at 8 days after storage however, 2 per cent of $CaCl_2$ treated fruits showed gradual increase in the respiratory rate at slower pace till 15 days of storage at $13\underline{+}1^0$C. Fruits treated with 1 per cent $CaCl_2$ recorded lower TSS and higher TA indicating the delayed biochemical chages whereas, untreated fruits showed rapid increase in TSS and decrease in TA during the storage.

V-13

Prospects of preservation of star gooseberry (*Phyllanth usacidus Skeels*) as Murabba

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India is the centre of origin for many tropical fruit tree species, most of which are not commercially cultivated but provide a significant source of livelihood support for many rural communities. Besides their importance for their nutritional value and as a source of household income, this fruit diversity also has a cultural and social value and contributes to the stability of ecosystems. One of the underutilized fruit species that is of great importance in India is Star gooseberry (*Phyllanthusacidus* Skeels)**.** The plant is an intermediary between shrubs and tree, reaching 2 to 9 m height. The tree's dense and bushy crown is composed of thickish, tough main branches, at the end of which is a cluster of deciduous, greenish, 15-30cm long branchlets.The fruits are pale yellow or white, waxy, crisp and juicy, and very sour. 4 to 6 seeds are contained in a stone at the center of each fruit. Fruit is oblate with 6 to 8 ribs and 1-2.5cm wide with pale-yellow to nearly white in colour when fully ripe. Mature fruit weigh 2-5.5g with a TSS of 4.5%, acidity- 2.27% and Ascorbic acid- 21.15 mg/100 g pulp.It is commonly found as a wild and semi-wild throughout the subtropical and tropical parts of India. Organized orchards are lacking in the east coast however, scattered plants in villages especially in homesteads are common in Odisha. This fruit has a limited consumption as table purpose due to its sour taste. In the state, it is minimally processed into the *chutney* and consumed at household level. However, the fruit can be processed into pickles, juice, jelly, candy etc. Thus, there is an ample scope to bring this important underutilized fruitcrop in the human diet by developing and standardizing the processing technology for producing its diversified processed products.An attempt was made to process the star gooseberry fruits on small scale by making its preserve- *Murabba*. For this, fruits (1kg) were blanched by keeping in boiling water for 3-5 minutes. The water was drained out and blanched fruits were cooled by putting under the fan. The cooled fruits were heated in freshly prepared sugar syrup (1kg sugar in 500ml water) till they turned their colour to pinkish brown. No preservativewas added into the product. The finished product could be stored easily for 4-6 months. The product was found acceptable to many organoleptically.

Medicinal and health benefits of strawberry guava (*Psidium cattleianum*)

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A decoction of the pods with leaves of *Psidiumcattleianum* is indicated as efficacious in some casesof profuse uterine bleeding.All parts of the plant, including the young fruits, are astringent. In China, a decoction of the leaves isantidiarrhetic.It is taken to treat stomachache or used externally as a lotion for skin complaints, ringworms,wounds, and ulcers. The boiled leaves can be applied as a poultice to take heat away from wounds.In Taiwan, dried ripe fruits are recommended as a remedy for dysentery. They are pectoral, tonic, andslightly laxative. This plant is a good source of vitamin B. It also contains triterpinoid, essential oils,tannin, fixed oils, and eugenol.Strawberry guava has a high level of total phenolics and vitamin C. It is a significant source of phenolic antioxidant, which may have potential beneficial effects on human health.Strawberry guava is high in pectin. The fruits are good for mixing with high-acid, low-pectin fruitsfor making jellies. The leaves are used for medicinal purposes as a remedy for diarrhea and for their supposed antimicrobial properties. In Asia, a tea is made from guava fruits and leaves.

V-15

Enzymatic separation of pulp and preparation of ready-to- serve beverage from soft bulb jackfruit

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A jack fruit with soft bulbs is commonly found in western ghats of Karnataka. This type of jack is having more fibre and sweet in taste. On ripening, bulbs become very soft and difficult for consumption due to high fibre content which resulted in wastage of large quantity of this jack in the season. Hence, an investigation was made at College of Horticulture, Sirsi for enzymatic separation of pulp and preparation of Ready-to- Serve beverage from soft bulb jackfruit.Results revealed that highest yield of pulp (710 g) was obtained from the bulb treated with pectinase 0.15 per cent and amylase 0.1 per cent and incubate at 41^0C for 2 hours. Using this pulp the Ready to serve beverage prepared by mixing 15 % pulp + 15^0 Brix TSS + 0.3 % citric acid and 0.01 % cardamom has obtained highest organoleptic scores.

V-16

Influence of maturity stage and with or without stalk on physical and physiological changes in jamun fruits

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Jamun (Syzygium cumini Skeels) is an important minor fruit in the flowering plant family Myrteaceae. Jamun is a climacteric fruit having very short shelf life of 2- 3 days. An experiment was conducted to study the effect of maturity stage (harvested at red and purple colour stage) and with (1cm) or without stalk on physical and physiological changes in jamun fruits stored at ambient temperature. The observations on various parameters were recorded on daily interval up to 4 days. Jamun fruits with purple colour without stalk have recorded higher PLW (2.72%, 6.17%, 13.54 % at 2nd, 3rd and 4th day, respectively) while, lowest PLW (1.16%, 2.55% and 3.47% at 2nd, 3rd and 4th days, respectively) was recorded in red colour fruits without stalk. Jamun fruits harvested in advanced stage of colour development (purple) without stalk have recorded lower firmness values (84.17 g/cm^2 at 2nd, 81.37 g/cm^2 at 3rd and 80.09 g/cm^2 at 4th day) While, fruit harvested without stalk at red stage have recorded higher firmness values (116.05g/cm^2, 114.87g/cm^2 and 113.55g/cm^2 at 2, 3 and 4 days, respectively). Respiration studies revealed that fruits harvested at purple stage without stalk recorded higher respiration rates at 2nd (79.18 mlCO_2/kg/h), 3rd (107.73 mlCO_2/kg/h), 4th (118.26 mlCO_2/kg/h) days and lowest respiration rates were recorded in fruits harvested at red colour stage without stalk at 2nd (84.17 mlCO_2/kg/h), 3rd (81.37 mlCO_2/kg/h) and 4th day (80.09 mlCO_2/kg/h). In conclusion, fruits harvested at red colour stage with stalk have retained maximum physical and physiological changes with better acceptability.

V-17

Putrescine influences physico chemical and physiological changes in jamun fruits

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Jamun (*Syzygium cumini* Skeels) is an important unexploited minor fruit of tropics rich in antioxidants and having neutracitical values. Fruits are highly seasonal and possess very short shelf life of few days. With intent to increase the useful life of fruits, they were treated with 1mM Putrescine for five minutes. Various physic-chemical parameters like physiological loss in weight (PLW), firmness, respiration rate

and TSS were recorded daily up to 4 days period under ambient condition. Fruits treated with putrescine have recorded minimum PLW of 4.58%, as compared to control (5.80 %) at 4th day of storage. Fruits treated with 1mM putrescine have maintained higher firmness (145.2, 131.4, 128.06, 120.16 at 1st, 2nd, 3rd and 4th days, respectively) while, untreated fruits recorded rapid loss of firmness during the storage. There was significant difference with respect to respiration rate, fruits treated with 1mM putrescine have registered lower respiration rates (127.87 mlCO_2/kg/h) while, untreated fruits recorded higher (186.59 mlCO_2/kg/h) respiration rates. Untreated jamun fruits have registered maximum changes in TSS (18.33°B) at 1st day to 12.25°B at 4th day. However, post harvest treatment of 1 mM putrecsine for 5 minutes recorded significantly minimum changes in TSS (18.30 at 1st to 13.66 °B at 4th day). In conclusion, postharvest dip treatment of 1mM putrescine for 5 minutes effectively delayed the physico-chemical and physiological changes in jamun fruits under ambient storage.

V-18

Rose apple - wax jambo jam - A potential value added product for commercialization

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Roseapple (*Syzygium jambos*) and White Wax jambo (*Syzygium samarangense*) trees are found abundantly in back yards of Goan houses. It is disheartening to find that most of these fruits get wasted. Therefore, an attempt was made towards value addition in these fruits. Jam was prepared from the freshly harvested fruits of rose apple and the residue after juice extraction from wax jambo and stored under ambient conditions. Four types of jam *ie.*, T-1: Wax jambo (100%), T-2: Rose apple (100%), T-3: Wax jambo (75 %) + Roseapple (25%) and T-4: Wax jambo (50 %) + Roseapple (50%)were prepared from these fruits and monthly organoleptic tests (sensory evaluation scores 1-9) were conducted for attributes like general appearance, colour, texture, aroma, sweetness, acidity, flavour, off-flavour, spread-ability and overall acceptability..T-1 scored an overall acceptability of 7.8 when fresh, which decreased to 5.5 after 6 months of storage. The overall acceptability score of T-2 jam reduced from 5.4 to 2.0; that of T-3 jam reduced from 7.2 to 3.5 and overall acceptability score of T-4 jam reduced from 5.8 to 3.0 over a period of six months. From the results, it is evident that, jam prepared out of 100 % wax jambo scored better than the other types of jams prepared, over the period of six months. Also panellists scored treatment 3 (Wax jambo (75 %) + Roseapple (25%)) for better acceptability.

V-19

Nutritional security of underutilized fruit crops

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The nutrition and sustenance of life for the native communities largely depend onthe underutilized fruits. In fact these fruits and nuts prevent widespread malnutrition intheir native regions, as a number of them are rich in vitamins, minerals, protein,carbohydrates and fats. Vitamins like A and E and minerals like calcium, magnesium and iron are abundantly available in these fruits, which help in building resistance againstdiseases. Deficiency of vitamin A affects more than 100 million children of lessthan 5 years and causes one-third of deaths in this age group. It is the main cause ofblindness in children in developing countries. The deficiency poses a serious threat in Indiandiet particularly to children. To overcome from this many underutilized fruits are used and they contain more vitamin C and pro-vitaminA than the widely available commercial species. Consumption of these fruits by the ruralpeople directly from the trees maximizes vitamin intake. Calcium and iron are important minerals required for healthy living. Calcium gives strength and firmness to the bones, forms healthy teeth and is also necessaryfor clotting of blood and movement of muscles these minerals obtained by Karonda (39.1%) and dates (10.6%).Thus promotingthe use of neglected and underutilized species is an effective way to help maintain a diverseand healthy diet and to combat micronutrient deficiencies, the so-called 'hidden hunger',and other dietary deficiencies.

V-20

Role of jamun *(Syzygium cuminii)* in enhancing the agripreneurial status of a farmer- A case study in dindigul district of Tamil Nadu

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Producers of fruits are mainly concentrating on the major fruits like Mango, Jack, Banana and other major fruits. Though there is potential in the minor fruits or under utilized fruits, its cultivation, exploitation and its distribution is not scientifically or commercially carried out in the research stations and in the farm lands of progressive farmers. It is mainly due to poor awareness creation and popularization of technologies. One such under utilized fruits which is less utilized and exploited is Jamun. A progressive farmer belonged to the village of J.Mettur of Dindigul District of Tamil Nadu is able to cultivate the Jambu Jamun which is brought from the Rajahmundry of Andhra Pradesh and cultivating the Jamun and he is realizing considerable yield. The harvested fruits are packed and distributed by the farmer himself to different consuming ends at the rate of Rs 140 per kg. Rest of the fruit is utilized for value addition and the Jamun juice is packed in 700 ml containers and the same are also distributed to different consuming ends through the dealers at the rate of Rs 240 per litre. Jamun is rich in essential nutrients and hence it is consumed by different segments. Such a useful fruits and its production is financially assessed for its investment worthiness and the parameters revealed that the Jamun cultivation and utilization is highly profitable and at the same time it is less competitive in open markets and hence the farmer is able to realize high price per unit. All these are discussed in detail in this paper. Progressive farmers and entrepreneurs who are really interested can explore this venture for profitability.

V-21

Marketing of avocado

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The opportunities available to domestic and international avocado industry from the India at various sectors viz., Farms and plantations, post harvest infrastructure, merchandising and consumption by end user of avocados. Avocado had entered in India with travelers from Srilanka, to Waynad in Kerala, Koorg in Karnataka, Kodaikanal in Tamilnadu in 19th century. The 3 to 4 avocado plants are grown in homesteads for family consumption.Avocado is a new fruits to the mainstream 90-95 % Indian consumers of modern India. Indian cuisine consists of the foods from India and to some extent neighboring countries, characterized by the extensive use of various spices, herbs, and other vegetables, and sometimes fruits grown in India and also for the widespread practice of vegetarianism in Indian society. Avocados are produced in parts of Maharashtra, Tamilnadu, Kerala, Karnataka, is the main region of Western Ghats of India .This is UNESCO's biodiversity hot spot. Sikkim is part of Himalayan ranges.The presently available varieties in public domain are Fuerte, Purple Hybrid, TKD 1 and Pollock. Farmers are planting avocados in big way on there own coffee plantations instead of jack fruit. Farm Workers and Consultants are getting the training and experience in avocado cultivation by farmers based on Good Agriculture Practices. Inputs and Implements Suppliers, Service Providers. The planting material need is huge as farmers know the opportunities in planting the avocados. The inquiries are flowing to avocado India plantation Laboratories for Soil, Water, PRA, Climate, and Biotech.They will need the training associated with the avocado cultivation. State Agricultural Departments in above states have a vital role in making and implementing policies related to plantation and marketing of avocado fruits like EGS Extension Agencies: like FICCI, FAO Etc. various chambers of industries & Agriculture are helping to spread the

message about importance of avocados in agriculture. Bankers & Investors: they are seeing positive investment opportunities to get good returns from avocados. Tamilnadu Agriculture University had started a research center in 1968 and they released the variety TKD – 1 in 1994 first of its kind in Asia, this is variety with the oil content up to 26 %.Other varieties available are Fuerte; Pollock and Purple Hybrid will be evaluated in multi location trials where they were not available.APEDA: is the Agriculture Produce Export Development Authority. Domestic Market / Domestic Retailers: as the consumers are aware the retailers like Spar, Spencer, big bazaar, etc. are selling avocados at premium prices. Marketing Board and Consumer Associations: are the promotion partners of avocado in india with Dieticians, Promotion Agencies and Media.

