SPICES OF ISLANDS: POTENTIALS AND WAY FORWARD FOR PROFITABILITY

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District Level Seminar on

SPICES OF ISLANDS: POTENTIALS AND WAY FORWARD FOR PROFITABILITY

Based on the invited papers for the State Level Seminar on Spices organized by ICAR-CIARI, Port Blair during 22-23 March, 2018

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FOREWORD

India produces a wide range of spices and holds a prominent position in world spice production. Because of the varying climates from tropical to sub-tropical to temperate almost all spices grow splendidly in India. In reality almost all the states and union territories of India grow one or the other spices. Spices have an important position among the horticulture crops with regard to huge domestic consumption, sizeable export earnings and more employment opportunities.

The Andaman and Nicobar Islands popularly known as Emerald Island is endowed with rich natural resources that offers great scope and opportunities for cultivation of different types of spices. The major spices grown in the Islands are black pepper, cinnamon, clove, bay leaf, nutmeg, ginger and turmeric. These spices are high value commercial crops that can fit very well into the plantation based cropping systems as inter/mixed and multi-storeyed cropping systems in both arecanut and coconut plantations to enhance the production and profitability per unit area available in the fragile Island ecosystem. However, there are a lot of challenges to be addressed to increase the organic spices production in the Islands with better returns to the farmers. In this regard, ICAR-CIARI is playing a vital role in organizing various training programmes, workshops, field days and seminars at village level, district level and state level for promotion of spices cultivation in the Island.

I am pleased to know that ICAR-CIARI is organizing a **state level seminar** on the theme "Spices of Islands: potentials and way forward for profitability" during 22 -23 March, 2018, which will include deliberations from various experts on spices aiming to help in addressing the challenges faced by the stakeholders of spices sector. I greatly appreciate the efforts taken by the team of scientists for compiling the presentations as a book which will serve as a reference material and also a ready reckoner for the spices stakeholders of the Island.

16th March, 2018

(Anand Kumar Singh)

PREFACE

Spices have played a very important role in shaping the history of human culture and civilization. Spices, condiments and aromatics were the first products to be traded by the ancient people. Spices are important high value commodities traded internationally for many centuries. Spices are low volume, high value, export oriented crops. The Andaman and Nicobar Islands which is known as hot spot of biodiversity, is bestowed with congenial climatic conditions for cultivation of different kinds of spice crops. Most spices are well adapted to grow under shaded conditions and hence integration of spices in the existing coconut and arecanut plantations is one of the viable option for increasing the area and production of spices in the Island. The Andaman and Nicobar islands have emerged as a popular tourist destination and there is a high demand for high quality spices. The consumer preference is more towards organic spices and hence there is a lot of scope for increasing the area under spices and branding the spice products as organic since there is a minimal or no usage of chemical fertilizers and plant protection chemicals in the Island for production of spices.

The major constraints faced by the farmers for spices cultivation were the non availability of quality planting material of spice crops and lack of awareness of recent developments in spices production technologies. ICAR-CIARI with the aid of the centrally sponsored scheme funded by Directorate of Arecanut and Spices Development Board (DASD) is involved in quality planting material production of spice crops and their distribution to farmers in different parts of the Island. Various training programmes, workshops and seminars are regularly conducted at village, district and state level to increase the awareness among the farmers about the improved technological developments in spices production. ICAR-CIARI is also constantly involved in conducting front line demonstration programmes of black pepper, ginger and turmeric to farmers in different parts of the Island. Many farmers in the Andaman group of Islands are successful in organic cultivation of ginger and turmeric and their success stories have been documented.

In this direction, a state level seminar on " Spices of Islands: potentials and way forward for profitability" is organized during 22-23 March, 2018 at ICAR-CIARI involving all stake holders comprising farmers, students, entrepreneurs and representatives from development departments. Experts working on spice crops are invited for giving deliberations on recent achievements in spices production technology and success stories. We are extremely happy to compile the lectures of the different deliberations as a book in a user friendly way that may be useful for spices sector stake holders of the Island as a reference material.

Authors

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1. STATUS AND STRATEGIES OF SPICES CULTIVATION IN ISLAND ECOSYSTEM

A. Kundu and K. Abirami
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India is largest producer and exporter of spices around the globe. USA and Vietnam are the main markets for Indian Spices while the maximum shipments of spices depart from Mundra Sea Port. It has the largest domestic market for spices with 109 varieties listed by ISO (International Organization for Standardization) in the world. India exports around 75 varieties of spices and it primarily exports cumin, red chilli, pepper, turmeric, green cardamom, fennel, black pepper, coriander, ginger etc (Fig 1). Spices in India have been grown in small land holdings with organic farming gaining importance in modern times. These are most sought after globally specified their quality, taste and medicinal values.

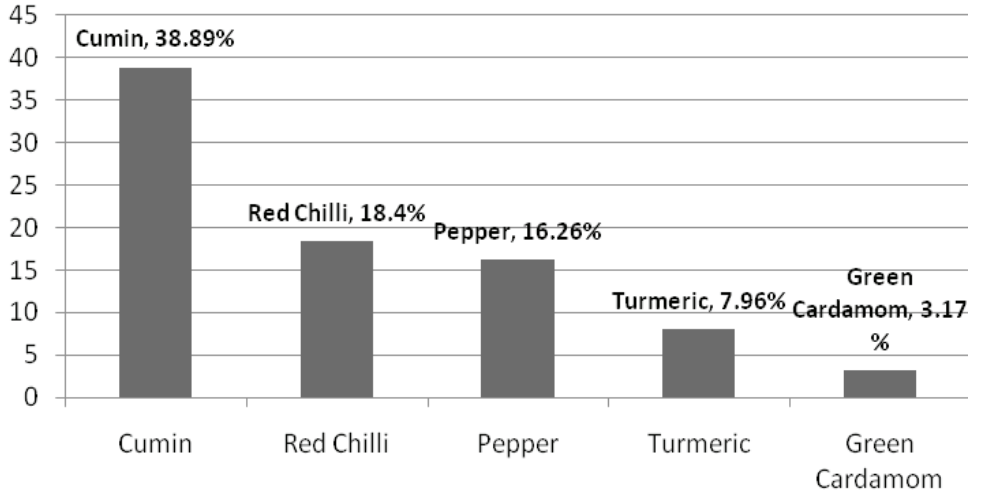

Fig 1. Export of spices from India (2017)

The states having major share on production of various spices are Andhra Pradesh, Rajasthan, Madhya Pradesh, Tamil Nadu, Orissa, Karnataka, Gujarat and Kerala. North-Eastern region including Sikkim and Andaman and Nicobar Islands have been identified as areas with great potential for growing organic spices in the country.

Table 1. Area and production of major spices in India

Spice crop	Area (ha)	Production (tones)
Black pepper	131790	48500
Cardamom	70080	23890
Chilli	742950	1497440
Cinnamon	320	70
Clove	2340	1200
Ginger	156910	1025110
Nutmeg	22360	15170
Turmeric	183480	967060

(Source: Spices Board of India)

Present Status of Spice cultivation in A & N Islands

Andaman & Nicobar Islands are a group of 572 Islands (of which only 38 are inhabited) located in the Bay of Bengal between 6-14^0 N latitude and 92 - 94^0 E longitude as a long (North-South direction spanning over 700 km length) and narrow stretch . Tsunami of 26 December, 2004 has resulted in loss of some cultivated area (6,000-7,000 ha) and at present 42, 839 ha (2013-14) is under cultivation. The land use pattern is dominated by plantation crops (coconut and areca nut with spices, fruit trees) in undulating lands and by rice in low lying areas in which vegetables are cultivated. The climatic condition prevailing in these Islands are warms and humid with a temperature ranging between 22^o-32^o C and high relative humidity (70 to 90%). The Islands get an annual rainfall of about 3000 mm from both South-West and North-East monsoons (with 154 rainy days) with a short dry spell between January and April. Soils in general, range from clay to clay-loam with patches of sandy loam in some Islands. The soil pH ranges from 5.2 to 6.6 with the nutrient status of medium in nitrogen and potassium and low to medium in phosphorus. Even though the agro climatic and soil conditions prevailing in these islands are highly suitable for growing spice crops there is a lot scope to increase the production and productivity of spices in the islands. The total area under spices cultivation in the Islands 1369 ha with a production of 3436 MT (2014-15). Among the spices, black pepper occupies maximum area followed by chillies, ginger and tree spices. The area under agriculture is shrinking in the Islands and hence growing spices under different cropping system model will be highly remunerative. Majority of spices are grown in plantation based cropping system.