V-22

Inspirational and successful growers: Growing high value tree fruits of exotic origin

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Coorg region is bestowed with wide agro-climatic variations from sub-tropical to tropical provides scope for growing large number of under-utilized fruit crops like rambutan, passion fruit, mangosteen, litchi, dragon fruit, avocado, *Garcinia* sp, karonda and longan. Several farmers of Karnataka and Kerala switched over to cultivation of exotic fruits which they find more lucrative and having high demand from the traders in South India. Among these fruits, rambutan resembles a litchi fruit in appearance and fruit texture but fruit skin carries numerous long, thick yellow or pink and red colored hairy growths. The edible part of the rambutan is the white pulp on a brown seed inside. Fruits are sweet, juicy and delicious with a pleasant flavor and aroma. Being the rubber and other plantations crop planter, he has always been a challenge to try something different. Mr. Jacob to diversify into the rambutan in a region conducive for arecanut, pepper, rubber, banana and other crops. Beginning of new innings started planting of 2 acres of rambutan. The grower Mr. Jacob, Puttur, Karnataka his dedication towards production concept, who visited CHES, Chettalli and interacted with Scientist about status of rambutan performance and production technologies which ultimately gave great confidence and further strategic management practices, earned maximum rates selling of rambutan fruits own farm outlets, thereby fetched better profit. In these region, rambutan orchard became centre of attraction for all the growers. His success story is an inspiration for other farmers too.

Many growers southern India are not aware of cultivation litchi and benefits of plantations. Successful grower and instrumental in off season litchi production, Mr. Kuruvilla Joseph, in his estate grows coffee, pepper and cardomum apart from litchi, mangosteen and rambutan. success in off season litchi cultivation inspired lot of people in Wyanad to take production of litchi through best practices and reap the benefits It's having huge demand in the fruit markets in bangalore, the fruit sold at cost of Rs. 100-150 per kg at farm gate level. In the northern states of India a litchi fruit matures in the month of May and June, contrary to this, the litchi matures in the month of November and December in the region of Western Ghats. Litchi is grown as home stead trees or as isolated trees in coffee plantations in parts of Coorg and Waynad. Litchi cultivation in these regions and it has a huge potential for the domestic supply even for the exports. Another grower Mr. C.S. Guruduth, succeeded in off season litchi cultivation and expressed most sold in within the farm, who has visited five years ago at CHES, Chettalli, interacted with scientist regarding production technologies which ultimately gave confidence and realised great opportunity to tap demand in market. Most challenging in the litchi farming is prevent the fruit damage from the bats, birds and squirrels.

Currently, there is an ever growing demand for mangosteen fruits in the metros. Keeping strong faith in the monetary prospects of this fruits. Mr. Ahmad Kutty, P.K., Calicut, he has taken interest in mangosteen farming in his estate. His got inspiration and guidance from Mr. Jacob, who is also planted mangosteen. We suggest the growers should tap the potential of rambutan, off season litchi and mangosteen cultivation in these region has a vibrant niche market and huge prospects not only for the domestic supply even for exports.

V-23

The 'Timla Fig' a valuable fruit for dry tract

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The Timla Fig (*Ficus carica*) is a subtropical fruit grown as an intercrop in large plantations and in home yards. The trees are drought resistant and due to its hardy nature it can be planted in the areas where assured source of irrigation is not available. It is grown in lager area at Hiriyur and Sivapur at Karnataka. In other parts of our country it is grown in a limited areas. The trees are medium to large in size. Fruits are blackish red in colour, berry like very soft and sweet to taste and easily spoiled at handling.The unripe fruits are used as vegetable. Ripe fruits are used for table purpose. It also used for preparation of jam and canning. It can be cut into pieces, dried and stored longer. It is having medicinal properties like, acts as blood purifier,reduces body heat,found to be effective in the treatment of chronic cough and piles and fruits are preserved in vinegar is used as medicine for the treatment of liver and spleen enlargement in children.TNAU has releaed Yercaud 1 Timla Fig in the year 1992 form Horticultural Research Station, Yercaud, Tamil Nadu. It can be grown in all types of soil. Grows well on deep rich loamy soils. 25 – 35°C is found to be suitable for its growth. It cannot withstand in severe winter, high temperature and heavy rain. Temperature above 39°C causes damage to the tree trunk and sunburn on fruits The bunch of fruits bears on the tree trunk and on the branches. Fruits are large in size and blackish red in colour. Rich in vitamin A and C. The grown up tree yields 4000 fruits/year. The plant produces fruits from 2nd year onwards. But commercial yield can be obtained in the 5th year .40 ppm GA spray increases 10% fruiting. Matured fruits are green in colour and the ripened fruits are blackish red. The fruits are come to harvest from May – September. The soft fruits are harvested when the latex flow is arrested on the stalk. A grown up tree yields 2500 – 4000 fruits/year. The fruits are highly perishable in nature. So it should be sent for sale immediately or can be stored at O°C for a week.

V-24

Composition of mineral elements in different accessions of jamun (*Syzygium cumini* L. Skeels.) seed

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Syzygium cumini, widely known as Jamun, is a tropical tree that yields purple ovoid fleshy fruit. Its seed has traditionally been used in India for the treatment of diabetes. The present study was aimed to determine mineral elements in jamun seed to understand the nutritive value of seed powder apart from known ethno-pharmacological composition. Nine accessions of jamun trees of seedling origin grown and maintained at the IIHR were selected for the study. The seeds were oven dried and made into powder with the help of seed grinder (Cyclotec) and processed and used for mineral analysis. Results revealed that there was a significant difference among the accessions with respect to K, Cu, Fe, Zn and Mn. The accession IIHR-SC-6/6 recorded the highest K percentage (1.29). The maximum Cu content (5.70 ppm) was found in the accession IIHR-SC-6/3. Highest Fe content (84.53 ppm) was found in IIHR-SC-7/6 while the accession IIHR-SC-6/1 exhibited the highest Zn content with a value of 4.30 ppm. The highest Mn content of 4.60 ppm was found in the seed powder of accession IIHR-SC-7/7. Calcium percentage in Jamun seed powder ranged from (0.19 %) in IIHR-SC-6/5 to (0.49 %) in IIHR-SC-6/3. Magnesium percentage varied between (0.09 %) in IIHR-SC-6/5 and IIHR-SC-7/6 to (0.12 %) in IIHR-SC-6/7 and IIHR-SC-6/4. In pursuance of the results, Iron content was found to be abundant in quantity in Jamun seed powder. Maximum seed percentage (16.34) was recorded in IIHR-SC-7/7, and thus accession can be selected for making Jamun seed powder which serves as medicinal value due to its anti-diabetic properties besides its fresh pulp was rich in carbohydrates, protein and minerals.

Drying characteristics of nutmeg and mace (*Myristica fragrans*) dried under different methods and its quality evaluation

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Drying of nutmeg (*Myristica fragrans*) and mace was conducted by four different methods like drying in solar tunnel drier with a biomass back up and mechanical drying at drying temperatures of 45, 50 and 55°C. The experiments on drying of nutmeg was conducted during July 2014 by spreading 2 kg of fresh nutmeg in stainless steel trays of size 90.5× 90.5 cm. While 0.5 kg mace (variety Vishwasree from ICAR- Indian Institute of Spices Research, Kozhikode) was spread over the stainless trays (90.5× 90.5 cm) and placed inside solar tunnel drier with biomass back up. All the tray ware mounted over mild steel stand provided 117 cm above the floor of the drier. In case of mechanical drying of nutmeg and mace, weighed quantities were placed inside the drier and drying was performed at varying temperatures of 45, 50 and 55°C. The loss in weight during drying was recorded every 3 h and drying was continued till constant weight was obtained. Three such replicates were maintained for all the experiments. The drying characteristics curves indicated that the moisture content of nutmeg and mace decreased constantly with increase in drying time. The process of drying nutmeg in solar tunnel drier was completed in 147 h and mace in 33 h. In mechanical drier, at drying temperatures of 45, 50 and 55°C, nutmeg drying was completed in 105, 102 and 78 h and mace drying was completed in 9, 9 and 6 h, respectively. Physical parameters of nutmeg like moisture (12.42%), bulk density (484.88 kg/m^3), drying time (147 h) and kernel recovery (70.63) were maximum in solar tunnel dried samples where as dry recovery (61.88%) and shell recovery (31.55%) were maximum in mechanical dried samples at 55°C and 45°C, respectively. Secondary metabolites like essential oil (10.67%) and oleoresin (23.25%) were maximum in mechanical dried nutmeg at a drying temperature of 45°C. Volatile oil constituents of nutmeg like β-pinene (9.21%), safrole (5.60%), terpineol (6.77%), γ-terpinene (2.97%), α-thujene (2.04%), α-terpinene (1.92%) and myristicin content were maximum in solar tunnel dried samples. Constituents like limonene (7.91%) and elemicin (5.48%) were maximum in mechanical dried nutmeg at 45°C. In case of mace, physical parameters like moisture content (5.48%), bulk density (171.59 kg/m^3) and drying time (33 h) were maximum in solar tunnel dried samples where as dry recovery (61.88 %) was maximum in mechanical dried mace at a drying temperature 55°C. Primary metabolites like carbohydrate (44.18%) were maximum in mechanical dried mace at 45°C. Secondary metabolites like essential oil (9.07%) were maximum in mechanical dried mace at 45°C where as oleoresin (23.25%). From the study, it was concluded that drying of nutmeg at a temperature of 45°C was ideal with maximum retention of essential oil (10.67%) and oleoresin (23.25%). And in case of mace, drying temperature of 45°C was found optimum with maximum retention of essential oil (9.07%) and the corresponding oleoresin content was 25.49%.

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V-26

Processing of nutmeg pericarp for value added products

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*Myristicafragrans*L., commonly known as nutmeg is an important tree spice component in arecanut / coconut based cropping system in Goa. Nutmeg is commercially cultivated for two types of highly valuable spice products viz., nutmeg seed and the mace. These two spice parts are enclosed by the pericarp of yellow coloured spherical or slightly oblong pendulous fruit, the drupe, born either solitary or in cluster on the tree. Upon maturity, the fruits split on vertical suture to partially expose the brightly coloured mace (aril) enclosing the seed. From the matured fruits, the seed nut and mace are collected and the pericarp (fruit rind) is left in the field for rotting, thus leading to enormous wastage of nutritive biomass. By fresh weight, pericarpbiomass of the nutmeg drupe is roughly about 5 – 7 times more than that of the seed depending on the variety. In general, Nutmeg fruit has about 80 – 85 % of pericarp by fresh weight. At the age of 15-20 years, trees of high yielding nutmeg varieties produce about 75-100 kg of fresh pericarp (fruit rind) per tree, besides the economic yield of spice products. This biomass of pericarp is simply left in the garden for rotting after collecting the seeds and mace. This biomass of Pericarp, having nutritive value, is worth processing for a number of value added products. A study was carried out to put to use the biomass of nutmeg pericarp for converting it into value added products for deriving additional income by avoiding the wastage of pericarp produce. This study illustrates the potential of nutmeg pericarp as raw material for a number of such value added products like nutmeg pericarp Jam, candies, nutmeg rind powder, beverage, syrup, fermented beverage, sweet pickle, chutney/ pickle, etc. Shelf life, quality attributes and production cost of the products are discussed in the paper. Sensory evaluation of some products like nutmeg pericarp candies and beverages recorded vast economic scope for processing of pericarp. This information on processing potential of nutmeg pericarp will form the basis for further pilot scale trial for commercialization of this technology.

Effect of blending of cashew apple (*anacardium occidentale l.,*) juice with mango, pine apple and sapota juice for the quality of rts beverage and its economic feasibility

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The present investigation was carried out on the value addition of cashew apple juice by blending with mango, pineapple and sapota juices in "RTS beverage" was utilization of cashew apple for preparation blended juice with mango, pineapple and sapota juices during the year 2012-2013 at Horticultural College and Research Institute, Dr. Y. S. R Horticultural University, Andhra Pradesh, in a Completely Randomized Design (CRD) with 3 replications and 10 treatments. In the present investigation the cashew apple juice extracted from the fruits was blended with the fruit juices of mango, pineapple and sapota at different percentages. Significant differences were observed among the different cashew apple blended juices for various physico-chemical parameters. Significant differences were found among the RTS prepared from different cashew apple blended juices for various physico-chemical properties and organoleptic scores at 0, 30 and 60 days after storage. It was observed that RTS prepared from the blend of 25% cashew apple juice + 75% mango juice (T_3) showed gradual decrease in p^H, titrable acidity, ascorbic acid content from 0 to 60 days after storage where as the density of blended juice was increased first gradually from 0 to 30 days of storage later, it was decreased gradually at 60 days of storage. The total soluble solids, reducing sugars, TSS/Acid ratio were increased gradually from 0 to 60 days of storage followed by RTS of 25% cashew apple juice + 75% pineapple juice (T_6).Further, the organoleptic score of RTS prepared from 25% cashew apple juice + 75% mango juice blend (T_3) followed by 50% cashew apple juice + 50% mango juice blend (T_2), 25% cashew apple juice + 75% pineapple juice blend (T_6) and 50% cashew apple juice + 50% pineapple juice blend (T_5) were found high for their quality *viz.,* colour, taste and overall acceptability up to 60 days of storage and they were found economical for utilization of cashew apple juice with different blends of mango and pineapple for their RTS preparation.

V-28

Effect of packaging and ventilation on the post harvest shelf life and quality of ethrel treated sapota (*Manilkara achras* (Mill.) Forsberg) cv. Kalipatti at ambient conditions

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Sapota or sapodilla [*Manilkara achras* (Mill) Forsberg] commonly known as chiku is a delicious fruit and valued for its mellow and sweet pulp which mainly used for table purpose in India. India is considered to be the largest producer of sapota in the world. Majority of the post harvestlosses in sapota occurs due to rapid ripening and softening of the fruit which in turn causes major handling problem Being a climacteric fruit, sapota ripens within 4 to 7 days after harvest and soon after full ripened stage rapid bio-chemical changes reduced the shelf life. An experiment was conducted at HC&RI,Venkataramannagudem to study the effect of packaging and ventilation on the post harvest shelf life and quality of ethrel treated sapota(*Manilkara achras* (Mill.) Forsberg) cv. Kalipatti under ambient conditions.The study revealed that the fruits responded to packaging and ventilation.The maximum shelf life (11days) was recorded in fruits of T_5 (200 gauge polybags of 1.2 percent ventilation) followed by T_4 (10.33).

V-29

Incorporation of different level of jackfruit seed powder enhance functionality of sweet biscuits

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To study the functionality, acceptability and storability of sweet biscuits prepared by incorporating jackfruit seed powder in different level . Sweet biscuits were prepared by using 100% Refined Wheat Flour (RWF) served as control and different levels of jackfruit seed powder of (5%, 10%, 15%, and 20%) were incorporated replacing the same quantities of RWF. The prepared biscuits were evaluated for nutritional and sensory characteristics during fresh and after three months storage. Results revealed that significant ($p<0.05$) increased in crude fiber content from 0.34 (100% wheat flour) to 0.78per cent (80% refined wheat flour+ 20% jackfruit seed powder) and it increased with the increase in the incorporation of jackfruit seed powder in sweet biscuits. Whereas, reducing, non-reducing and total sugar decreased

from 9.12 to 8.25 per cent, 1.52 to 1.21 per cent and 10.44 to 9.86 per cent, respectively during storage period of three months as revealed by their mean values. Moisture content and water activity were increased from 4.5 to 5.32 per cent and 0.33 to 0.45, respectively during three months of storage. Results revealed that biscuits processed from refined wheat flour supplemented by 15% of jackfruit seed powder had higher acceptance scores for sensory characteristics during initial (4.5 out of 5) and throughout the storage period (4.0 out of 5) then the other blends.

V-30

Fortification of carrot, jackfruit and amla powder to enhance nutritional and sensory qualities of sweet biscuits

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To study the nutritional and sensory qualities of sweet biscuits through incorporation of optimal quantities of carrot, jackfruit and aonla powder.Sweet biscuits were prepared by using 100% Refined Wheat Flour (RWF) which served as control and powders of carrot (10% and 20%), jackfruit (25% and 50%) and aonla (10% and 20%) were incorporated replacing the same quantities of RWF. The prepared biscuits were evaluated for nutritional and sensory characteristics when fresh and after three months of storage. Results of chemical analysis indicated that crude fibre content increased significantly ($p<0.05$) from 0.35 (100% wheat flour) to 0.95 per cent (80% refined wheat flour+ 20% carrot powder) and it increased with the increase in the incorporation of carrot, jackfruit and amla powders in sweet biscuits. Whereas, reducing, non-reducing and total sugar decreased from 9.82 to 9.25 per cent, 1.72 to 1.51 per cent and 11.54 to 10.76 per cent, respectively during storage period of three months as revealed by their mean values. Moisture content and water activity increased from 4.88 to 5.62 per cent and 0.35 to 0.47, respectively during three months of storage. Results revealed that biscuits processed from refined wheat flour supplemented by 25% of jackfruit powder had higher acceptance scores for sensory characteristics during initial (4.58 out of 5) and throughout the storage period (4.16 out of 5) then the other blends.

V-31

Studies on Physico-chemical characteristics of jamun fruits

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Jamun (*Syzygium cumini* L.) is a minor and underutilized fruit crop of Indian origin. The harvesting span of jamun fruit is very short (30 to 40 days) during monsoon months. Jamun production in India is unorganized and scattered one and there is huge loss of this fruit every year. Compared to other popular fruits like sapota, papaya, banana and guava, jamun have higher level of antioxidant activity. The higher antioxidant activity in the fruit is attributed due to presence of antioxidants, vitamins, tannin and anthocyanins. In general, traditional methods are used during the processing and preservation of jamun fruit which is uncommon. This study was carried out to know about the physic-chemical properties of jamun fruit in order to facilitate its handling and processing. The morphological parameters includes weight, volume, length, diameter, shape, color, firmness/softness, edible and non-edible contents, specific gravity, juice and seed contents. Two prominent cultivars of Jamun like Bada Doli (Improved Type) and Local type and were analyzed. The improved cultivar Bada Doli was found superior in all parameters compared to local type was found to be substandard except seed portion which was more in it. The weight, length, width and volume of the improved variety Bada Doli was determined as 9.40 g, 3.85 cm, 2.85 cm and 7.40 ml whereas local type was determined as 6.54 g, 2.65 cm, 2.10 cm and 5.30 ml respectively. Moreover, edible portion was 68.50% whereas non-edible portion was 31.50% in Bada Doli. In case of Local type, edible portion was determined as 38.50% whereas non-edible portion was 61.50%. The observations indicate that Bada Doli is comparatively better than local type. The research findings will be highly beneficial for processing industries and and fruit exporters.

V-32

Marketing of underutilized fruits in Coorg region

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Coorg region of Karnataka is well known for its rich flora. Underutilized fruits *i.e.* Avocado, Rambutan, Litchi, Passion fruit, Kokum, Mangosteen, Karonda, Sour sop are cultivated in orchards and gardens, numerous other fruits exist in the wild and are utilized by the local people or the tribals, either fresh or after processing for various dishes. Fruits are mainly sold through local, regional or international markets. Initially a farmer may only market fruit that is produced in excess to the family's requirements and usually at a roadside stall or through an occasional visit to a local market. The regional markets comprise the largest cities and tourist centres of the region. Demand within regional markets fluctuates and is

generally somewhat unpredictable. As a result, the marketing infrastructure continues to develop. It is the production regions adjacent to these markets that can most easily meet demands as they arise. Farmers, farming communities and even countries, often form groups in order to compete more successfully on the international market. The value of such associations is now accepted and allows for better market intelligence, training and overall market penetration and retention. Market development and expansion comes with inclusion of marketing channels like regulated markets, co-operative marketing, contract farming and e-commerce. Branding is beneficial and can aid expansion and introduction of new crops and varieties. The identification of novel products and increased use of underutilized crops can be expected to gain momentum and provide farmers with alternative market opportunities. However, it is necessary to first develop markets for locally grown produce. The regional markets do offer an opportunity to improve rural income. The development of these markets demands management skills and close links with marketing agencies, which in turn allow for the development of new business ventures, new crops and new periods of supply.

SESSION VI

FARMERS - SCIENTISTS - ENTREPRENEURS INTERACTION

Popularization of underutilized fruits: An entrepreneur's observations

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Southeast Asia is represented by more than 500 species of fruits (Arora & Rao, 1995), while the Hindustani center of origin represents 344 species (Arora, 1995). Most of these fruits have a great potential as new crops. It is interesting to note that many of these fruits are growing in wild or semi-wild condition. Only a few fruits such as Banana, Mango, Guava and Citrus got popularity and acceptability by the people. Many of the indigenous tropical and sub-tropical fruits still remain underutilized due to the lack of awareness of their potential, production and market demand. Organized production and processing for value addition of products play an important role in their sustainable utilization. Genetic resources for these underutilized fruits are facing a great threat of extinction due to large scale urbanization, global weather change and developmental projects. Popularization and conservation strategies are key areas to safeguard the germplasm of these species.

The diverse climatic conditions bestowed on South India allow the production of a wide range of fruit crops having national importance in view of their potential for export. These include rambutan, pulasan, mangosteen and durian. The exotic fruit crops had arrived in the state long back and were confined to certain pockets of Kottayam, Pathanamthitta and Ernakulam districts. They were brought to this part of the state by people who had migrated to Malaysia and other Southeast Asian countries. Farmers in many parts of kerala and Karnataka have seriously taken the cultivation of these crops. There is an ever growing demand for these fruits in the metros and production has not grown to support even a fraction of the current demand.

In view of the ever-increasing demand for these fine fruits, Homegrown Nursery and Farms ventured into the business of producing high quality planting materials in large quantities. Home grown Nursery and Farms is one of the leading fruit crop nurseries in South India, established in 1999 with the primary objective to supply high quality planting materials to the farming community. It is a reputed business concern backed up by professional expertise, high fidelity and state-of the art technology.

Among the underutilized fruits, the place of rambutan is very high. It is an excellent fruit suited where high rainfall, humidity, and a temperature range of 24 to 35 C. Some of the important points to keep in mind for a person who is interested in rambutan cultivation are the availability of irrigation water, 65 to 85% relative humidity, annual rainfall of at least 2500 mm and a site where maximum sunlight can be captured. The tree thrives in almost any type of soil, except sandy soil with high amounts of chlorides. Our R & D work on the reproductive biology answered many questions on the reproductive behavior and thus enhanced production.

Using high quality planting material of superior varieties such as N 18, King, Malwana, School Boy, Deli Baling, Muar Gading, Jit lee, Binjai etc., good cultural and management practices including proper spacing, tree training and pruning, minimizing post harvest losses and farmer awareness programs can enhance productivity. Rambutan is a seasonal crop and there are ways to lengthen the fruit production. The most important practice is to cultivate rambutan in different agroclimatic locations such as high-ranges of Idukki and Wayanadu, Low land areas of Kottayam and Pathanamthitta and some parts of Ernakulam. Mangalore belt is another area where fruit production period extend up to September. Thus, there is a possibility of lengthening the fruit supply by almost nine months.

Our extensive work on spacing has showed that giving 40 x 40 ft spacing is the best practice under Kerala conditions. By giving good spacing, many of the problems such as vertical competition, irregular canopy development, disease and pest outbreak etc could be checked. A semi-circular canopy with the potential of capturing maximum sunlight can be easily achieved by this practice. Use of International quality packing/gift boxes and packing the fruits in the orchard itself are some of the best practices to fetch good returns.

Another important fruit we are working is durian. It is considered to be the world's most expensive fruit. Nutritionally speaking, durian is exceptionally rich in minerals and vitamins: calcium, iron, magnesium, phosphorus, potassium, zinc, copper and manganese, thiamin, riboflavin, niacin, pantothenic acid, vitamin B-6, folic acid, vitamin A, retinol etc. What is interesting in durian is that it has got a hormone called phyto-estrogen, which has found use in boosting fertility in humans. Durian is exceptionally high in protein and fat while 100% Cholesterol free. It is providing excellent calories for those who are looking to build strength while others will lose weight with it as it is strongly cleansing and detoxifying the body.

Selection and improvement work on Durian resulted in the release of a large number of varieties in many Southeast Asian countries. The most popular varieties of Malaysia are Musang King, D 24, Red Prawn, XO, D 2, D 101, D 88, Orchid, Trekka; Thailand varieties are Mon Thong, Chanee, Kan yao, and Phuangmanee. The popular varieties of Philippines are Arancillo, Duyaya, Kob and Puyat. Work is in progress at Homegrown to mass multiply all of these varieties through budding by 2016. Three of the varieties, namely, D 24, Mon Thong and D 101 will be released to farmers on September –October 2014. We are also working on production of planting materials in soilless media for the export market.

Our pioneering work on rambutan gave us enough confidence to propagate and popularize 18 more underutilized fruits. Standardization of cultural practices for Mangosteen and Pulsan took a fresh momentum in the production of fine fruits among progressive fruit growers of Kerala and some parts of Tamil Nadu and Karnataka. Our Jackfruit varieties find a high position among world's most popular varieties. They are Deng Suriya of Thai Land, J 33 Tekam Yello, J 31 (NS 1), Bangalore Red and Then Varikka. Then Varikka is a local selection with excellent flavor and aroma. Both Deng Suriya and Bangalore Red are red flesh types.

Cempadek is a recent introduction from Malaysia. It is a close relative of Jackfruit with strong flavor and great taste. The fruits are up to 2.5 to 3 kg. Cempedak can grow in a variety of soil types. Cultural practices are similar to jackfruit. What makes Cempadek popular is its long shelf life (up to 8 days), high yield (a well-managed 10 year old tree can produce up to 150 fruits).

We also produce planting materials of "Chakkara" mango, which is a highly aromatic, sucking type with high yield, very suitable for Kerala conditions. Indonesian Bread fruit and Varikka Anjili (Artocarpus hirsutus), Star Apple, Guava, Soursop, Avocado, Passion fruit, Jaboticaba, Mamey Sapota, Dragon fruit are the other fruits we propagate and popularize.

Hurdles for underutilized fruits cultivation – A grower views

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These are few thoughts that I would like to share:

1. Biggest hurdle is developing production systems for these fruit crops for each growing region. There should be a system in place where farmers and scientists from each area can interact and at the end of each harvest season a conclave is held in that region where recommendations can be made which should be made available to everyone on national and international level. This will help develop production systems relevant to each growing region.
2. There should be conscious decision made to ensure that no Patent is filed under the above system, like for instance a trellis is designed by someone which could be patented.
3. Free access to knowledge and sharing of scientific data is essential. Example: possible tendency of mutants generated in the case of Micro propagation.
4. Developing several trust worthy sources of planting material and informing farmers about advantages and disadvantages of the planting material so also unknown factors that could contribute to success and failure of the planting material in a given growing region.
5. Developing strategies for using plant growth regulators in production.
6. Using protected cultivation practices including sun screens, netting, bagging, poly houses etc. in the production of tree fruits.
7. Developing awareness among consumers by use of media, and familiarizing use through Chefs.

Mr. C.F. Jacob is a leading Rambutan grower from Dakshin Kannda district of Karnataka planted more than 50 acres of Rambutan and he is guiding and encourage many farmers to grow underutilized fruits

Plant, protect and promote jack tree Procure, process and prop up jackfruit

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Jackfruit is the biggest fruit in the nature and is a native of our western Ghat. As we write about Palakkad district of Kerala there are about twelve lakhs of jack trees with 33.5 million fruits per annum. Only about 40 % of the crop is utilized for various food needs and 12% sold to other states as tiny exports and the remaining 48% of the crop is unutilized every year. The economic value of this unutilized fruit at raw level is almost 9.73 crore and 38.94 crore on value addition. Can we arrest the huge loss? Why can't we eat jack dishes thrice a week? Can we tap the opportunity of processing and value addition? PSSP's two year experience shows an achievable target.Jackfruit is the only fruit which can be processed at various stages of growth. Different stages viz; tender, medium, mature, Ripe and seed. These different stages can be made to value added products. The tree which bear the apt fruit for each stages of value addition is the know how only available with the farmer/owner of the tree. Collection of this knowhow and empanelling of farmers and trees to procure the fruits assure superior quality to value addition and makes the customer demand in upper graph for the products. The only fruit tree which can be cultivated and produced without chemical and pesticide support is Jackfruit. The major fruit which supported the hunger of Keralites in the famine era is Jackfruit. The only meal which can be eaten for chronic diabetic patients in full stomach is Jackfruit. The fruit with high dietary fiber and Gluton free nature which can give immunity to Blood pressure and life style diseases is Jackfruit. The anti oxidants in the jackfruit is powerful enough to prevent cancer- many studies reveals the fact. The fruit with superior taste and nutritious level and can be grown with least care is jackfruit. So People's Service Society Palakkad (PSSP) made a venture for processing and value addition of jackfruit in Palakkad district.