2. SPICES – HEALTH BENEFITS AND MEDICINAL PROPERTIES

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Spice is defined as "a strongly flavoured or aromatic substances of vegetable origin, obtained from tropical plants, commonly known as a condiment". A spice is a dried 'seed, fruit, root, bark, bud or other vegetable substance used in nutritionally insignificant quantities as a food additive for the purpose of flavouring. Spices are distinguished from herbs, which are part of leafy green plant parts used for flavouring or as a garnish. American spice trade association (ASTA) defines spices as "any dried plant product used primarily for seasoning purposes". It includes all tropical aromatics (pepper, cinnamon, cloves, etc), leafy herbs (basil, oregano, marjoram, etc), spice seeds (sesame, poppy, mustard etc) and dehydrated vegetables (onion, garlic, etc). Spices are utilized in for various purposes such as food preservation, medicine, religious rituals, cosmetics and perfumery or as vegetables. Many spices have antimicrobial properties.

From ancient times to the present, Asia has been well known as the "Land of Spices". The Moluccas Islands in Indonesia are referred as Spice Islands. Kerala in India is referred as "Spice bowl of the world" and India produces majority of spices and export to world market. The fame of Indian spices is older than the recorded history. The story of Indian spices is more than 700 years old. Centuries before Greece and Rome had been discovered, sailing ships were carrying Indian spices, perfumes and textiles to Mesopotamia, Arabia and Egypt. It was lure of these that brought many seafarers to the shores of India. Theophrasus described black pepper and long pepper in the 4th Century BCE. In the ancient times, powerful Chola Kings took black pepper to Indonesia (Parthasarathy *et al*, 2007). Ancient people such as the Egyptian, the Arab and the Roman made extensive uses of spices, not only to add flavor to foods and beverages, but as medicines, disinfectants, incenses, stimulants and as aphrodisiac agents. Spices like turmeric and paprika are used more for imparting an attractive colour than for enhancing taste (Ravindran, 2006). The Chinese traditionally used spices for integrating food, nutrition and health and included in specially prepared soups, dishes or beverage for their health benefits. Many traditional diets around the world include considerable amounts of added spices. Indian cooking uses spices to add distinctive and rich flavours and significant quantities can be consumed in one meal. The spice extracts are used as infusions, decoctions, macerations, tinctures, fluid extracts, teas, juices, syrups, poultices, compresses, oils, ointments and powders. The spices are also rich in antioxidants and possess antimicrobial activity.

Spices classified based on usage

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

Common ethnomedicinal uses of some spices

Spices	Ethnomedicinal Uses
Allspice	To cure toothache carminative and stimulant
Alpinia	Used in infusion to heal stomach cramps and dysentery
Black pepper	Dried powder used for curing urinogenital complaints and berries with onion are used to extract guinea worms
Clove	Bark infusion used for diarrhea, dysentery and leaf infusion for diabetes. Fruits are remedy against diarrhoea, as beverage and tonic. Seeds are used to treat blood pressure and sugar in urine
Fennel	Leaf infusions for stomach ailments, remedy to vomiting
Ginger	Rhizomes used for treating haemorrhage, malaria, headache, as a digestive, carminative and antiasthmatic
Nutmeg	Spice, fruit is chewed to alleviate stomachache
Turmeric	Treating sprains, bruises, as analgesic, to treat stomach pain
Vanilla	Used against poor blood circulation and skin ailments

(Source: Sasikumar, 2008)

Constituents of major spices

Spices have been known to be used for their aroma, flavor, colour and preservatives for thousands of years. The medicinal properties of spices are reportedly due to the presence of secondary metabolites, essential oils and oleoresins. The various phytochemicals present in spices include flavonoids, terpenoids, lignans, sulfides, polyphenols, carotenoids, coumarins, saponins, plant sterols, phthalides etc.

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

(Parthasarathy *et al*., 2010)

Black pepper

Black pepper berries are rich in Manganese, Iron, Calcium, Potassium, Vitamin A, C, K, Zinc, Chromium and other nutrients. The health benefits of black pepper include relief from respiratory disorders, coughs, common cold, constipation, indigestion, anemia, impotency, muscular strains, dental diseases, pyorrhoea, diarrhoea, and heart diseases. It also increases the hydrochloric acid 'secretion in the stomach, thereby facilitating digestion and the outer layer of pepper berries assists in the breakdown of fat cells. Black pepper has a number of pharmacological properties *viz*., analgesic, stomachic, carminative, antipyretic, antimicrobial, antifungal etc which have been attributed to the pungent principles in the berries, piperine. Anticonvulsive and vasodilatory properties are also exhibited by this compound and its various homologues like piperettine, piperanine, piperyl Co A, piperolin B and pipericine. The effect of piperine on the bioavailability and pharmacokinetics of propranolol and theophylline has been examined clinically by Bano *et al* (1991). In traditional

Chinese medicine, a dried powder containing radish and pepper corn (1:99) is being used to treat epilepsy. Due to this property of piperine, pepper is used in the treatment of epileptic fits in Ayurveda.

Ginger

Ginger has been widely used as a dietary spice, as well as in traditional oriental medicines. The rhizome of ginger contains pungent vannilyl ketones including gingerol and paradol and has been reported to possess a strong anti inflammatory activity. The gingerols are a group of structurally related polyphenolic compounds isolated from ginger and known to be the active constituents. Manju and Nalini (2005) demonstrated the chemopreventive efficacy of ginger in colon cancer. The number of tumors as well as incidence of cancer was significantly decreased on treatment with ginger. [6]-gingerol a pungent ingredient of ginger has antibacterial and anti-inflammatory properties. Studies by Stoilova et al. (2007) established the antioxidant activity of ginger extract. Yoshikawa *et al* (1994) investigated the stomachic principles in ginger. Dried rhizome of ginger is used in traditional medicine to treat headaches, nausea, stomach ache and colds. Ginger is known to warm the body curing chills caused by common colds. The liver protectant property of ginger is due to the presence of 6 –gingerol, 10-gingerdione and 6-dehydro gingerdione.

Turmeric

Turmeric has been attributed a number of medicinal properties in the traditional system of medicine treating for several common ailments. Turmeric possesses powerful antioxidant properties and has been prescribed for years in the treatment of various diseases. Curcumin which are found in turmeric possess anti cancer properties, anti microbial and improves heart health. Turmeric also possess anti inflammatory activity due to the presence of curcuminoids. Turmeric extracts possess antibacterial and antiviral activities. Curcumin in turmeric also inhibits the aflatoxins produced by the mould. Turmeric is helpful in the treatment of Arthritis, Rheumatoid arthritis, Osteoarthritis, injuries and trauma (Parthasarathy *et al.*, 2010).

Small cardamom

Small cardamom known as the 'Queen of spices' is a rich spice obtained from the seeds of a perennial plant. It is one of the highly prized spices of the world and is the third most expensive spice after saffron and vanilla. The essential oil has traditionally been used as a tonic to the digestive system, as well as a component of many aphrodisiac blends. The oil has the aroma of freshly dried cardamom pods, far superior to the comparatively flat steam distilled variety of this oil. Cardamom oil may relieve spasm, making it possibly beneficial

for colitis, irritable bowel syndrome, indigestion and cramps. Cadamom oil may be of benefit where the digestive system is affected by nervous tension. Small cardamom possess various medicinal properties such as stomachic, carminative, stimulant. It is also reported to have antimicrobial and anti-inflammatory activity. Results showed that the cardamom had inhibitory activity on microbes *like E coli, M. luteus, S. aureus, K. pnuemoniae, E. faecalis, C.albicans* (Agaoglu *et al.*, 2005).