PSSP's processing is carried out with Four farmers SHGs as regional processing units. The processed jackfruit products of these farmers Regional processing units procured by PSSP are Dehydrated Tender Jackfruit, Dehydrated Matured Jackfruit, Dehydrated Ripened Jackfruit, Jackfruit concentrate, Jackfruit chips dehydrated Jack seed and Seed Flour. With Dehydrated Tender, Matured, the customer can cook any dish same as the items in fresh form after rehydration for two hours viz. Chakka puzhukku ,chips, pickle, different whole curries or replacing mushroom, meat, potato etc. and can add to chappathy porotta puttu even in Dhosa mix after powdering. It can be kept for one year at room temperature. Dehydrated Ripened Jackfruit and Jackfruit concentrate both can be used for Kmbil appam, Puttu, different Adas, Payasam, Ice cream, Pudding and Snacks. Ripe dehydrated kept in honey is a unique snack capable of inducing memory and grasping power. Chips mainly as snacks. Jack seed dried can be stored for two years and we can use at any time after re hydration of one day and seed powder is the best taste maker and can make any items replacing or adding with grain flour.

The value addition methodology of PSSP is very simple just dehydration after sterilization. Many other value addition methodologies promise high potential market for the products and the tapping of such avenues will enhance the arrest of un-utilization of Jackfruit in the season and the round the year availability with zero effort of preparation. PSSP envisage to make an endeavor to such avenues in the coming Years as the Jackfruit mission of PSSP's motto is Plant, Protect and Promote Jack Tree. Procure, Process and Prop Up Jackfruit.

Success story of nutmeg cultivation - A spice in spice

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The westernmost belt of Tamil Nadu encompassing the western ghats has abundant wealth of horticultural species comprising of spices and plantation crops. Pollachi, globally known for the world's highest productivity in coconut is acclaimed as the 'Coconut City'. Geographically, the Pollachi region is blessed with conducive agro climatic conditions. Coconut, cocoa, black pepper and nutmeg are predominant crops of this region. Farmers of this region are more informative on the advanced technologies of crop production. Besides, coconut based agro processing industries and close vicinity of the spices growing Kerala districts have accounted for increased productivity of these crops. Moreover, the farmers are at advantageous location of tapping all the technological inputs from scientific institutions like Tamil Nadu Agricultural University, Kerala Agriculture University, Department of Horticulture & Plantation crops besides central institutes like Indian Institute of Spices Research, Central Plantation crops Research Institute, Indian Institute of Horticulture Research, Coconut Development Board, Spices Board, Directorate of Arecanut and Spices Development etc for enhancing the productivity of coconut and spices. Hitherto, nutmeg was known only in very few places like Kallar, Burliar and Courtallam.

I established my coconut plantation 44 years ago in an extent of 75 acres at Odayakulam village, Pollachi taluk, Coimbatore district which is located along the foot hills of the westernghat hills of Tamil Nadu. Foreseeing the possibility of exploring high value spices as intercrop in coconut, I adopted a wider spacing of 29 feetfor coconut which was not in practice that period. Now I realise that the effort has become so fruitful that I have observed the per tree yield of coconut is far better than that of the normal spacing. Besides, the per unit area production also increased remarkably.It is my view that the single palm yield would be more when the palms are widely spaced but the unit area production would come down. Coconut is regarded as the Tree of Life which grows by itself besides facilitating the other crops also to flourish in its area by inducing favourable micro climate. The grown up coconutpalm occupies 25 per cent of atmospheric area and 25 per cent of root zone area. I found lot of unutilized space available in my coconut plantation to the extent of 75 per cent. The leaves and fronds have a peculiar arrangement which allows sunlight to penetrate the ground. Witnessing this, I started exploring the possibility of mixed cropping for the effective utilization of the free space besides improving the net income from my plantation.With all these attributes, I regard coconut as 'Foster Mother of Plantation crops of the tropical plains' and is the best companion crop to be grown with many crops like cocoa, nutmeg, banana, black pepper.

I introduced nutmeg from Fruit Research Station, Kallar in 1987. Those days, only seedling progenies were available. The problem with the seedling progenies was that nutmeg is dioecious and male and female plants would be identified only after 6-7 yearswhen it flowers. These progenies give 40 per cent of male population and 60 per cent female population. I later observed that among the 60 per cent female trees, very few were elite; as a result the productivity was low. Moreover, the grown up seedling progenies with less productive female and male trees needs top working to improve the productivity. For top working, the unproductive male and female trees are beheaded just above the first tier branches. The period of beheading should be one year before budding. Lot of coppicing emerges along the main stem. Two healthy orthotropic shoots should only be allowed after removing the remaining shoots. Brown patch budding is done on both the selected shoots. If both the buds are successful, one will be allowed for collection of bud woods and the other bud wood for producing the main crop. If bud woods are continuously collected from trees, it results in reduction in yield of trees. To overcome this problem, bud woods can be collected from closely planted selected budded trees.

I started searching for alternate to improve the productivity of nutmeg. The only option was vegetative propagation through brown and green patch budding and also approach and epicotyl grafting. In nutmeg, the growth habit is in two forms viz., orthotropic (vertical shoots) and plagiotropic (lateral branches). I experimented vegetative propagation using orthotropic shoots as scion from my farm besides from other places. I was not convinced with this practice because I found lot of variation between trees. Finally, I started searching for the pedigree planting material. I could manage to procure scion from selected mother plants from Vaikom, Kerala in 1994. These pedigree plants yielded in three years after budding, besides having precocity of bearing with high yield as high as 1000 fruits in 7th year and 2000 fruits in 12th year and more than 10000 fruits after 20 years with good dry nut weight and dry mace weight. Here I would like to point that the nut and mace weight and size would go down when the tree yields heavily with more number of fruits and under such circumstances the farmer does not get the high grade mace and nuts.

When I brought the scions for the first time, I found that the success rate of budding was low due to the huge time gap from the cutting of scions and budding operation. I once again repeated this process of bud wood collection from Kerala, however this time by using ice box to transport the bud wood scion. I could findlot of improvement in the success rate.

With this experience, I started in situ budding with root stock of 18 months old in which Myristicafragrans was used as root stock. But based on the literature as well as my field visit to other farms in Kerala, I found that M.fragrans is a surface rooter and highly prone for wind damage as well as persistent rainfall. So I tried using wild root stocks viz., M.beddomei and M.malabarica. However these root stocks were found to have poor compatibility and these are suitable only for very high humid places and high ranges. Finally, I decided to use only M.fragrans as root stock on which budding was done two tiers above and I could observe lot of male branches growing below the bud union which I consider as an advantage.

While using seedling progenies, the recommended female male ratio is 10:1. But through vegetative propagation, male and female flowering branches can be possible within the same tree facilitating better pollination. However, more scientific work is required to confirm this.

I am currently taking an experiment by budding male budwoods 5-6 steps higher and further by budding female budwoods at subsequent levels above the male branches with an aim of achieving 100 per cent pollination year after year.As the yield in nutmeg depends on the age, height and canopy with more vegetative shoots, allowing fruits during early stages will arrest the vegetative growth leading of exhaustion of plants and dying. Therefore my suggestion to nutmeg growers is that the plants should not be allowed to fruit earlier than five years. The demand for nutmeg scions is on increase and I would suggest adopting closer planting of scion trees to meet the demand. Alternately, plagiotropic branches can be cut at half way to induce more orthotropic water shoots to be used as bud wood.Vegetative propagation through plagiotropic shoots is also in practice but canopy management is very difficult which depends on the place from which the scion is collected either from primary, secondary or tertiary and is normally bushy in nature.

Similar to other crops, nutmeg also exhibits alternate bearing resulting in over production during the first year and low yield in the subsequent year. I have also observed that root stock influences the yield pattern. When scion collected from a same plant was budded on the common root stock (M.fragrans), I find lot of variability in yield pattern among the trees even though no genetic variation with physiological variation could be observed.I have also observed that in many budded trees, the root stock performed better than the scion which I could observe the two tiers below the bud union.The success rate of budding depends upon the season and the health of root stock as well as scion. I recommend regular maintenance of both root stock and the scion trees by maintaining uniform and scattered sun light besides optimum irrigation and manuring.

All the literature says nutmeg comes only under warm and humid conditions like west coast (Kerala), Srilanka, Indonesia, Pacific Carribean and Malaysia. But I owe the success of nutmeg in Pollachi region to the moderate climatic conditions, availability of irrigation throughout the year, annual rainfall of 1200-1300 mm in both south west and north east monsoon, humidity range of 70-85%. Under such climatic condition, the transpiration loss compared to the other conventional nutmeg growing regions is higher. Since we are supplementing with irrigation through fertigation, this loss is compensated. Moreover, due to the supplemental irrigation, the moisture and nutrient uptake is enhanced. In Pollachi, irrigation is mainly through drip and the required macro and micro nutrients are supplied through drip every week. Because of this, harvesting is extended upto two months. The nutmeg production in Pollachi region is expected to surpass the production of leading countries like Indonesia and second largest producer Grenada. In this context I like to add that rise in humidity due to unprecedented rain, the tree become conducive for Phytophthora fungal infestation leading to defoliation and nut fall which occurred in Kerala for the last two years.In my experience, I account the soil and root health as the successful factor to decide on the output of the nutmeg. So far, it is a general practice of putting all the efforts to manage the canopy alone ignoring the rhizosphere. Nutmeg being a shallow rooter, the root health should be regularly monitored. Organic mulching using dried and shredded coconut leaves and fronds, cocoa leaves are one good management practice. Mulching helps in maintain the soil moisture as well as to protect the raising soil temperature during summer and equally to keep the soil temperature warm during winter. It should be noticed that the mulch should have ample clearance from the trunk to avoid fungal problems. Soil microbes play a major role in betterment of root and plant health. Application of biofertilizers and biocontrol agents can help in maintaining the tree health with reduced input cost.

In India, Kerala being the leading nutmeg producer faces very high difficulty of harvesting aflatoxinfree nutmeg and mace due to heavy rains and high humidity for a prolonged period besides availability of work force. Nutmeg producers in Pollachi region are making use of this opportunity by producing aflatoxinfree nutmeg and mace. The western countries like Europe and USA who consume more have imposed stringent quality restrictions like aflatoxin free produce and free of carcinogens. Under these circumstances, farmers of Pollachi region by adopting ethical and scientific practices using solar driers with back up heating during monsoon by other energy resources like biomass energy earn a better income from nutmeg.The success of nutmeg production depends on spacing, nutrition, shade management in the initial stages, plant protection. As a mixed cropping in coconut plantation, spacing is a limited criteria and normally adopted at 1:1 ratio. Each nutmeg is planted at the centre of four coconut palms. A common spacing of 27 feet between nutmeg to nutmeg is recommended. However this depends on the nature of scion trees and age as the tree shape is conical with some trees broader at base and few narrower. Broader trees need more spacing which results in interlocking of trees and poor penetration of sunlight and poor yield.In my experience, I have found that coconut nutmeg and cocoa as a good combination in the ration of 1:1 (coconut nutmeg) and 1:2 (coconut cocoa). In later stages, cocoa needs to be removed to maintain nutmeg. Black pepper also performs well under this cropping system, however too much of crops would result in higher micro climate and invite fungal problems.Nutmeg being a shallow rooted crop is sensitive to water logging, moisture stress and drought. Therefore irrigation and nutrition at optimum level are important. High soil organic content is required besides meeting the macro and micro nutrients. The crop responds well to foliar nutrients comprising macro and micro nutrients. Depending on the vegetative stage or flowering stages and fruiting stage, the nutrient level varies. Humic acid gives better result as fertigation as well as foliar application.Training is an important operation in nutmeg. Orthotropic (water shoots) shoots should be removed other than the main vertical shoots. Pruning the lower branches is required to facilitate cultivation operation like weeding, manuring, harvest, collection of fruits. Harvesting in nutmeg is a skilful operation requiring manpower and knowledge. Split fruits are immediately harvested and no fruits should be allowed to fall on the soil. By using nylon nets, fruits can be safely harvested without spoilage. The flower mace fetches premium price and therefore the mace should be removed carefully without any breakage. The mace should be shade dried to prevent volatilization and colour change and depending upon the weather conditions, it takes 5-8 days. Both nut and mace requires gentle and slow drying. The dried mace should be packed in air tight containers and kept in dark cooler places. The colour of dried and stored mace would change from red to orange, yellow and amber.

The price range is seasonal depending upon the requirement. Low temperature and low humidity will result in premature splitting. In 2012, December and January, the night temperature went to 12^{o} C and humidity went to 40% and day temperature reached 29-30^{o}C. Premature nuts and mace will not have colour and weight. During the summer, the temperature is increasing year by year due to climate change and shade management is recommended.I am currently experimenting with mechanised drying to ease the manpower and to get the quality product.In 2011-12, the price of nutmeg was Rs.550/kg and that of flower red mace was Rs.2000/kg. Why? The second largest producing country Grenada (Caribbean) witnessed the hurricane IVON in 2004 and EMILY in 2005. Now the prices are going down. Why? Extensive coverage of area comprising Pollachi, Udumalpet, Theni, Nagercoil, uptoKonkan region under nutmeg in the last few yearsis the main reason. There is a limited usage and not a common edible produce. Nutmeg goes for culinary, pharmaceutical, food processing as sauce and sausage processing. Under these circumstances my advice is to go for mixed cropping and not monocropping. Even the pericarp of nutmeg is used in preparation of food products like pickles, jam, jelly and wine.

Nutmeg prefers warm tropical humid region ranging from plains to 3500 feet for successful cultivation and the mean temperature requirement is 22^{o}-34^{o}c.

Nutmeg is a seed of a fruit, farmer friendly, sleep friendly spice.

Thirst for knowledge, travelling within the country and abroad, reading, net browsing, interacting with scientists, experienced farmers and crop specialist-Attributes of my success. Thanks.

Successful grower and experience in off season litchi cultivation and marketing in Southern India

Kuruvilla Joseph

Rose Garden Estate, Meppadi (Po),Wayanad (dt), Kerala

In India Litchi is grown in Bihar, West Bengal, Uttar Pradesh, Jharkhand, Uttarakhand states of the in our country. Many growers southern India are not aware of cultivation litchi and benefits of plantations. Mr. Kuruvilla Joseph, in his estate grows coffee, pepper and cardomum apart from litchi, mangosteen and rambutan. I inspired through the childhood education tour to North India. I started planting of litchi and found season difference in fruit, further, decided to explore the off season benefits. My success in off season litchi production inspired lot of people in Wyanad to take cultivation of litchi through best practices and reap the benefits It's having huge demand in the fruit markets in bangalore, the fruit sold at cost of Rs. 200- 250 per kg at farm gate level. In the northern states of India a litchi fruit matures in the month of May and June, contrary to this, the litchi matures in the month of November and December in my region of Waynad. Farmers with a will to work hard and an area with bright sunlight and minimum irrigation facility can explore the benefit of this off season crop. The average yield per tree is 200 to 500 kg depending upon the age of the plant. My litchi fruits sold in Bangalore, Cochin and Coimbatore. I faced the atrocities from the middle man in the business and then started own marketing channel and proper packing system. When fruit reaches directly to customer, they gave me feedback about the quality and had lot satisfaction and further got more lucrative attractive prices. I sold the litchi fruits around Rs.200-300 per kg through my outlet. The cost of production is high when comparatively Northern Indiawhen the prevent the fruit damage from the bats, birds and squirrels. I also multiply litchi plants and distributes to his planters friends and all of them are performing well. Adopt the recommended technical production technology of litchi growing such as nutrition, pest management, protection against birds /flying foxes etc. Ultimately, I passionate with litchi cultivation and use to give confidence to our growers and realised great opportunity to tap demand in market.

Feeding value of fruit residue for livestock

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Livestock farming is an integral part in providing economic, social and food security. The demand for animal products in India is on increase and to meet this demand large quantity of feed resources will be required.In India, there already a feed deficit in terms of concentrate, green fodder and dry fodder. There are limitations in increasing the fodder production and alternative option is use of non-traditional feed resources. In many Asian countries, there is a gradual shift in the cropping pattern from cereals to more remunerative fruit and horticultural crops. This results in generation of huge quantity of fruit and vegetable residues. Presently such residues are not effectively used and either composted or dumped in land fills causing environmental pollution. There is a need to develop suitable methods to convert waste to wealth and contribute to value added feed resources. Some of the potential fruit residues that can be used in feeding are summarized in this paper. In India annually about 1.74 million tonne of apple is produced and waste consists of peels, seed and pulp, which represents 25-35% of fresh apple. The apple pomace on dry matter basis consist of 4.72% crude protein and 48-60% total sugar. It is a good source of energy (75%) and can replace maize grain in ruminant ration up to 30%. The residue contains high moisture and can be dried in sunlight or at 65% moisture level can be made as silage for preservation to use as feed.

Fruit based multi tier cropping system in coffee

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Crop potential in lower palany hills of Tamilnadu

There is a 12,000 Hectares of plantation area in lower Palany hills in Dindigul District of Tamil Nadu. The plantation area starts from the height of 2800 feet to 4800 above sea level. Maximum growers of this area are Traditional Ancestral planters and the 80% of the plantation belongs to the small holdings. Totally rain fed area and around 90 rainy days with the maximum of 1400 to 1600 Mm of rainfall in a year. Very few plantations are having the irrigation system. I am very proud to introduce my-self as a planter of fourth generation in my family with the God's gift of rewards from Govt. of India and Govt. of Tamilnadu for my plantation crops like Hill Banana and Mandarin Oranges and Uthan Ratha Award from ASM Foundation in the year 2012, respectively. The success of my plantation is due to multi cropping system with different crops, viz., Coffee, Hill Banana, Mandrine, Oranges, Pepper and Avocados which do not have any Root competition among them. In my estate I maintain the plants population of all the crops in square feet basis, which helps to maintain the maximum plant population. If we have a required quantity of plant population, we are assured of the crop harvest with good income moreover, your cultivation package like weeding shade regulation are much reduced.

To make it profit

8. Very good road facilities to be organized to carry the all the inputs to the field in time.
9. Water availability in all the blocks by the motor-pipe system.
10. Being a perennial crop, the selection of seedling or seeds are very important.
11. Before the planting, Plan well for your interest of plants with regular spacing and the planting pits are in good in size and enriched with compost and biological inputs before the planting. And the soil P.H. is also balanced by adding, Dolomite to the pits. Keeping in mind that we cannot open the planting pits up to the life up the plants of 30-40 years. Make assure of enriching the planting pits before planting.
12. Planting material should be raised in our estate soil and environment with the choice of very good selected seed materials with the correct technical support.
13. Plantation is also like a business to make profit we have to invest from the beginning to the end with the very good financial plan and management. We have to choose the area as per our real financial situation which should not have any huddle in between.
14. Barbed fencing (or) solar fencing is essential to product the crop from animal damage and our safety.

My experience with plantation

After taking these preliminary planting steps, One acre of land is planted with 10 feet x 10feet spacing of hill banana of 400 numbers. In-between the banana 1200 no's of Arabica coffee seedling (7 feet x 5 feet spacing of Coffee seedling, var. Chandragiri), Grafted mandarin oranges 150 to 170 with spacing of 16 feet x 16 feet with silver oaks seedlings of 100 no's by 20 feet x 20 feet spacing and Avocado 30 numbers with spacing of 40 feet x 40 feet. So we are assuring of 1890 numbers of plant population, apart from the shade trees.

Banana

Among the four hundred bananas planted, if we have 300 trees with the crop of 5 bunches in 36 months; the income of the harvest 300 trees x 5 bunches x 8 kg/bunches is 12,000 kg x fruits Rs.50/kg. Approx Rs.6,00,000/- which including the cost of cultivation of Rs.1, 50,000 for the 36 months, so the net income of banana is Rs.4, 50,000/-per acre for three years, by these three years rest of the crop like coffee, orange, silver-oak pepper in the silver oak trees and Avocados are in the third year and are ready for yielding. Among the four hundred Banana trees planted, we have deducted 100 trees for the crop damage by bunchy-top Virus and Fungal disease sigatoka.

After the V th year

By this time the Banana is almost completed and removed from the field, and all other crops are well maintained with fertilizer, fungicide and other cultural operaions.

The cultural package of an acre

In the month of April, May 3000 kg of well compost cattle manure which is all enriched with bio-logical factors are broadcasted to the land. 3 to 4 application of N: P: K (Urea+DAP+MOP) combination 0.250gm to Coffee, same to pepper and ½ to 1kg of fertilizer to Oranges along with two systemic fungicides and one Bordeaux sprays to Coffee and Oranges. Shade regulation, weeding, handling, tonic N: P: K sprays four time in a year will be costing totally Rs.63, 000/per acre.

By this investment the following returns will be expected.

1. Coffee

Arabica parchment with two tier Coffee plants of 800kg to 900 kg of parchment x Rs.200,

Rs. 1, 60,000.00

2. Oranges

300 fruits average from a tree x 150 trees in an acre
150 trees x 300 fruits the total
45000 fruits x Rs.3/per fruit- Rs. 1, 35,000.00

3. Pepper

2 kg Average dry pepper/per tree
100 trees x 2 kg the total yield of 200 kg x Rs.700 Rs. 1, 40,000.00

4. Avacoda

Crop Contract per tree Rs.2000/per year x 40 trees, Rs. 80,000.00
(40 trees x 250 fruits 10,000 fruits x Rs.10/per fruit) ---------------------------------

Cross income Total Rs. 5, 15,000.00

Even though the Cross Income is Rs. 5, 15,000 we can't take the prevailing price to consideration because the pepper and Coffee prices are in very high now. Even though it is 50% of the expected income and rate we are very grateful to our plantation and the valuable support given by all the good hearts from the entire Department, Scientists Coffee board and the Government schemes.

Mechanization in multi-tier cropping system in Western ghats

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In recent years there has been more stress on farm mechanization which has been due lack of availability of labour. If workers are available the question has always been the timely availability of workers for farm operations, which has greatly affected the productivity of our crops. Farm mechanization has solved most of the issues within farming community, but the question is how far it's been successful in Western Ghats under multi-tier cropping and unfriendly terrain. Farm mechanization has been quite successfully done in flat lands or machinery friendly terrains, which has significant contribution towards productivity. With the present method of cultivation practice it has been very difficult to introduce machinery in our plantation and orchards. As farmers we have to design our farms to fit in machinery. In a gentle slope land it is best to plant our coffee, oranges, cardamom, bananas etc along the slopes; if it's a steep slope terracing has been a solution to farm mechanization. Idle spacing for coffee to mechanize has been 12 feet between rows and 3 feet between plants, and changes with different varieties. In terrace cultivation 12 feet terrace has provided sufficient space for machinery without loss of population, but has impact on area. The use of mini tractors has been efficient in moving around tight corners of plantations. Buying of compact sprayers mounted on tractors has been effective in spraying for different crops. The total area covered in a day has been 8 Acres with one labour compared our traditional system of 2.5 labours per acre. By using tractor mounted sprayer, there has been a savings of 70% of volume of water and 40-50% on chemical. By modifying our system we can avoid giving cocktail sprays to plants and make sure the sprays is done when needed.

The second most important problem in farms has been Irrigation and fertilizer application. Drip irrigation has been successful form of irrigating the plants and with recent developments; fertigation has shown significant improvement to the productivity of farm. Using automation system we can provide timely water and fertilizer to plant at optimum dose, and also has been labour free to minimum labour for large area.

Similarly use of tractor based weeding equipments has solved problems in weeding. The major advantage of tractor based weeding other than labour, cost and time; it has been the impact of soil erosion in terracing. By using slash weeder we can maintain the soil and field temperature, and prevent soil erosion. Multi-tier cropping has played significant role in financial stability of farm and thereby price factor not affecting our inputs to the plants. Diversification of farm can consume more labour if not mechanized and done properly; which eventually can affect your primary crop.

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Proceedings of National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits

(CHES, Chettalli, December 1-3, 2014)

Organized by

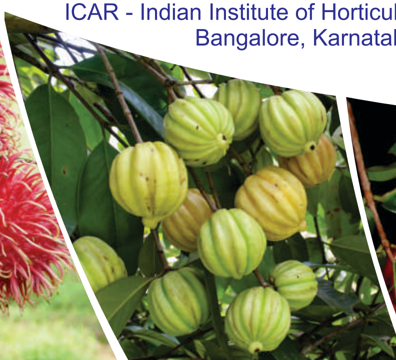
CENTRAL HORTICULTURAL EXPERIEMENT STATION (CHES)

ICAR - Indian Institute of Horticultural Research (IIHR)
Chettalli, Kodagu, Karnataka.

and

SOCIETY FOR PROMOTION OF HORTICULTURE (SPH)

ICAR - Indian Institute of Horticultural Research
Bangalore, Karnataka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ICAR - Indian Institute of Horticultural Research

Bangalore, Karnataka

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Central Horticultural Experiment Station (CHES)

Society for Promotion of Horticulture (SPH)

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Summary Proceedings

National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits was organized at Central Horticultural Experiment Station, (ICAR- IIHR), Chettalli, Kodagu, Karnataka, on 1-3rd December 2014 in collaboration with Society for Promotion of Horticulture (SPH). The seminar aims to create a platform for exchange of ideas and thoughts among the scientific fraternity, entrepreneurs, farmers, growers, students *etc*. from ICAR institutes, SAUs, KVKs and other Govt. and Non-Govt. organizations from different parts of the country who have been associated with underutilized fruits. Dr. T. Janaki Ram, Assistant Director General (Horticulture), ICAR inaugurated the National seminar. He emphasized on conservation and utilization of these less known fruits for food and nutritional security of the common people. He also expressed that a Centre of Excellence of Underutilized fruits should be started to provide momentum to the research on these crops. Dr. T. M. Rao, Director, Indian Institute of Horticultural Research(IIHR), Bengaluru described the achievements of the station for the past two years for the research and development of the underutilized fruits particularly Rambutan, Mangosteen, Avocado, Passion fruit *etc*. He emphasized for more work on production technologies of these fruits. Dr. P. C. Tripathi, Head CHES, Chettalli welcomed the dignitaries and delegates, growers *etc* During this 3 days seminar, six technical sessions on status, PGR, production, protection, utilization, marketing, value addition *etc*, were conducted. Concurrent session of poster presentations was also organized alongside the respective technical sessions. The seminar was participated by the delegates, students and farmers from twelve states and thirty institutions. More than 25 lead papers and 125 posters presentation were made during the seminar. Dr. V. A. Parathasarthy, National Coordinator for UNDP-TFT Project, Dr. S. K. Sharma, Director, CIAH, Bikaner, Dr. P. L Saroj, Director, DCR, Puttur, Dr. H. Ravisankar, Former Director, CISH, Lucknow, Dr. Vishal Nath, Director, NRC Litchi, Muzzafarpur, Dr. P. Chowdappa, Director, CPCRI, Kasaragod, Dr. Ramanath Rao, Bioversity International, Dr. N. Kumar, Former Dean (Hort), HC&RI, TNAU, Coimbatore, Dr. B.C. Uthaiah, Ex. Dean, College of Forestry, Ponnampet, Dr. B. C. Deka, Joint Director, ICAR - NEH, Barapani, Dr. G. S. Pandey, Director of Agriculture, Andaman& Nicobar, Dr M. R. Dinesh, Head, Division of Fruit Crops - IIHR, Bangalore were among the lead speakers. On the 3rd day seminar, the Scientists- Farmers-Entrepreneurs session was also organized, more than 16 progressive growers, processors and marketing experts were presented during the deliberations. More than 500 farmers from Karnataka, Tamil Nadu, Maharashtra and Kerala participated during the programme. An exhibition was also organized during this occasion which was inaugurated by Dr. T. Janaki Ram, Assistant Director General (Horticulture), ICAR on first day of the seminar. Many ICAR Institutes, Research station, KVKs, CHES, IISR, DCR, DASD, Spices board, Coffee board other research institutes displayed their achievements and technologies. A special exhibition of various underutilized fruits was also displayed under UNDP TFT Project and to three farmers who are maintaining and utilizing underutilized fruits were given certificate of appreciation. The plenary session was chaired by Dr. A. N. Ganeshmurthy, Head, Division of Soil Science and Agro Chemistry, IIHR, Bengaluru and Deputy General Manager, NABARD, Deputy Director, NHB, local representatives were expressed their views during this session. Speakers appreciated the various deliberations of the seminar and hope that all the recommendations emerging out of this seminar will be implemented in coming years.

The delegates and farmers were also taken for the field visits to various research blocks of CHES, Chettalli *viz*, Rambutan, Avocado, Litchi, Passion fruits, minor citrus fruits *etc* on 2nd and 3rd December 2014. The programme was coordinated by Dr. P. C. Tripathi, Organizing Secretary and Dr. R. Senthli Kumar, Dr. V. Sankar and Dr. G. Karunakaran were acted as Co-organizing Secretaries.