Large cardamom

India is the largest producer of large cardamom with more than 85% production from Sikkim. It is the most important cash crop of the Himalayan region and is widely cultivated with Himalayan alder (*Alnus nepalensis*) as shade tree (Sharma *et al*, 2002).Large cardamom possess various medicinal properties like Antiseptic (pulmonary), antispasmodic (neuromuscular), aphrodisiac, expectorant, anthelmintic, antibacterial, cephalic, cardiotonic, diuretic, emmenagogue, stomachic and digestive. This spice is used to treat infections in teeth and gums, to prevent and treat tooth troubles, congestion of the lungs and pulmonary tuberculosis. The fruit of large cardamom known as 'Heel kalan' or Bari ilaichi is used in Unani system of medicine in gastrointestinal disorders (Jafri *et al.*, 2001).

Cinnamon

Cinnamon is used as an ingredient in many 'Ayurvedic' and 'Unani' medicinal preparations. The bark of cinnamon is an aphrodidiac, anthelmintic and tonic. It is useful in the treatment of 'vata', biliousness, parched mouth, bronchitis, itching, heart disease and urinary diseases. The bark is a carminative and expectorant, it is useful in hydrocele, flatulence, head ache and piles (Kirtikar and Basu, 1984). Cinnamon possess various biological activities such as antioxidant, antimicrobial, antidiabetic and antiallergic activities.

Nutmeg

Nutmeg is more commonly used in oriental medicine. The seeds are carminative, stomachic, astringent, deodorant, narcotic, aphrodisiac and useful in flatulence, nausea and vomiting. The antioxidant property of nutmeg was reviewed by Krishnamoorthy and Rema (2000). Both nutmeg and mace are used in the pharmaceutical industries. Powdered nutmeg is rarely administered alone but it enters into the composition of numerous medicines as aromatic adjuncts.

Oil of nutmeg is useful in the treatment of inflammation of the bladder and urinary tracts, dyspepsis, flatulence, impotence, insomnia and skin diseases. It is also used externally as a stimulant and ointment as a counter irritant. Essential oil contains several compounds

which are valuable in industry. Mace oil possess almost identical physiological and organoleptic properties as nutmeg oil. Nutmeg butter is a mild external stimulant used in the form of ointments, hair lotions and plaster and used against rheumatism, paralysis and sprains. Another application of nutmeg oil is in aromatherapy, which is gaining importance these days. The main constituents of nutmeg and mace-myristicin, elemicin and isoelimicin when present in aroma forms act as stress relievers. Both nutmeg and mace contain the active ingredient myristicin, which possesses narcotic properties. Nutmeg butter also contains elemicin and myristicin, which cause pshychotropic effects. Ingestion in large quantities produces narcosis, delirium, drowsiness, epilpeptic convulsions and even death (Parthasarathy *et al.*, 2010).

Clove

Cloves have been used by India's traditional Ayurveda healers since ancient times to treat respiratory disorders and digestive ailments. Like many culinary spices, cloves help relax the muscle lining of the digestive tract. Aqueous extract of clove flower bud inhibits immediate hypersensitivity in rats by inhibition of histamine release from mast cells *in vivo* and *in vitro* (kim *et al.*, 1998).

Cloves are more often used to assist the action of other herbal remedies rather than alone. It is spicy, warming, stimulant, anodyne, anesthetic (topical), anti-emetic,vermifuge, uterine, stimulant, stomachic, carminative, antiseptic, antibacterial, antifungal, antispasmodic, expectorant, promotes salvation and digestive juices. Oil is expectorant, anaesthetic and emmenogogue. Clove bud oil has various biological activities such as antibacterial, antifungal, antioxidant and insecticidal properties. The high level of eugenol present in the essential oil imparts strong biological activity and antimicrobial activity (Raghavendra *et al.*, 2006). Clove and eugenol possess strong antioxidant activity, which is comparable with the activities of the synthetic antioxidants, BHA and pyrogallol (Dorman *et al.*, 2000). Clove kills intestinal parasites and exhibits broad anti-microbial properties thus supporting its traditional use for treatment of diarrhoea, intestinal worms and other digestive ailments. Eugenol, the primary component of clove's volatile oils, functions as an anti-inflammatory substance. Clove contains a variety of flavonoids, including Kaempferol, β-caryophyllene and rhamnetin, which contribute to clove's anti-inflammatory and antioxidant properties (Ghelardini *et al.*, 2001).

Thus spices are important horticultural crops with varied health benefits and medicinal properties. The demand for spices is increasing day by day for use in food and pharmaceutical preparations. The Andaman and Nicobar Islands are bestowed with favourable climatic

condition for growing spices. As most of the spices are adapted to be grown in plantation based cropping system, the area under spices may be increased by the combined efforts of the government institutions and farming community. Since the Islands have wide scope for organic spices cultivation, the spice products can be marketed with organic brand and may be of high utility in industry of AYUSH.

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3. SCOPE OF INTEGRATION OF SPICES IN PLANTATION BASED CROPPING SYSTEMS

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Coconut (*Cocos nucifera* L.) is a versatile crop providing food, medicine, health drink, shelter, fuel, timber and fibre. In India, coconut is primarily a crop of small and marginal farmers. About 98% of the coconut holdings in the country are less than 2.0 ha in size and more than 90% of them are less than 1.0 ha in extent. Coconut as a monocrop provides employment only for about 135 man days/ha under rainfed conditions and 175 man days per ha under irrigated conditions. Consequently the family labour remains unemployed for larger part of the year.

In perennial crops like coconut, where the land remains committed to the same crop for several decades, one of the feasible ways of increasing the production is to raise additional crops in the interspaces. Coconut based cropping systems (CBCS), involving cultivation of compatible crops in the interspaces of coconut offer considerable scope for increasing productivity per unit area, time and inputs by more efficient utilization of resources like sunlight, soil, water and labour. Unlike in annuals, the potential for increasing productivity per cent area of land, time and inputs is considerably higher in perennial crops (Bavappa and Jacob, 1982).

An agronomically desirable system should ensure that all the components of production are exploited at optimal level ensuring that the long term production capability of the system as a whole is not affected. Study of the response of component crops and the environment of the farming system under a given situation using various parameters is of utmost importance for understanding the dynamics of the systems and making mid-term corrections for their improvement. Though the yields obtained from the tropical perennial plantation crops are high, further yield increases could be achieved by improvements in light interception, conversion efficiency and harvest index (Corley, 1985). He also indicated that minimizing stress with irrigation or fertiliser application increases conversion efficiency in oil palm, coconut, cocoa and rubber. Increase in planting density to achieve early ground cover, careful management of shade and use of varieties with greater tolerance of exposure to full sun light, reduced maintenance respiration and better harvest index are the other factors suggested by Corley as pathways for increasing yield. The interaction effects in intercropping systems are more complex than monocultures or sequential systems since they vary as widely as over storey crops with coffee and cocoa or legume grass pasture mixture (Allen *et al*., 1976).

Intercropping is popular because of many advantages like, increased productivity per unit area, better use of available resources (land, labour, time, light, water and nutrients), reduction in damage caused by pests, diseases and weeds and socio-economic factors (greater stability, economics, human nutrition and biological aspects)

Earlier workers have also reviewed the research carried out on coconut based intercropping and cropping system in India (Nair, 1979; Rethinam and Venugopal, 1994; Reddy and Biddappa, 2000). In this chapter, elaborate work on the system approach, its impact on soil characters, socio-economic benefits and recycling of biomass from cropping system are presented and discussed.

Coconut based cropping systems

In India, research on CBCSs was initiated during the thirties at the Coconut Research Stations at Kasaragod, Pilicode and Nileshwar and was intensified in the seventies. A number of CBCSs involving annuals, biennials, perennials and combinations of both annuals and perennials have been developed to suit the farmers' needs, availability of resources like labour, rainfall, irrigation facilities, finance etc., soil characteristics and market demand. The crops found suitable for raising as subsidiary crops in coconut gardens include tuber crops, rhizome spices, tree spices, cereals, pulses, oilseeds, fruit crops, vegetables, and medicinal and aromatic plants.

Management of the cropping systems

Selection of suitable component crops

The success of a crop mixing programme under coconuts depends very much on the selection of compatible crop combinations in which each crop will exploit a distinct and different zone of atmosphere and soil so that individual competition for moisture, nutrients, space and solar radiation will be the minimum. When the individual crops in the system utilise mutually exclusive rooting zones, the demand for additional nutrients and moisture need not necessarily be directly proportional to the cropping intensity adopted. Differential root activity under crop mixing not only enables better utilisation of the native and added nutrients but also prevents loss of nutrients from leaching and mobility (Thampan, 1980). It is not very necessary always to fulfil all these exacting requirements to have successful crop combinations. But one must ensure that the correct crop is chosen. In most cases, failure of inter/mixed cropping is due to the wrong choice of the crop(s).

A large variety of crops have been found suitable for growing under irrigated and rainfed conditions in coconut garden. The important successful crops among them are listed in Table 1.

Unlike in annual crops, intercropping in coconut need not affect the productivity of the main crop. The selection of crops should be such that they make best use of the natural resources without unduly competing with coconut. Although the intercrops may not compete with coconut for light, they are likely to compete for soil moisture and nutrients. If these two inputs are supplied as per the requirements of various crops, there may not be any adverse effect on coconut yield.

The success or failure of a coconut based farming system is often decided by the choice of the system components. Studies on the shade response of different intercrops revealed sweet potato as shade sensitive, coleus and colocasia as shade tolerant and ginger and turmeric as shade loving. Attempts have also been made to identify varieties suitable for multiple cropping situations in crops like banana, pepper, ginger and turmeric.

Table 1. Common perennial crops grown in coconut garden as mixed crops

Crops	References
1. Fruit crops	
Banana, Pineapple, Papaya, Guava, Lemon, Lime	Nelliat *et al.* (1974), Nair (1977*),* Gopalasundaram and Nelliat (1979), Gopalasundaram *et al.* (1993), Maheswarappa *et al*. (2003a), Subramanian *et al.,* (2009)
2**. Fodder crops**	
Pusa Giant, Hybrid napier-NB-21 and BH18, Guinea grass, Stylosanthes, Fodder cowpea, Mochi (*Lab-lab purpureum),* Hybrid napier PBN-16, Hybrid napier DHN 3 + Centrosema, Hybrid bajra napier (CO-3), Hybrid napier+ S*tylosanthes gracilis*	Ramakrishnan Nayar and Sahasranaman (1978), Jacob Mathew and Shaffee (1979), Sahasranaman *et al*., (1983), Maheswarappa and Hegde (1995), CPCRI (2004), Subramanian *et al.,* (2007)
3. Medicinal and Aromatic crops	
Chittadalodakam (*Adhatoda beddomei),* Karimkurinji (*Nilgirianthus ciliatus),* Nagadanthi (*Baliospermum montanum),* Vetiver (*Vetiveria zizanioides)*, Indian long pepper (*Piper longum*)	Maheswarappa *et al.* (2008a), CPCRI (2008), CPCRI (2003)

4. Flowering crops	
Heliconia, Anthurium, Jasminum sp.	CPCRI (2003), Arunachalam and Reddy (2007)
5. Tree crops	
Acacia mangium, Acacia auriculoformis, Casuarina equisetifolia, Ailanthus sp., *Tectona grandis, Tamarindus indica, Erythrina indica*	CPCRI (1989)
6. Spices/Tree spices	Nelliat *et al.* (1974), Nair (1977), CPCRI (1984), Maheswarappa and Anitha Kumari (2002), Maheswarappa *et al.* (2003b), CPCRI (2009)
Black pepper, Nutmeg, Cinnamon, Clove, Vanilla	
7. Cocoa	Nelliat *et al.* (1974), Nair (1977), Abdul Khader *et al*. (1984), Bavappa *et al.* (1986), Nair *et al.* (1975)
8. Mulberry	CPCRI (2002)

Irrigation

Water requirement of any crop is very much influenced by the evaporative demand of the climate. When other crops are introduced under coconuts there will be a perceptible change in the microclimate of the area favouring a reduced rate of evapotranspiration. Consequently, the overall water use efficiency increases in a multi-cropping system and under certain situation, the combined water requirement of all the crops in the system may remain almost the same to that of coconut alone in the same area (Thampan, 1980). In a mixed cropping trial conducted at the CPCRI, Kasaragod, India, involving a crop combination of coconut, cocoa, pepper and pineapple, the observation over a period of seven years revealed that there was considerable reduction in the irrigation requirement once the crop-mix got established. Crop growth and productivity were not affected when irrigation was given at wider intervals as compared to the frequency adopted during the initial years of the trial (Nelliat, 1978). Mixed cropping in coconut should be practiced only with assured water supply conditions during summer months. Sprinkler irrigation or perfo sprays is most suitable for the inter or mixed cropping systems where the entire area is required to be wetted. As the water is conveyed through pipes, irrigation efficiency in sprinkler or perfo-spray is high compared to flood or basin irrigation. The quantity of water applied should be at least equal to 75 % of the open pan evaporation. In the mixed farming system, wherein fodder grasses and legumes are grown in the interspaces, overhead sprinkler will be an ideal choice (Maheswarappa *et al*., 1998). However, in multi-storeyed or high density cropping systems, where a large number of tall perennial plants are included, perfo-spray is preferable. During the initial years, when

the canopy size of mixed crops is small, banana can be raised in the space available which will serve as the shade for mixed crop seedlings and also gives additional returns to the grower. In mixed cropping, since a number of crops are grown over a given area of land, a greater depletion of the plant nutrients may occur in the soil. Hence, it is necessary that recommended dose of fertilizers for each crop be applied individually to all the crops in the system. As far as possible the crop residues should be recycled to the plot by way of mulch or by incorporation into the soil. This also provides conducive environment for the multiplication and activity of beneficial micro-organisms. Irrigation through perfo irrigation was the best method for adoption in mixed cropping system for uniform distribution of water to all the crops. Water to a depth of 20 mm at the IW/CPE ratio of 1.0. is optimum for higher productivity in the system (Reddy *et al*., 2002 and Maheswarappa *et al*., 2003b).

Benefits of coconut based mixed cropping systems:

A number of perennials like cocoa, clove, nutmeg, coffee, pepper, mulberry, jack, breadfruit, mango, sapota, papaya and timber yielding trees can be grown in association with coconut. Studies carried out at CPCRI and elsewhere have revealed that pepper, clove, nutmeg and cinnamon besides other crops such as cocoa are the most compatible crops with coconut and can be grown as mixed crops in the west coast region.

Mixed cropping of Black Pepper in Coconut and Arecanut gardens

In India, plantation crops like coconut and arecanut are grown over an area of about 2.18 M hectares. These crops, which occupy the land continuously, utilize the natural resources only to a very limited extent producing less than 10per cent of the potential dry matter production in the tropics. Studies conducted at Central Plantation Crops Research Institute (CPCRI), Kasaragod have shown that the effective root zone of an adult bearing coconut palm growing under normal management is confined laterally within a radius of 2 m around the base of the palm (Kushwah et al. 1973).