Inaugural Session

President

Dr. T. Manjunatha Rao
Director (A), IIHR, Bengaluru

Chief Guest

Dr. T. Janaki Ram
ADG (Horticulture), ICAR, New Delhi

Guests of Honour

Dr. V. A. Parthasarathy
National Project Coordinator, TFT, IIHR, Bengaluru

Dr. N. A. Prakash
Dean, College of Forestry, Ponnampet, Kodagu

Dr. C. Aswath
Principal Scientist
IIHR, Bengaluru & Vice President, SPH, Bengaluru

Organizing Secretary

Dr. P.C. Tripathi
Principal Scientist & Head CHES Chettalli

Co- organizing Secretaries

Dr. R. Senthil Kumar
Dr.V. Sankar
Dr.G. Karunakaran
CHES, ICAR-IIHR,Chettalli.

National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits (NSUF) was organized at Central Horticultural Experiment Station, (ICAR-IIHR), Chettalli, Kodagu, Karnataka, on 1-3rd December 2014 in collaboration with Society for Promotion of Horticulture (SPH), Bengaluru. The seminar aims to create a platform for exchange of ideas and thoughts among the scientific fraternity, entrepreneurs, farmers, growers, students etc. from ICAR institutes, SAUs, KVKs and other Govt. and Non - Govt. organizations from different parts of the country who have been associated with underutilized fruits. Dr. T. Janaki Ram, Assistant Director General (Horticulture), ICAR, New Delhi, inaugurated the National Seminar. He emphasized the need for conservation and utilization of these less known fruits for food and nutritional security of the common people. He also expressed that a Centre of Excellence for Underutilized fruits should be started to provide momentum to the research on these crops. Dr. T. Manjunatha Rao, Director (A), Indian Institute of Horticultural Research, Bengaluru described the achievements of the CHES, Chettalli in the recent years for the research and development of the underutilized fruits particularly Rambutan, Mangosteen, Avocado, Passion fruit *etc*. He emphasized for more work should be initiated on production technologies of these fruits. Dr. V. A. Parathasarthy, National Co-coordinator for UNDP-TFT Project emphasized the role of Underutilized fruits and tree spices in the livelihood security of rural and tribal people. He stressed the need for on farm conservation of the indigenous underutilized fruits and tree spices. Dr. N. A. Prakash, Dean, College of Forestry, Ponnampet also spoke in the National Seminar. Dr. C. Aswath, Principal Scientist, IIHR, Bengaluru & Vice President, Society for Promotion of Horticulture (SPH), Bengaluru described about the Society of Promotion of Horticulture, its activities, objectives and also proposed vote of thanks for the inaugural session. Earlier, Dr. P. C. Tripathi, Head CHES, Chettalli welcomed the dignitaries and delegates, growers and described about genesis, programmes, aims and objectives of the seminar. The souvenir and abstract and CD of the seminar and nine technical bulletins on underutilized fruits compiled by CHES Chettalli were also released. On this occasion an exhibition displaying the biodiversity of underutilized fruits and technologies developed by various organizations was also organized which was inaugurated by Dr. T. Janaki Ram, Assistant Director General (Horticulture), ICAR, New Delhi. More than 1500 people including scientists, Govt. officials, students, farmers, entrepreneurs, industry peoples were attended the programmes during three days.

Session- I

Status of underutilized fruits and tree spices with special emphasis on

Western Ghats

Chairman

Dr.V. A. Parthasarathy
National Project Coordinator, TFT, IIHR, Bengaluru

Co-Chairman

Dr. M. R. Dinesh
Head, Division of Fruit Crops, IIHR,Bengaluru

Rapporteurs

Dr.T. Sakthivel
Principal Scientist, Division of Fruit Crops, IIHR, Bengaluru

Dr. Najeeb Naduthodi

Scientist, PC Unit, IIHR, Bengaluru

Three theme papers were presented in this session. The session started with the presentation of Dr. V. A. Parthasarathy, National Project Coordinator, TFT, IIHR, Bengaluru. He mainly presented about the various aspects of tree spices, *viz*. Nutmeg, Cinnamon and *Garcinia*. He highlighted the progress made in spice crops in the area of registration of varieties as well as farmers varieties, compared to other horticultural crops cultivated in the country. He also highlighted the importance of patenting in these spices. He mentioned that farmers are the systematic breeders of the most of the spice varieties which we are using now are selected and developed through many generations.

The second presentation was made by Dr. B.C. Uthaiah, Former Dean, College of Forestry, Ponnampet, Kodagu on "Underutilized fruits of Western Ghats". He presented about fifty species of edible fruits available in the region. These are either indigenous to Western Ghats or introduced and acclimatized in the region. He stressed about systematics its descriptions including fruit qualities, season of fruiting and stage of harvest for consumption of these underutilized fruits. He highlighted that some of the species were potential crops for the future such as *Carissa gangetica,* edible fruits as well as Kernels in *Elaeocarpu tuberculatus etc*. Some of the fruits are rich in nutritive components like mannitols, hydroxy salicylic acid, alkaloids and flavonoids. Some of the fruits were used as spice as well as souring agents in curries traditionally. He also mentioned that some of the underutilized fruits have huge tree size *e.g. Chrysophyllum roxburghii*, thorniness (*Flacourtia indica*), higher bird damage (*Canthium dicoccum*) which make them difficult for harvest. Dr. Dinesh, Co-chairman of the session stated that these fruit crops are components of future ecosystem.

The third presentation in the session was made by Dr. K.V. Saji, Principal Scientist, IISR, Calicut on "Tree Spices of Western Ghats". He focused on tree spices like Nutmeg, Cinnamon, *Garcinia* and Tamarind. Large number of wild species of tree spices is available in the Western Ghats. He also added that the Western Ghats is considered as secondary centre of origin for Cinnamon with origin of around 15 related species.

He mentioned about species of *Cinnamum* and *Garcinia* occurring in the country. Presenter also mentioned about various tree spices of commercial importance. He mentioned about the germplasm repository made at IISR, Calicut for these tree spices. He also highlighted the importance of the spices in curing human diseases.

Recommendation:

1. An inventory of wild fruits and tree spices available/ originated in these regions should be prepared and efforts should be made for their conservation and utilization.

Session - II

Genetic resources, diversity, conservation and utilization of underutilized fruits

Chairman

Dr. S. K. Sharma
Director, CIAH, Bikaner, Rajasthan

Co-Chairman

Dr. N. Kumar
Professor (Hort.) & Former Dean (HC & RI), TNAU, Coimbatore

Rapporteurs

Dr. C. Vasugi
Senior Scientist (Hort.), IIHR, Bengaluru

Dr. M. Jagadeesan

Plant Breeder, Coffee Research Sub Station, Chettalli

Seven lead presentations and 24 posters were presented in this session. The session started with the presentation by Dr. M.R. Dinesh, Head, Division of Fruit Crops, IIHR, Bengaluru on TFT Project objectives and achievements. He presented on conservation of local seedling mango varieties at Chittoor, Andhra Pradesh State. It was also stressed upon the documentation of the custodians of genetic diversity. Diversity fairs were organized to identify the local indigenous types. In the discussion questions were raised on how this model can be successfully applied for underutilized fruits. It was replied that by creating awareness and motivating the farmers to conserve on farm the genetic wealth available with them. A question was raised on the difficulty faced by farmers for marketing of indigenous varieties. It was suggested to set up highway stalls for marketing of indigenous varieties as one of the approach.

The second presentation was on "On farm conservation and utilization of underutilized fruits and tree spices" by Dr. Ramanatha Rao, Research Fellow, Bioversity International. He emphasized that In *situ* / on farm conservation of indigenous fruit and tree spices depends on various criteria *viz.*, importance of the crop, market potential, risk levels, cultural identity and importance for food and nutrition security *etc*. The role of *in situ* / on farm conservation which helps in conservation of agro bio diversity was also discussed. The requirements for establishing on farm conservation were also highlighted. In the discussion questions were raised on the critical input for successful implementation of project. It was replied that the project should be of dynamic nature and with novel approaches involving farmer's participation.

The third presentation was on "Status of underutilized fruits in North Eastern States" by Dr. B. C. Deka**,** ICAR Regional Complex for NEH region, Meghalaya. He presented diversity of underutilized fruit crops in North Eastern hill region of India. In addition, the nutritional and biochemical properties of these fruits were also presented. The production technology for *Prunus nepalensis* (Sohing) and *Eleagnus latifolia* (Sohshang) has been standardized at the institute and the protocols for preparation of various value added products were also highlighted.

Dr. S. K. Sharma, Director, CIAH, Bikaner made presentation on “Genetic resources of underutilized fruits of arid region”. He briefed about the genetic wealth of arid zone fruit crops especially hot arid (Rajasthan, Gujarat, Punjab, Haryana, Peninsular India) and cold arid region (Himachal Pradesh, Jammu & Kashmir). The strength, opportunities and threads of arid eco-system was also highlighted. It was pointed out that CIAH, Bikaner is one of the National Active Germplasm conservation site for 14 arid zone fruit crops which conserves 456 accessions of arid crops. Importance was given for development of drought tolerant / resistant lines to withstand adverse abiotic stress conditions. In view of the limited scope for area expansion under the fruit crops in tropical and sub_tropical parts of the country the Conservation of genetic resources of arid fruit crops is very much essential for future crop improvement programme is neglected and marginal lands.

The fifth presentation was made on “Genetic resources of underutilized fruits of tropical region” by Dr. N. Kumar, Prof. (Hort.) & Former Dean (HC & RI) TNAU, Coimbatore. He presented the genetic wealth of Underutilized fruit crops like Wood Apple, Jamun, Jackfruit , Bread fruit, Ainipala, Mangosteen, Durian, Malayan Apple, Wax Jambu, Rose apple, Surinam cherry, Bilimbi, Carambola, Cherimoya, Atemoya, Sour sop, Sweet tamarind, Karonda, *Pithecollobium*, Kokum, Moottu, Minor Citrus fruits, Egg fruit, Pepino, Lovi-lovi, West Indian cherry including the research work on collection and evaluation of these fruits.

The sixth presentation was on “Role of biotechnological means for genetic resource utilization of underutilized fruits” by Dr. C. Aswath, IIHR, Bengaluru. He presented the role of bio technological means in underutilized fruits on tissue culture, transgenics and molecular markers. Under tissue culture the production of haploid plants embryogenesis embryo rescue and *in vitro* fertilization cell suspension culture, somatic embryogenesis use of cryopreservation were highlighted. Also, the production of *in vitro* plant regeneration using immature cotyledon as explants in Macadamia nut indirect organogenesis in *Garcinia*, embryo rescue in Avocado, somatic embryogenesis in Litchi were briefed. The use of bio-reactors for large scale production of the plants as viable tool was emphasized. He also expressed that whole genome sequencing of underutilized fruit crops will help in enhancing the ability to improve these crops. The use of marker assisted selections in underutilized fruit crops was also discussed.

The seventh presentation was made on "Status and prospects of underutilized fruits in Goa" by Dr. S. Priya Devi, Sr. Scientist, ICAR Research complex, Goa. She presented the enormous genetic wealth of underutilized fruit crops in Goa. The research attempts taken up on selection and post harvest management of these fruits were briefed. Survey, identification and selection in Kokum, Jackfruit, Jamun, Jagomas done at the institute was also briefed. The scope of other fruits like Rose Apple, Carambola, Bilimbi, Bread fruit, Adams fruits *etc* were also explained and the technologies standardized for storage and value addition of minor fruits in Goa was also highlighted.

Recommendations:

1. To create awareness programmes to conserve the existing variability of underutilized fruits in-*situ*/on farm.

2. Database development on underutilized fruits needs to be taken up and should be made available to the researchers for further utilization.

3. Efforts are to be made to evaluate and document the active principle, nutritional and neutracetical values of underutilized fruits so as to popularize the consumption of underutilized fruits among youth.

4. Introduction of new crop species under varied agro-ecological regions may be taken up for its performance keeping in view of the biotic stress factors.

5. A network project on Jack and Jamun may be initiated to exploit the enormous diversity exist in these crops, for further improvement and utilization.

6. As the existing genetic variability available in the introduced exotic fruits are very limited, efforts are to be made to introduce to the promising commercial varieties for widening the genetic base.

Session - III

Production technology and cropping systems of major underutilized fruits and tree spices

Chairman

Dr. H. Ravishankar
Ex. Director, CISH, Lucknow & Principal Scientist, IIHR, Bengaluru

Co-Chairman

Dr. B.N.S. Murthy
Principal Scientist, Division of Fruit crops, IIHR, Bengaluru

Rapporteurs

Dr. Anuradha Sane
Principal Scientist, Division of PGR, IIHR, Bengaluru

Dr. Rudra Gowda
Agronomist, CRSS, Coffee Board Chettalli, Madikeri.

In this session, there were nine lead talks, one oral presentation and 20 poster presentations were made.

First presentation was made by Dr. H. Ravishankar, Former Director, CISH, Lucknow and Principal Scientist, IIHR, Bengaluru on Rambutan and prospects of its genetic improvement. He emphased on need to develop compact ideotypes with off- season bearing, bolder fruits, more aril content and smaller seed size, freestone with good shelf life in Rambutan. Since Southeast Asian countries have reasonably good varietal diversity with some of the desirable traits, there is need to introduce trait- specific varieties for enlarging the genetic base for crop improvement. Identification of rootstock(s) and High Density Planting (HDP) systems is crucial. Rambutan species / allied genera should be exploited for rootstock purpose. Modern biotechnological tools need to be exploited for molecular characterization of germplasm, identification of genes governing traits, marker assisted selection to develop trait specific varieties to meet aspirations of the stakeholders The second presentation on "Advances in production technology of Ber and Karonda" was made by Dr.P. L. Saroj, Director, Directorate of Cashew Research, Puttur, He described various recent production technology of Ber and Karonda including micro site improvement and plant geometry such as hedge row and square system of planting for orchard management practices and standardize suitable cropping system.

Dr. Vishal Nath, Director, NRC for Litchi, Muzaffarpur presented "Potential of off season litchi cultivation in humid tropical zones of Western Ghats". He narrated that Litchi can be successfully cultivated in South India, as it can bear fruits in the months of January-March, which is off season in the traditional Litchi growing areas, where inconsistent flowering, low fruit set in addition to attack by bats and birds are the major problems to solve. Higher altitudes of Karnataka, Tamil Nadu and Kerala have ideal conditions for commercial cultivation of this crop. He emphasized the need to encourage exclusive research work on Litchi non-traditional areas in South India.

Dr. V. S. Korikanthimath, Former Director, ICAR Research Complex, Goa, made an elaborative presentation on "Fruit crops based cropping systems in Western Ghats of India". Different combinations of underutilized fruit crops as component crops in different cropping systems is Western Ghats region were presented in detail. Kokum cultivation in Western Ghats, its processed products and value addition were also described.