The vertical distribution of roots have shown that the top 30 ern layer soil was practically devoid of functioning roots and that about 86 per cent of the roots were found between 30 and 120 ern depth from the surface. However, the morphological feature of the coconut palm necessitates its planting at 7.5 x 7.5 m spacing. These observations indicate that 77.7 per cent of the total available land area in a pure stand of coconut is not effectively utilized by the coconut roots. The venetian structure and orientation of coconut leaves permit sizeable amount of solar radiation incident on the crown to penetrate to the lower levels. The light intensity at ground level was always higher than 6700 lux at all the periods of the year (Nair, 1979).

Of the solar radiation received. On an average about 50 per cent alone is intercepted by the coconut canopy. Making use of the underutilized soil space and solar radiation in monocrop stands, a variety of crops having different stature, canopy shape and size and rooting habits can be mix planted to form compatible combinations. Such mixed plantations will intercept and utilize light at different vertical intervals and forage soil at different layers and columns maximizing biomass production per unit area of land, time and inputs.

Similarly, arecanut (Areca catechu L.) as a sole crop does not utilize fully the natural resources such as soil, space and light. The compact nature of arecanut crown raised well above the ground (10 to 15m) allows more sunlight to pass down to ground and maintain high humidity which in tum favour excellent growth of shade loving crops. Studies at CPCRI have revealed that orientation and structure of arecanut canopy permits 32.7 47.8 per cent of incident radiation to penetrate down depending on the time of the day. Normally in an areca garden spaced at 2.7 x 2.7 m, the light energy reaches the ground and wasted. Rooting pattern revealed that arecanut palms planted at 2.7 x 1.7 m spacing could use effectively only 30 per cent of the land area. The normal cultural operations are also confined within about 75-80em radius from the base. Thus, the areca palm exploits only 2.27 sq.m of (r=0.85 m) land area out of 7.29 sq.m (2.7 x 2.7 m) land available to each palm.

Arecanut plantations are mostly located in fertile soils in the coastal and Ghat regions and show good soil fertility and moisture holding in the soil throughout the year except for a few months in the summer. Thus, the arecanut plantations also are more ideal for inter/ mixed cropping.

Among perennial spices, pepper is an important spice crop which is commonly cultivated in coconut garden. The review of work done on pepper mixed cropping with coconut and arecanut plantations in different agro climatic zones of the country has established its suitability as a remunerative crop in various cropping models (Reddy and Thomas, 2001). As early as 1971-72, Panniyur-1 variety of pepper planted as mixed crop and trailed on palms aged over 60 years in one ha plot at CPCRI, Kasaragod yielded a mean of 2 kg dry pepper /vine/year (CPCRI, 1977). The highest yield was 5.5 kg pepper/vine/year (CPCRI, 1977). Among the various mixed crop combinations studied at CPCRI, Kasaragod, economics of coconut-pepper system was found to be more remunerative. This system could generate a net return of Rs 26,200/ha/year in a mixed cropped coconut garden as compared to Rs 22,300/ha/year from coconut mono crop. While evaluating the performance of six varieties of pepper in the multi-storeyed cropping system Potty *et al*. (1979) suggested that Karimunda and Panniyur-1 varieties perform better under mixed cropping situations.

Experiments of CPCRI, Kasaragod on coconut mixed with pepper, clove, nutmeg and cocoa indicated that clove could yield 3 kg dry flowers, nutmeg average 1.5 to 2.0 kg mace and 8 to 12 kg nuts. The highest net return was obtained with coconut +nutmeg cropping system (Rs. 94,300/ per ha) followed by coconut+clove (Rs. 46,800/- per ha) compared to coconut+pepper(Rs. 26,200/-) and coconut +cocoa (Rs. 31,400/-). The net return under coconut alone was only Rs. 22,300/per ha (Nair *et al*., 1991).

In 1970's, CPCRI has developed a multi-storeyed cropping model, the most productive and remunerative combination of coconut-pepper (trained on coconut palms)-cocoa-pineapple system. These crops developed their canopies at varying heights, simulating the features of a multi-storeyed building. Nelliat *et al*. (1979) reported the beneficial effect of growing cocoa, pepper, clove, nutmeg and cinnamon in terms of higher productivity and net return per unit land.

A field experiment was undertaken at CPCRI, Kasaragod to study the performance of different varieties of pepper as mixed crop in coconut garden under irrigated condition during 2003 to 2008. In general, *Phytophthora* slow wilt disease incidence was observed in Panniyur-2, Panniyur-3, Kottanadan, OPKM, HP 34 and HP 813 varieties/hybrids. In severe cases, the vines were uprooted and gap filled with disease free cuttings during 2003. The growth observations recorded during December 2007 indicated that the height of vines differed significantly among the varieties/hybrids and Collection 1041 recorded the maximum height (5.2 m) followed by HP 105 (5.1 m). The lowest height was recorded in HP 34 (2.9 m) hybrid. Number of laterals (in 1 m column height) differed significantly and collection 1041 recorded significantly higher number of laterals (56.6) and significantly the lowest was recorded in HP 34 hybrid (15.06) (Maheswarappa *et al.,* 2008b). The dry pepper yield obtained during 2006-07 was significantly higher in Collection 1041 (1.1 kg/ vine) followed by Panchami (0.82 kg/vine) and HP 813 (0.78 kg/vine). The variety OPKM recorded significantly the lowest yield (0.25 kg/vine). From the preliminary data on growth and yield of different varieties, it can be derived that varieties like Collection 1041 (Thevam), Panchami, Sreekara, HP 813, Panniyur- 1 and Panniyur- 4 are found to perform well in the coconut garden. More data are to be collected to arrive at final conclusions.

In an experiment started in 1972 on coconut based multi storied cropping system with cocoa in single and double hedge system, pepper and pineapple, the yield of coconut increased markedly during the experimental period compared to the pre-experimental yield in all the five crop combinations (Table 6) (CPCRI, 1984 and 1985).

Table 2. Yield of cocoa, pineapple and spices in coconut garden under multistorey cropping

Crop combination with coconut	Coconut (nuts/palm/year)			Yield of mixed crops				
				Pineapple during 1983-84 (kg/ha)	Cocoa (pods/tree) during 1984	Pepper (kg/ vine) during 1983-84	Cinnamon (g/plant) during 1982-83	
	Pre-Expt. (1969-72)	During 1983 - 84	Increase during the last 10 years over pre-Expt. (1974-84				Quils	Quillings
Cocoa SH+pepper+ pineapple	45.3	101.2	123	777	59	1.23	-	-
Cocoa DH+pepper+ pineapple	36.1	89.6	148	102	35	0.68	-	-
Cinnamon in SH+ Pine-apple+ pepper	25.1	88.2	251	1196	-	1.46	162	115
Cinnamon in DH+ Pine-apple+ pepper	40.1	81.3	103	565	-	1.60	85	49
Cinnamon DH	40.8	96.2	136	-	-	-	115	36

SH: Single hedge, DH: Double hedge (CPCRI,1984 and 1985)

Research findings have indicated that under coconut based HDMSCS and mixed farming systems, pepper variety Panniyur -1 has performed better and yielded 1.2 to 1.66 kg/vine/year and the yield was higher under 2/3rd recommended fertilizer dose (1.66 kg/ vine) (CPCRI, 2004, Palaniswami et al., 2007). Clove yield ranged from 1.0 to 1.55 kg dry clove per tree under coconut based HDMSCS (Reddy et al., 2002) and was the highest under 2/3rd recommended fertilizer dose (Palaniswami et al., 2007). Harvesting is a major problem in clove and hence, there is a need to breed short statured varieties. Banana (kadali var.) yield ranged from 3.9 kg to 5.76 kg/bunch and was the highest under full dose of fertiliser recommended (Palaniswami et al., 2007). Nutmeg yielded on an average 1.0 to 1.2 kg mace and 7 to 8 kg seed/ tree/ year under coconut based HDMSCS in root (wilt) affected area (Maheswarappa and Anitha Kumari, 2005). In coconut based HDMSCS, the

recyclable biomass available was the highest under 2/3rd of recommended fertiliser treatment in different crops compared to the other fertiliser treatments (Subramanian et al., 2005) (Table 3).

Table 3. Total annual biomass available for recycling from 1 ha of coconut based HDMSCS under different fertilizer levels (t/ha)

Amount of biomass removal/ crops	Coconut	Clove	Banana	Pineapple	Total
Full	15.80	0.666	1.295	0.435	18.196
Two-third	16.46	0.676	0.962	0.399	18.497
One –third	14.11	0.619	0.927	0.387	16.043
One-fourth	12.50	0.524	0.738	0.351	14.133
One-fifth	11.65	0.392	0.575	0.263	12.832
Control (no fertilisers)	11.60	0.349	0.503	0.215	12.667

(Subramanian *et al*., 2005)

Nambiar *et al*. (1989) have reported that under HDMSCS, the P fractions increased and there was general increase in all the fractions of K over a period of three years cropped with different species.

Associative N_2 fixing *Azospirillum* spp. was found colonising the roots of coconut and black pepper in varying intensities under different cropping systems such as HDMSCS, multi-storeyed cropping and mixed farming (Ghai and Thomas, 1989). The isolates of *Azospirillum* from coconut and black pepper exhibited significant level of nitrogenase activity, which indicated contribution of substantial amounts of N2 to the cropping system by way of biological nitrogen fixation. The isolates from coconut roots were identified as *Azospirillum brasilense* and those from black pepper as *Azospirillum lipoferum* based on biochemical and morphological features of the isolates.

Under the experiment on evaluation of vanilla as a mixed in cocoanut garden, the number of inflorescences produced and fresh bean yield were significantly higher with application of vermicompost (5 kg/vine) + biofertilizers (25g/vine) and cow dung slurry (6 tonnes /ha) application, respectively compared to the other treatments. The fresh bean yield

was significantly higher with in cow dung slurry application (1.18 kg/vine), which was on par with application of vermicompost @5 kg/plant, vermicompost @5 kg/plant +biofertiliser application and biogas slurry application (6 t/ha). Absolute control recorded significantly lower fresh bean yield (0.42 kg/vine) (CPCRI, 2009).

Future research areas

i. Need for screening high value horticultural crops/varieties including spices and selecting best suited ones for maximising output and income of the system.

ii. Studies on effect of irrigation, integrated nutrient management, organic management and weed management and plant protection of the entire cropping system.

iii. Studies on the soil moisture relationship, microclimatic changes, carbon sequestration and nutrient availability and uptake in the system.

Coconut based cropping systems, involving cultivation of compatible crops in the interspaces of coconut offer considerable scope for increasing productivity per unit area, time and inputs by more efficient utilization of resources like sunlight, soil, water and labour. From the above review it is clear that mixed cropping in coconut garden is beneficial in terms of sustainable production and productivity over the years. Such diversification in coconut helps to conserve natural resources and protect environment. With many ecological and social benefit of mixed cropping a change in shift of mono cropping to specialise mixed cropping system with more diversified cropping is highly beneficial.

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4. STATUS OF PLANTING MATERIAL PRODUCTION OF SPICES IN ANDAMAN AND NICOBAR ISLANDS

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The archipelago of Andaman and Nicobar Island is a chain of 572 Islands stretched from North to South and located about 1200 kms of mainland on longitude 93° to 94° East and latitude 6°to 14° North. Topography is undulating and climate is congenial for Plantation crops like coconut, arecanut and Horticultural crops like tropical fruits and spices. Agriculture is important to the UT of A & N Islands for income and food security. Agriculture in the Island is important because of limitation on alternate livelihood possibilities and dependence on mainland for many essential food items. In terms of livelihood, about 50% of the population is directly dependent on Agriculture & Allied Activities. The total land being used for agriculture is relatively small due to paucity of non-forested land and numerous competing infrastructural demands. Thus, only about 6% of the non-forested land out of 50,000 ha is being used for agricultural purposes of which 10561 ha is under field crops and 29774 ha is under plantation crops. Devastating Tsunami of December, 2004 has further damaged permanently about 9% (4206 ha) of Pre -Tsunami Agricultural Land. Half of the agricultural land is used for Coconut Plantation, 10% is for arecanut and 20% for Fruits, Vegetables and Root Crops and 20% is for Paddy Cultivation. The soils of Andaman and Nicobar Islands have been developed under the dominant influence of vegetation and climate over diversified parent materials. These soils show considerable variation in profile and characteristics. There is extreme variability of soils from place to place which itself rules out uniform crops either for field or for plantation. The agroclimatic conditions of these Islands are congenial for the horticultural crops like plantation crops, fruits, vegetables, spices, tuber crops and flowers. The area and production of different horticulture crops in the Island is given in the Table 1. The Islands is rich in biodiversity and houses a large number of endemic and rare plant species of horticulture importance. The consumption of chemical fertilizer and pesticides in these islands is fairly low which could be turned into advantage through organic farming to fetch increased returns of the produce. With proper care, attention and organic certification system, these Islands can emerge as an organic island in a gradual phase.

Table 1. Area and production of major horticultural crops in the Island (2013-14)

Name of Crops	Area (hectares)	Production (MT)
Coconut	21900.00	128.95 (M/nuts)
Aeracanut	4290.90	9966.40
Paddy	8005.20	24368.20
Pulses	578.25	279.54
Oil Seed	40.40	14.23
Vegetables	5693.50	33597.00
Fruits	3620.95	31390.60
Spices	**1488.20**	**2907.60**
Tuber crops	880.60	16103.00

Source (A & N Administration)

SCOPE FOR HORTICULTURE DEVELOPMENT IN THE ISLAND

Despite repeated efforts to develop horticulture there has been no tangible impact in terms of increase in productivity and income generated by farmers. The productivity of most of the horticultural crops is however low, mainly due to the inadequate awareness of hi-tech intervention & primitive methods of cultivation being practiced by the local population. The current level of fruits and vegetable production is not adequate to meet the requirement of the population of islands which is further affected by increasing tourist influx. There is need to prioritize horticulture sector and make it a vibrant industry for the overall economic development of the Islands by giving focused attention through integration of efforts in a mission mode having horizontal and vertical linkage. Plantation crops and spices having high commercial value play a vital role in the agriculture economy of the islands. Coconut being the major plantation crop has been associated with the socio cultural life of the people and therefore the farming will have to be orientated towards Coconut based farming system.

SWOT ANALYSIS

Strength

- ❖ Congenial agro climatic condition for the cultivation of various horticultural crops.
- ❖ Large scope of rainwater harvesting.

- ❖ Consumption of chemical fertilizer and pesticides is very low.
- ❖ Proximity of South East Asian countries, for International market.
- ❖ Scope for Silviculture/Agro forestry.
- ❖ Govt. plantations with the department for production of planting materials.
- ❖ Presence of CIARI / KVK's in the Union Territory.

Weakness

- ❖ Remoteness and scattered nature of the islands and poor connectivity.
- ❖ Non-availability of organized marketing and processing facilities.
- ❖ Lack of perennial water resource.
- ❖ Natural calamities, erratic rainfall
- ❖ Prevalence of pest and diseases due to conducive weather condition.
- ❖ Fluctuating price trends of farm produce.
- ❖ High labour cost.
- ❖ Undulating land topography.

Opportunity

- ❖ Potential for organic farming and export of value added organic products.
- ❖ Potential for multiple cropping mixed farming in the existing coconut /arecanut garden as multitier cropping systems.
- ❖ Potential for development of organic spices as integrated farming in plantation based system.
- ❖ Potential for commercializing High Value Crops, indigenous medicinal & aromatic plants and extraction of essential oils.
- ❖ Potential for promotion of mushroom cultivation and apiculture.
- ❖ Strengthening of post harvest infrastructure facilities and establishment of processing, marketing infrastructures and storages.
- ❖ Scope for Silviculture/Agro forestry.
- ❖ To attract and retain educated youth in agriculture related activities.
- ❖ To increase competitiveness of commodities.
- ❖ Employment generation through non-farm activities.