Dr. Prakash Patil, Project Coordinator (Fruits), ICAR-IIHR, Bengaluru presented on "Advances in Jackfruit production technology". He presented detail of the various production and protection technologies of Jackfruits developed in the country. He emphasized that although the importance of Jackfruit has been well recognized; very little research work has been done on this crop and still remains underutilized. Standardization of technologies for propagation, production, post-harvest handling, processing of products and their marketing are still lacking for this crop. Systematic experimentation is needed to develop optimum agronomic packages for Jackfruit in different agro-ecological areas.

Recent advances in cultivation of passion fruit in India were presented by Dr. V. V. Sulladmath, Principal Scientist, Division of Fruit Crops, IIHR, Bengaluru. He gave the detail of the "Production technologies of passion fruit". He told micro propagation for increasing quality planting material production, control measures for nematodes, *Fusarium* wilt complex developing new rootstocks and value addition need to be given priority.

Dr. M. Ananthan, Professor, Agricultural College and Research Institute, (TNAU) Madurai, Tamil Nadu presented paper on "Improved cultivation techniques in Avocado". He presented the details of various varieties and improved production technologies of avocado available India.

Dr. P. Sampath Kumar, Principal Scientist, Division of Fruit Crops, IIHR , Bengaluru presented, "Production technologies of *Annona* species". The emphasized the importance of pollination in Annona particularly in cv. Arka Sahan to get higher productivity.

D. B. Krishnamoorthy, Former Head, Division of Crop production, Indian Institute of Spices Research (IISR), Calicut, Kerala, gave detail of production technologies for seventeen tree spices. The commercially important tree spices are Nutmeg, Clove, Cinnamon, Cassia, Allspice, Cambogia, Kokam, Tamarind, Curry leaf and Pomegranate *etc* grown in India. The commercial products of these crops are whole spice, ground spice, spice oil, oleoresin *etc* and find applications in flavouring food, pharmaceutical, perfumery and cosmetic industries. The areas under these crops are very meager and hence, there is a lot of scope for expanding the area under traditional and non-traditional areas thereby increasing the production.

Varieties and quality planting material production of important underutilized fruits was presented by Dr. Sunny George, Home Grown Nursery and Farms, Kanjirapally, Kerala gave the details of the exotic and improved varieties of Rambutan, Durian, Avocado, Pulasan, Mangosteen, special varieties of Jack Fruits and indigenous Mango varieties *etc* maintained and multiplied by them.

Recommendations:

1. Many of these underutilized fruits are exotic and introduced from abroad, the production technology for cultivation as of now is not available and as these are '*crops in waiting'*. There is need to develop the same for the potential crops under the respective agro-ecologies.

2. There is a need to encourage exclusive work on Litchi by AICRP Centres in suitable non-traditional areas in South India.

3. There is need for production of good quality planting materials of these crops and establish model farms or adopt Govt./Private agencies for demonstration. Mass multiplication of planting material needs to be taken up.

4. The growers should be made aware of crop diversification with underutilized fruits for health benefits and profitability. Focus is needed on developing quality planting materials, water and nutrient management and sustainable cropping system, since land is a constraint.

Session - IV

Biotic stress – Current scenario and management strategies

Chairman

Dr. P. Chowdappa
Director, ICAR – CPCRI, Kasargod, Kerala

Co-Chairman

Dr. A. K. Chakravarthy
Head, Division of Entomology and Nematology, ICAR IIHR, Bengaluru

Rapporteurs

Dr. K. G. Pillai
Principal Scientist, Division of Entomology and Nematology, ICAR - IIHR, Bengaluru

Dr. C. N. Biju
Senior Scientist, ICAR – IISR RS, Appangala, Madikeri, Karnataka

Over all, in this session there were 21 abstracts, 3 invited papers, 2 oral presentations and 5 poster papers were presented.

Dr. P. Chowdappa, Director CPCRI, Kasargod, presented the "Status of diseases in underutilized fruits". He gave a detail of various diseases and their control measures in underutilized fruits. He stressed on bio- security issues and procedures associated with introduction of planting materials of several fruit crops. He gave the introduction and spread of *Phytophthora infestans* and incidence of late blight of tomato in India. He emphasized to follow strict bio security measures while importing the planting material from abroad.

Dr. P. Mandal, Senior Scientist, CHES, Bhubaneshwar, presented "Status of insect pest of underutilized fruits". He gave the details of major pests of underutilized fruits in the Eastern and Northern part of India. Further he told that there are no major insect-pest in underutilized fruits but there is possibility that many pests may be major pests, once the area under these crops increases, therefore precautions should be taken for effective control of these pests.

The presentation on "Pest and disease management in tree spices" was made by Dr. R. Suseela Bhai, Principal Scientist, ICAR-IISR, Calicut, Kerala. She elaborated the details pest and disease of important tree spices, economic losses and effective management practices for control.

Recommendations:

1. Bio security issues and procedures associated with introduction of planting materials of underutilized fruits should be followed strictly to minimize the chance of introduction of new diseases and pests.

2. Nursery system should be made foolproof in the supply of disease and pest free planting materials to the farmers.

3. Host plant resistance, bio control, cultural and

mechanical methods should form main theme for pest management in underutilized fruit crops.

4. Developing database for the key pests of underutilized fruits is need of the hour.

Session - V

Post harvest management and value addition

Chairman

Dr. P.L. Saroj
Director, Directorate of Cashew Research, Puttur, Karnataka

Co-Chairman

Dr. Prakash Patil
Project Coordinator, AICRP Tropical Fruits, IIHR, Bengaluru

Rapporteurs

Dr. R.B Tiwari
Principal Scientist, PHT, ICAR- IIHR, Bengaluru

Dr. Sharon Aravind
Scientist, ICAR – IISR RS, Appangala, Madikeri,

The session had 7 invited papers, 3 oral presentations and 13 poster presentations were made.

First presentation was on post harvest management and value addition in underutilized fruits presented by Dr. Shamina Aziz, IIHR, Bengaluru. She gave a detailed account about the nutritional significance and various value added products that can be made from underutilized fruits including some of the products made at IIHR from Aonla and Avocado.

Development of value added products from non conventional fruits and vegetables grown in different parts of

India was presented by Dr. O. P. Chauhan, DFRL, Mysore. He presented in detail about value added products being developed using low cost technology in various fruits such as carambola (Hurdel Technology product, Jam, RTS, Osmo dried products), Bread fruit (Deep fat fried products, Minimally proceed products, dehydrated products,), Palmyra (Hurdel Technology product, Jam, RTS, Osmo dried products, Minimally processed products), Elephant apple, *Gethi,* ghingharu, Noni, *Colocasi*a *etc.,* grown in different parts of country.

Dr. Mahava Naidu, CFTRI, Mysore highlighted the various research work being done from Cashew apple and Kokum.

Dr. B. B. Borse, CFTRI, Mysore highlighted about the need for understanding about the flavour and nutritional profile of underutilized fruits.

Dr. Naburn Bhattacharya, C-DAC, Kolkata presented about the work being done by agri division such as *e-nose*, *e-tongue* and *electronic* vision technology for application in various activities in agriculture sector. He also emphasized the need for additional requirement of tools to be developed.

Dr. R.B. Tiwari, Principal Scientist, PHT Division, IIHR highlighted the various research works being done on dehydration and osmotic dehydration of underutilized fruits such as a Aonla, Jack fruit, Karonda, Malayan apple. There is great prospect for use of Kokum juice for developing dried products from above fruits through infusion. These simple technologies are very suitable to be adopted in rural areas.

Dr. K. Shiby Verghese, DFRL, Mysore presented the value added technology for making spray dried powder and lassi powder, dry ice cream powder from avocado.

Dr. S. Priya Devi, Senior Scientist, ICAR Research Complex, Goa stated that Wax apple and Rose apple can be utilized for making jam.

Recommendations:

1. Post harvest technologies of most of the underutilized fruits need to be developed. The traditional product made by the local people needs to be evaluated and popularized.

2. The biochemical and nutraceutical values of underutilized fruits crops need to be analyzed and documented.

Session - VI

Farmers – Scientists – Entrepreneurs Interaction

Chairman

Sri. N. Bose Mandanna
Former Vice-Chairman, Coffee Board, Sunticoppa

Co-Chairman

Dr. Stephan Samuel
Deputy Director (Research), CRSS, Coffee Board, Chettalli

Rapporteurs

Dr. S. J. Ankegowda
Principal Scientist & Head, IISR RS, Appangla, Madikeri

Mr. M. Prabhakar
Subject Matter Specialist (Hort.), IIHR-KVK, Gonikoppal

The farmers, entrepreneurs and scientists were shared the experiences of production, protection, value addition and marketing of different underutilized fruit crops in this session.

Dr. S. Ganesh, Principal Scientist & Head, Plant Genetic Resource, IIHR, Bengaluru made a presentation on Genetic resource management of underutilized fruits of Western Ghats. He gave the detail account of useful plants of Western Ghats region.

Sri. Somasundaran, Progressive Farmer, Pollachi, Coimbatore, Tamil Nadu shared his 30 years experience of his success of nut mug cultivation grown under coconut plantation. The selection of planting material (grafts/ budded plants), elevation, spacing, shade, pruning, nutrition (soil/foliar), irrigation, right stage of harvesting, post harvest handling play a pivotal role in augmenting the quality and income of the farmer. It prefers high humidity and moderate rainfall and filtered shade for successful cultivation.

Sri. Jose Jacob, Proprietor, Home grown nursery, Kerala shared his experience of collection, establishment, evaluation and planting material, production of Rambutan, Mangosteen, Durian and other minor fruit crops in his orchard cum nursery *etc*. The promising line of Rambutan, Mangosteen and Durian were identified, assessed and production of planting material and its distribution is taking place in the southern part of India. These fruit crops need complete or partial sunlight for better performance. The ideal spacing is 30x30 ft or more in Kerala conditions, its requirement with respect to varieties, situations and marketability in Kodagu need to be assessed.

Sri. Regis Gustave, Progressive Planter, Lower Pulney Hill, Tamil Nadu emphasized the need for mechanization in coffee and other fruit crops for alienating the problem of low yield, high and non availability of labourers. Mono cropping is ideal for mechanization and ensures higher production and productivity, for adoption this practice, proper lay outing (leveling, terracing) and planting (paired row system, contour) method should be adopted. Also he shared his experience of coffee based cropping system (coffee, banana, orange) and its management with high tech irrigation and plant protection tools through mechanization.

Sri. C. F. Jacob, Progressive grower, Belthangadi, spoke about the hurdles in growing underutilized fruit crops (Rambutan, Mangosteen, and Durian) as there is no technologies with respect to pruning, spraying of hormones for avoiding immature fruit dropping, thinning of fruits, pre and post harvest practices.

Dr. N. K. S Gowda, Principal Scientist, NIANP, Bengaluru narrated the utility of fruit residues as animal feed, which are rich in nutrition, increase the palatability and avoid environmental hazard after thorough removal of moisture, studying pH and its sugar content for better palatability and shelf life. The bulk quantity of fruit waste of fruit industries in Pineapple, Banana, Musk melon, Apple Mango, Jack fruit, vegetable can be scientifically standardized to produce total mixed ration as animal feed and its knowledge percolating among the animal husbandry farmers to ensure increase in the milk yield in dairy animals.

Mr. Sebastian, People's Service Society, Palakkad Pastoral Centre, Pallipuram, Palakkad, Kerala presented his successful experience of co operative effort for popularization of Jack fruit and its products with the able support of NABARD at rural area by proper packing, branding and marketing of jack products.

Mr. Ahmad Kutti, Mangosteen grower, Kerala shared his 40 years of experience of growing 300 trees of Mangosteen and 4 acres of Litchi garden and just planted Rambutan in his orchard to the august body.

Sri. Shivakumar, Farmer, Madikeri, Kodagu, Karnataka shared his experience of collection, conservation and documentation of more than 60 different wild and edible underutilized fruit crops in Kodagu.

Mr. Kuruvilla Joseph, Grower, Kerala shared experience of marketing of Litchi. He added that there is a wide scope of growing litchi in southern part of india as the fruits come to harvest in the month of November and December (Off season) and it fetches good prices in the market. Also, he suggested to take up precautionary measure for fungal infection during fruit setting and fruit borer infestation during marble stage, fruit colour development stage and alternate bearing can be avoided by proper pruning and irrigation practices. Proper netting of tree is compulsory to overcome the problem of birds and bats menace during ripening stage. Mangosteen can be taken up in Kodagu as a mono crop in the paddy fallows as the fruits come to harvest during June-July till November (off season).

Mr. Madhusudan, Managing Director, Vishal Organic Foods Ltd, Bangalore bring to the notice of companies contract farming based various crop production, its value addition and its marketing. He also expressed an opportunity to enter to the crop – Avocado collection and its value addition, which are naturally grown in coffee orchard in Kodagu district. Company has been started for survey of the population of the trees and quantity of the fruits availability to establish a chain of procurement and processing as a freeze food product.

Mr. Rathu Beliappa, Planter, Hakatuur, Kodagu shared his experience of naturally grown kachampuli trees in his estate and its processing, packing, branding and marketing. He collects fruits from his garden and as well as from others during the season and processes with the low cost machine for extraction of juice and further concentration at homestead level as per the standard set by CFTRI, Mysore.

Mr. Abhilash, Secretary, Avocado Growers Association, Nashik, Maharashtra expressed the potential of avocado fruits value addition and its marketing in India and abroad as it is rich in carbohydrates, fat, nutritional and financial security for the farmers.

Dr. Laxmi Raj, Managing Director, HOPCOMS, Department of Horticulture, Bengaluru spoken on the importance of growing fruits with a high state of mind for better health and wealth security of the people.

Mr. K.V. Mathai, Kottayam shared his experience of Passion fruit pulp marketing to the august body.

Dr. Dal Singh, Deputy Director, NHB, Bengaluru spoke on the role of NHB in promotion of horticultural crops and the various schemes to the growers for production, processing and mechanization of horticultural crops to get maximum productivity per unit area per unit time

Recommendations:

1. Commercial production technologies for underutilized fruit crops is lacking and it need to be developed and demonstrated.

2. Data base on these crops need to be developed.

3. Marketing knowledge and other facility required to be established

Plenary Session – VII

Panel discussion and formulation of action plan

Chairman

Dr. A. N. Ganeshamurthy
Head, Div. of Soil Science and Agric. Chemistry ICAR-IIHR, Bengaluru

Co Chairman

Dr.Vishal Nath
Director, ICAR- NRC Litchi, Muzaffarpur,Bihar.