Threat

- ❖ Uncertain weather condition leading to disruption of ferry services and communication.
- ❖ Lack of storage facility and market facility.
- ❖ Reluctance of the youths to take up farm activities.
- ❖ Occurrence of pest and diseases.
- ❖ Fluctuating price trends of farm produce.

STATUS OF SPICES IN ISLANDS

There is a limited area for cultivation in the Island. Out of the total cultivable area of 50,000 ha, plantation crops are cultivated in 50% of the area (25,400 ha) and spices like black pepper, clove, cinnamon, ginger, turmeric and nutmeg are grown in an area of 1750 ha (Srivastava, 2006). At present, spices are grown in an area of 1488.30 ha with production of 2907.60 MT (Table 2). Among the spices, black pepper occupies maximum area followed by chillies, ginger and tree spices which are mainly confined to Andaman district with the maximum production in ginger followed by chilli and other crops. South Andaman district of the Island occupies major area under spices followed by Middle and North Andaman. However, the production is maximum from North and Middle Andaman as compared to South Andaman. Nicobar district occupies very negligible area under spices.

Table 2. District-wise Area and Production of Major Spices in A&N Islands 2013-14

Name of Crops	Area (Hectares)				Production (MT)			
	South Andaman	N & M Andaman	Nicobar	A&N Islands	South Andaman	N & M Andaman	Nicobar	A&N Islands
Chillies	117.50	206.30	5.70	329.50	289.00	346.70	5.60	641.30
Black pepper	405.50	160.20	7.60	573.30	61.25	13.82	1.45	76.52
Ginger	80.60	101.00	5.40	187.00	485.30	916.00	16.30	1417.60
Turmeric	17.07	63.40	0.00	80.47	162.10	559.50	0.00	721.60
Nutmeg (Nos.)	42.50	19.60	1.95	64.05	3.30	1.40	0.20	4.90
Clove	93.00	20.40	5.30	118.70	5.80	3.63	0.30	9.73
Cinnamon	62.72	63.20	9.36	135.28	14.85	18.02	3.08	35.95
Total	818.89	634.10	35.31	1488.30	1021.60	1859.07	26.93	2907.60

The majority of the spice cultivation in the island is under intercropping system with coconut or arecanut plantation/gardens and spices like ginger, turmeric and chilli are also grown in open conditions in some areas for better productivity. The productivity of spices is very low in Bay Islands when compared to main land, as these crops are being grown with negligible attention, without proper management practices and additional inputs. In fact, the fertilizer consumption of the territory is far below the national average due to the fragile nature of ecosystem. Since most of the spices grown in these islands are under plantation crops, better management practices assume greater significance in improving the production and productivity, besides selecting quality planting materials.

Important spices grown in the Island and varieties

The important spices grown in the islands are chillies, black pepper, ginger, turmeric, nutmeg, clove and cinnamon. Black pepper is successfully grown under arecanut and coconut gardens and also in homesteads on mango, jackfruit, and gliricidia as standards. Panniyur-1 is the most popular variety grown with a yield of 0.5 to 2.0 kg/vine. Quick wilt of pepper was identified as the major constraint causing decline in pepper yield. Tree spices like clove, nutmeg and cinnamon are grown as intercrops in arecanut and coconut gardens with a spacing of 5.4 x 5.4 m and 7.5 m x 7.5 m respectively. A yield of 0.5 to 3.0 kg/tree in clove, 150-500 g/plant in cinnamon and 200 to 300 nuts in 10 years old nutmeg tree are observed. Ginger or turmeric is generally grown under shade in arecanut or coconut plantation.

Table 3. Important varieties of spices grown in the Island

S. No	Crop	Varieties
01	Black Pepper	Panniyur 1, Panniyur 2, Panniyur 5
02	Ginger	Jorhat, Maran and Nadia
03	Turmeric	IISR Kedaram, Allepey Supreme and IISR Pratibha
04	Nutmeg	Local
05	Clove	Local
06	Cinnamon	Local
07	Chillies	Local and hybrid varieties

Cropping system of spices in the Island

Coconut and arecanut are the major crops in the Island. Diversification in plantation based cropping system is important for sustainable livelihood opportunities of the farmers. Farmers cannot hope to survive unless they convert at least part of their holdings to other

cash crops (Prathapan 2003). Expansion of area is not possible as the land on agriculture is shrinking in the Island. Spices like black pepper, nutmeg, clove, cinnamon, ginger and turmeric are the important spice crops which could fit in High density multi species cropping system (HDMSCS).

The predominant HDMSCS systems with spices in the Island are as follows

- Model I: Coconut +cinnamon
- Model II: Coconut + nutmeg
- Model III: Coconut + black pepper
- Model IV: Coconut + clove
- Model V : Coconut + black pepper + cinnamon + clove/ nutmeg
- Model VI : Coconut +pine apple +banana +black pepper +cinnamon +clove/nutmeg
- Model VII: Coconut + clove + banana + black pepper + pineapple (CPCRI model)

Requirement of planting material of different spices and gaps identified

Among the different spices, there is a great demand for the planting material of ginger followed by Black pepper. Ginger is grown as an organic crop mainly under coconut plantation in the Island. The demand for turmeric is comparatively less when compared to ginger due to the lack of processing facilities. Black pepper is trained on coconut or arecanut and hence there is a continuous demand for new planting and replanting in the Island. Among the tree spices, the planting material of cinnamon has less demand as the farmers experience great difficulty in harvesting and peeling of cinnamon since it requires maximum labour. Nutmeg and clove are grown as intercrop in plantation cropping system and there exists medium demand for the planting material. The released variety of nutmeg, Keralashree has been procured and planted in our experimental field for production and supply of nucleus planting material in future.

The land area available for cultivation is very less in the Island and hence based on the demand and availability of space, farmers are interested to take up the planting material of black pepper, chillies, ginger and clove as compared to the other spice crops. However, under the banner of DASD, ICAR-CIARI is supplying the planting material of spices free of cost to enable the farmers for taking up spices cultivation in their homesteads and as intercrop in plantation based cropping system (Table 3)

Table 3. Details of planting material supplied to the famers by ICAR- CIARI

Sl No	Crop	Variety	2008-2012	2012-13	2013-14	2014-15	2015-16	Total
1	Black pepper	Panniyur-1, Panniyur 2 & Panniyur-5	58,530 nos	4229 Nos	9520 nos	8000 Nos	25000 Nos	105,279 Nos
2	Clove	Local	9566 Nos	367 Nos	1215 Nos	2000 Nos	4000 Nos	17148 Nos
3	Cinnamon	Local	7959 Nos	1210 Nos	2420 Nos	1800 Nos	4500 Nos	17889 Nos
4	Nutmeg	Local	8721 Nos	316 Nos	733 Nos	500 Nos	1800 Nos	12,070 Nos
5	Ginger	Jorhat	1560 Kgs	650 Kgs	775 Kgs	600 Kgs	1000 Kgs	4585 Kgs
6	Turmeric	IISR Kedaram, Allepey Supreme and IISR Pratibha	-	-	-	400 Kgs	500 Kgs	900 Kgs

For the past one decade, a series of awareness training programmes on spices had been taken up in different parts of the Andaman and Nicobar Island which includes 13 village level seminar and trainings, 5 district level seminars (S. Andaman & Middle Andaman), 21 farmer's trainings and 3 National level seminars cum workshop on spices cultivation was organized in Islands. FLD programmes on organic cultivation of ginger in coconut plantation is taken up in all the districts of Andaman and Nicobar Islands and farmers are showing their keen interest to expand the area under ginger since it is a highly remunerative crop.