Dr. P.C.Tripathi
Principal Scientist and Head, CHES, Chettalli

Guests of Honor

Mr. Anand Kasif
DGM, NABARD, Bengaluru

Mr. Dhal Singh
Deputy Director, NHB, Bengaluru

Dr. M. N. Venugopal
Former Head, ICAR- IISR- RS, Appangala, Kodagu

Mr. A. A. Chengappa

ASFK, Kodagu

Mr. Amirtha Raj

Tata Coffee Limited, Polibetta, Kodagu

Mr. B. D. Manjunath
Progressive Planter, Somwarpet, Kodagu

Mr. Mani Uthhappa
Progressive Planter, Somwarpet, Kodagu

Rapporteurs

Dr. R. Senthil Kumar
Principal Scientist, CHES, Chettalli, Kodagu

Dr. V. Sankar
Senior Scientist, CHES, Chettalli, Kodagu

Dr. G. Karunakaran
Senior Scientist, CHES, Hirehalli, Tumkur

The Plenary session of National Seminar on 'Strategies for Conservation, Improvement and Utilization of Underutilized Fruits' was held in the afternoon of December 3rd, 2014. This session was chaired by Dr. A. N. Ganeshmurthy, Head, Division of Soil Science and Agri. Chemistry, IIHR, Bengaluru and representative of Director IIHR Bengaluru. The other dignitaries present on the dais were Mr. Anand Kasif, DGM, NABARD, Bengaluru, Mr. Dhal Singh, Dy. Director, NHM, Bengaluru, Dr. Vishal Nath, Director, NRC for Litchi, Dr. Amritha Raj, Manager (Research) Tata Coffee Limited, Polibetta, Kodagu Dr. M. N. Venugopal, Ex-Head IISR, Appangala, Shri B. D. Manjunath, Chairman, District Co-operative Bank, Kodagu, Shri Mani Uthappa, Chairman Agri. Committee Zilla Panchayat, Kodagu and Shri K.G. Chengappa, President, Agri. Scientist Forum of Kodagu.

Dr. A. N. Ganeshmurthy, Chairman highlighted the salient features of the seminar and hope that the underutilized fruits will be a part of the crop diversification of this region.

Dr. Vishal Nath, Director ICAR- NRC Litchi, Muzaffarpur, Bihar emphasized that this area has large potential for off season litchi cultivation and the farmers should come up for cultivation of litchi for crop diversification and income generation.

Mr. Anand Kasif, DGM, NABARD, Bengaluru described various promotion schemes of NABARD and told almost Rs 5000 crores is earmarked for the horticulture during XII plan.

Mr. Dhal Singh Deputy Director, NHB, Bengaluru explained various promotional schemes of National Horticultural Board (NHB) and he told that NHB is giving subsidy on establishment of nursery, construction of polyhouse, drip irrigation and protected cultivation *etc.* to the farmers to increase the production and productivity of Horticulture crops.

Mr. Amrith Raj, Manager (Research), Tata Coffee Limited, Polibetta, Kodagu told that this seminar will be useful for the coffee growers of the entire Western Ghats for crop diversification.

Mr. B. D. Manjunath, President, District Cooperative Bank, Kodagu congratulated the achievements of station and scientists for organizing such large programme on underutilized fruits. He told that the people should take the benefit of the work done on these fruits at the station.

Mr. Mani Uthappa, Chairman Agri. Committee Zilla Panchayat, Kodagu told that the station should focus more on the smaller farmers so that they can get the benefit of the work done on these at the station.

Dr. M. N. Venugopal, Former Head, ICAR- IISR- RS Appangala, Kodagu congratulated the scientists and the staff of the station for the organizing seminar at CHES, Chettalli and pointed out that these underutilized fruits will be certainly helpful in income generation of the local farmers/planters.

In this session, three progressive farmers were felicitated with **CUSTODIAN FARMER'S AWARD** which was sponsored by UNDP-TFT Project, IIHR, Bengaluru. Further a total of 12 posters from all sessions were adjusted/ awarded as **BEST POSTER** to encourage researchers/students.

The session ended with wrap up vote of thanks delivered by Dr. R. Senthil Kumar, Principal Scientist, CHES, Chettalli.

The National Seminar was Co - ordinated by Dr. P. C. Tripathi, Organizing Secretary & Head, CHES, Chettalli and Dr.R. Senthil Kumar, Principal Scientist, CHES, Chettalli, Dr. V.Sankar, Senior Scientist, CHES, Chettalli and Dr. G. Karunakaran, Senior Scientist, CHES, Hirehallii, Tumkur were acted as Co-organizing Secretaries.

Final Recommendations:

1. To create awareness programmes to conserve the existing variability of underutilized fruits in situ/ on farm.

2. Database development on Underutilized fruit crops needs to be taken up and should be made available to the researchers for further utilization.

3. A network project on these crops may initiated to

exploit the enormous diversity existing in these crops, for further improvement and utilization.

4. As the existing genetic variability available in the introduced exotic fruits are very meager, efforts are to be made to introduce the promising commercial varieties from South Asian countries for widening the genetic base.

5. Many of these underutilized fruits are exotic and introduced from abroad, production technology for cultivation as of now is not available and as these are crops in waiting there is need to develop the same for the potential crops under the respective agro-ecological zones.

6. Need for production of good quality planting materials of these crops and to establish model farms or adopt Govt. and private agencies for demonstration. Mass multiplication of planting material needs to be taken up. Work on bio reactors for mass multiplication of planting material may be taken up for easy and efficient production within a short span of time.

7. Developing database for the key pests and diseases of underutilized fruits is need of the hour. Nursery system should be made foolproof in the supply of disease and pest free planting materials to the farmers. Host plant resistance, bio control, cultural and mechanical methods should form main plank for pest management in underutilized fruit crops.

NSUF - Lighting of Lamp by Dr. T. Janaki Ram, ADG, ICAR, New Delhi

Welcome Address by Dr. P. C. Tripathi, Head, CHES, Chettalli

Inaugural Address by Dr. V. A. Parthasarathy, Former Director, IISR and National Co-ordinator for UNDP-TFT Project

Inaugural Address by Dr. T. Manjunatha Rao, Director (A), IIHR, Bangalore

Release of Publications

National Seminar Participants

National Seminar Exhibition

‘Lead Presentation by Dr. S. K. Sharma, Director, CIAH, Bikaner, Rajasthan

Lead Presentation by Dr. Prem Nath, Director, NRC Litchi, Muzzafarpur, Bihar

Lead Presentation by Dr. Dal Singh, Deputy Director, NHB, Bengaluru

Lead Presentation on Tree spices by Dr. P. Krishnamurthy, Ex. Head, IISR, Calicut

Poster Session

Plenary Session

Custodian Farmer's Award

Cultural Programme

Newspaper Coverage

Curtain's Comes Down on Seminar at CHES

C R Shivakumar of Madikeri, Vasanthi Ponnappa of Sunticoppa and Edward Rebello of Moodabidri were felicitated by incharge director of Horticulture Research Station Bengaluru, Ganesh Murthy at a Seminar organised in Chettalli recently. The trio were recognised as successful intensive cultivators of fruits in Kodagu.

The programme organised at Central Horticultural Experiment Station (CHES) was co-sponsored by the Indian Institute of Horticultural Research and Society for Promotion of Horticulture.

Over 300 scientists from various parts of the country interacted with the farmers. Murthy said the weather in Kodagu is ideal to grow fruits. By using modern methods of technology, farmers should grow fruits and takeup the cultivation in more areas, he said.

Deputy General Manager of NABARD, Bengaluru, Anand Khasif said the Central Government has allocated Rs. 5000 crore in the budget to develop horticultural crops and its marketing.

Uttar Pradesh-based scientist Vishwanath spoke about Litchi cultivation. The weather in Kodagu is congenial to grow Litchi and other fruits, he said. Scientist from Tata Coffee Amurthraj, Kodagu District Central Cooperative Bank President B D Manjunath, ZP member B Mani Uthappa and head of the Chettalli centre P C Tripathi were present.

-CLN News Desk.

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I.M. 12 Dec 2014

Seminar at CHES

Coffee Land News : 1/12 05-12-2014

Central Horticulture Research Institute ADG (horticulture) Dr T Janaki Ram speaking, after inaugurating a seminar on cultivation of fruits and its conservation organised by the Indian Institute of Horticultural Research and Horticulture Society, he said that there will be good demand for fruits in the future. Research is being carried out on Passion fruit, Dragon fruits.

Central Horticultural Experimentation Station (CHES) Chettalli has been carrying experiments on variety of fruits for the last 15 years. Kodagu district has conducive atmosphere for cultivating fruits. Indian Institute of Horticultural Research (Bangalore) Director Dr T Manjunath Rao said that fruits grown in forest has medicinal values.

National Horticulture Research Institute Project Coordinator Dr V A Parthasarathi said that along with the cultivation of vegetables and spices, farmers can cultivate fruits to supplement the income. N A Prakash of Ponnampet Forestry College said that there is a need to encourage cultivation of fruits and vegetables. Fruits are grown only on 50,000 hectare land in the country. There is ample of opportunities to grow fruits in coastal belt, hilly regions and dry interior places.

-CLN News Desk.

M* Friday, December 5, 2014

Deccan Herald

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At a glance

ACHIEVERS: 'Best farmer' award being conferred on (from left) progressive farmers C R Shivakumar of Madikeri, Edward Rebello of Moodabidri and Vasanthi Ponnappa of Suntikoppa during the valedictory of national-level seminar on cultivation, at Horticulture Research Centre near Chettalli near Madikeri on Thursday. DH PHOTO

ICAR ADG (horticulture) T Janaki Ram, Indian Institute of Horticultural Research (Bangalore) Director Dr T Manjunath Rao, National Horticulture Research Institute Project Coordinator Dr V A Parthasarathi and others look at fruits exhibited at Chettalli near Madikeri on Monday. DH PHOTO

'Explore cultivation of fruits'

Fruits are grown only on 50,000 hectare land in the country. There is ample of opportunities to grow fruits in coastal belt, hilly regions and dry interior places, said Central Horticulture Research Institute ADG (horticulture) Dr T Janaki Ram, reports *DHNS* from Madikeri.

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Deccan Herald

M 3-12-2014

HE NEW INDIAN EXPRESS
ENGALURU TUESDAY 2 DECEMBER 2014

REG

Seminar on Underutilised Fruits Begins

press News Service

An expo of underutilised fruits and other equipment used in agriculture and horticulture was inaugurated by Kodagu ZP member B Mani Uthappa

adikeri: A three-day na- nal seminar was inaugu- ed at the Central Horticul- ral Research Station in ettalli on Monday.

The seminar is organised the Indian Institute of rticulture and Research l Society for Promotion of rticulture.

he seminar aims to for- late strategies on conser- ion and utilisation of un- utilised fruits.

naugurating the seminar Additional Director General of Institute of Horticulture Research, New Delhi, T Janaki Ram appealed to people to grow jungle fruits along with passion fruit, dragon fruit, cherry, nutmeg, rambutan and garcinia.

He said only 50,000 hectares has been utilised for the underutilised fruits across the country.

Coastal areas, mountain ranges and dry places are most suitable for jungle and other fruits, Ram said. These fruits are rich in vitamins and control cholesterol in blood, he said and predicted that they would be in much demand in the coming days.

Director of National Horticulture Institute, Bangalore, T Manjunath Rao, senior scientist and project coordinator, V A Parthasarathi addressed the gathering.

An expo of underutilised fruits and equipment used in agriculture and horticulture was inaugurated by Kodagu ZP member B Mani Uthappa.

Scientists from West Bengal, Tamil Nadu, Kerala, Puttur and Tumkur took part in the seminar.

o was inaugurated at the seminar in Chettalli on Monday | EXPRESS PHOTO

THE NEW INDIAN EXPRESS
BENGALURU FRIDAY 5 DECEMBER 2014

REG

Progressive Fruit Growers Felicitated

Express News Service

The trio with their awards at Chettali | EXPRESS PHOTO

Madikeri: C R Shivakumar of Madikeri, Vasanthi Ponnappa of Sunticoppa and Edward Rebello of Moodabidri were felicitated by in-charge director of Horticulture Research Station, Bengaluru, Ganesh Murthy, at a seminar organised in Chettalli recently.

The trio was recognised as intensive cultivators of fruits by the organisers of the three-day national seminar.

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ಹೊಸದಿಗಂತ ದಿನ ಪತ್ರಿಕೆ ದಿನಾಂಕ:- 02/12/2014

ಅಲ್ಪ ಬಳಕೆ ಹಣ್ಣು ಬೆಳೆಗೆ ಆದ್ಯತೆ ನೀಡಿ

ರಾಷ್ಟ್ರ ಮಟ್ಟದ ವಿಚಾರಸಂಕಿರಣದಲ್ಲಿ ಹಣ್ಣು ತಜ್ಞರ ಕರೆ

ಮನ ಸೆಳೆದ ಹಣ್ಣು ಕೃಷಿ ಪ್ರದರ್ಶನ

02.12.2014 ಮಂಗಳವಾರ ಸಂಪುಟ 58 ಸಂಚಿಕೆ 266 ಪುಟ 6 ಬೆಲೆ ₹ 1.50 ಕೊಡಗಿನ ಪ್ರಥಮ ಕನ್ನಡ ದಿನ ಪತ್ರಿಕೆ SHAKTHI THE FIRST DAILY OF KODAGU ಜನತೆಯ ಧ್ವನಿಗೆ 57 ವರ್ಷ

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'ಶಕ್ತಿ'
ಪುಟ 5
ಚೆಟ್ಟಳ್ಳಿಯಲ್ಲಿ ವಿಚಾರ ಸಂಕಿರಣ


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National Seminar on Strategies

ಚೆಟ್ಟಳ್ಳಿಯ ತೋಟಗಾರಿಕಾ ಕೇಂದ್ರದಲ್ಲಿ 'ಹಣ್ಣು ಬೆಳೆ ಸಂರಕ್ಷಣೆ ವಿಧಾನಗಳು, ಬಳಕೆ' ರಾಷ್ಟ್ರಮಟ್ಟದ ವಿಚಾರ ಸಂಕಿರಣ

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ದೊಡ್ಡ ಸುದ್ದಿ

ಕಾಚಂಪುಳಿ, ಕೋಕಮ್, ಚಿನಕಪುಳಿಯಿಂದಲೂ ಹೆಚ್ಚು ಆದಾಯ

Vijay Karnataka 2-12-2014

ದಿನಾಂಕ :- 02/12/14

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