ICAR-CIARI along with the Andaman and Nicobar administration is continuously involved in production, distribution and popularization of spice cultivation in the Island. However, there are a few challenges which are to be addressed in the near future. Lack of quality planting materials of improved varieties of spices is one of the major constraints faced by the farmers. Considering the area under plantation crops (about 25,000 ha), there exists wide gap between demand and supply of planting materials of improved varieties of spices especially in nutmeg, cinnamon and clove. Though a series of training programmes are conducted, there is lack of awareness among the farmers on recent developments in crop management and cropping systems of spices. Moreover, the tribals of the Island are reluctant to take up spices under plantation crops.

Facilities in the island for planting material production

In the Andaman and Nicobar Island, CIARI plays a vital role in production and supply of quality planting material of spices along with department of Agriculture, A & N Administration. There are no private nurseries in the Island for production and sale of spices planting material. The infrastructure facilities for production of spices planting material

under shadenut house is maintained at Sippighat farm of CIARI in addition to the progeny farms of the department of Agriculture, A & N Administration. At the nursery, utmost care is taken for production of disease free planting material of spices from the elite mother block. Tissue culture facilities are not available for mass multiplication of spices in the Island.

Future Strategies for expansion of spice cultivation in the Island

Procurement of high yielding improved varieties released from mainland and establishment of nucleus seed garden in the Island will enable the production and supply of planting material of spices. Emphasis should be given for organic cultivation of spices as there is wide scope for marketing of organic branded spices in the Island considering the increasing tourist flow. Managing the plant nutrition through organic recycling within the system, adopting plant protection measures through bio control agents are some of the potential scopes to convert the spices cultivation in to organic in Bay islands. Organic certification to encourage farmers for wide adoption of spices as a major intercrop or mixed crop in plantation based cropping system. Creation of processing facilities of turmeric to the farmers with the aid of government organizations with subsidies may increase the area and production of turmeric.

Among diseases, quick wilt of black pepper, soft rot and bacterial wilt of ginger result in 50-80% economic crop losses. The major insects infesting pepper, ginger and turmeric are shoot borer, rhizome scales and root grub etc. Identification of variability in the pathogen and their long term survival in soil and plants need to be addressed to develop location specific management strategies. Since organic cultivation of spices is major focus in the island, use of biocontrol agents and eco friendly way of management of pest and diseases will result in substantial increase in yields and pesticide free produce. Development of ideal storage conditions is vital for ensuring healthy rhizomes for planting ginger and turmeric.

Value addition of spices has great scope considering present International trade scenario in the Island. There is extended period of rainfall in the Island to a period of eight months. Hence intervention in the mechanization of spices is essential for uniform drying and retention of better quality. Farmers should be educated on proper drying and storage techniques. Establishment of community processing units and cold storage facility for storage are essential in the Island as majority of the farming community are small and marginal farmers to process and store their produce without quality loss. Cottage industries can be promoted to produce value added spice products such as ginger candy, jams, syrups, biscuits etc. as there is high value and increased demand for these products.

Planting material production of spices in public sector (in state dept farms/SAUs/ Research stations etc) and Gap between estimated requirement & current production in spices

In the Andaman and Nicobar Islands, spices are grown as intercrop in plantation based cropping system. Assuming 50% area under plantation crops (13095 ha out of 26,190 ha) to be intercropped with tree spices, the total requirement of planting material of spices are Black pepper-538.6 lakhs (Nos), cinnamon 359 lakhs (Nos), clove -23.2 lakhs (Nos) and nutmeg -23.2 lakhs (Nos). Apart from CIARI, the department of Agriculture, A & N Administration is involved in production of spices planting material at departmental nurseries at Sippighat, Haddo, Jirkatang, Mannarghat at South Andaman district, Panchwati, Nimbudera and Keralapuram farms at N & M Andaman supported by NHM scheme. On an average the department of agriculture produced about 3 lakh cuttings of black pepper, 5500 nos of clove, 65000 nos of cinnamon seedlings and 2500 nos of nutmeg seedlings per year (A & N Administration report, 2013-14). Hence there exists a gap between production and demand for the planting material of spices.

Even though there is a scope for intercropping of tree spices in the existing plantation crops, but farmers are reluctant to adopt in large scale. However due to continuous awareness campaigning and free distribution of spices planting material by the government agencies, the area is increasing considerably from the past 10 years and in near future with the support, aid from NHM and the untired efforts of research and development institutes in the island there is away forward to integrate at least 50 % of the are under plantation crops with tree spics as one of the major intercrop and to make the Island achieve self sufficiency as well as one of the spice exporter of Andaman branded organic spices.

The agro-climatic conditions of these Islands are very much favourable for spices crops and have a great potential for growing spices despite of the constraints and problems beset with the crops. In spite of these, the Island has witnessed an increase in area of spices to 1488.30 ha in 2013-14 with a production of 2907.60 MT. There is an increase in area to about 55% and the production has been increased to a tune of 121% during the last one decade. The availability of quality planting materials of new varieties, lack of infrastructures for on-farm processing and lack of farmer's awareness on improved technologies are few major constraints. Accordingly state or central sector schemes may provide enough programmes to remove these bottlenecks through supply of planting materials and instruments like driers to the farmers. Proper extension activities through intensive training to enhance their knowledge on technology adoption and promotion of community level approach or women empowerment through self help groups will provide potential scope for intensive cultivation of spices in the existing plantation crops (coconut/arecanut), thereby augmenting the income of the farmers.

5. PLANTING MATERIAL PRODUCTION TECHNOLOGY IN PERENNIAL SPICE CROPS

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India is in commanding position in spices and has been designated as home of spices. It is the largest producer, consumer and exporter of spices and spice products. Now a days, spices sector is gaining overwhelming response from Indian farmers for being one of the agriculture sectors where in assured profit could be activated in most of the crops. Attracted by high return, low management requirements and agro-climatic suitability. However spices industry suffers a number of problems like large area are covered under old/senile plantations, poor quality of seeds and planting material, low rate of replacement of existing cultivars with improved varieties/hybrids, lack of irrigation, poor postharvest and processing, week database etc. seeds and planting materials are one of the most important inputs in horticultural crops. The production and quality of crops is depending on the quality of planting material used. Non availability of adequate quality planting material is always felt as one of the important production constraints in spice crops. Therefore, there is need for production of large quality of planting material in the country.

Propagation is a means of perpetuating plants from one generation to another. The off springs or individuals produced by different means should be identical to their mother/ original plants. Propagation can be done in two ways, sexual propagation involves the reproductive organs of a plant and it is through seeds. Asexual propagation involves taking a tissue from a mother plant and regenerating itself into a new plant. The new plant produced is identical to its mother plant.

I. Sexual propagation (seed)

Seeds can be used for reproduction. Seeds are typically produced from sexual reproduction within a species, since genetic recombination has occurred, plants grown from seed may have different characteristics from its parents. Some species produce seed that requires special conditions to germinate like stratification, cold treatment etc.

II. Asexual propagation or vegetative propagation

Plants have a number of mechanisms for asexual or vegetative reproduction.. Some of these have been taken advantage of by horticulturist and gardeners to multiply or clone plants rapidly. People also use methods that plants do not use, such as tissue culture and grafting. Plants are produced using material from a single parent and as such there is no

exchange of genetic material, therefore vegetative propagation methods almost always produces plants that are identical to the parent. Vegetative reproduction uses vegetative plant parts or roots, stems and leaves. Therefore, propagation via asexual seeds or apomixis is asexual reproduction but not vegetative propagation.

Techniques for vegetative propagation

a) Cuttings

Plant cutting, also known as striking, is a technique for vegetatively (asexually) propagating plants in which a piece of the source plant containing at least one stem cell is placed in a suitable medium such as moist soil, potting mix, coir,etc . The cutting produces new roots, stems, or both, and thus becomes a new plant independent of the parent.

Typically, striking is a simple process in which a small amount of the parent plant is removed. This removed piece, called the *cutting*, is then encouraged to grow as an independent plant. Several compounds are used to promote the formation of roots such as the auxins. Among the commonly used ones is indole -3-butyric acid, or IBA, used as a powder, solution or gel. This compound is applied either to the cut tip of the cutting or as a foliar spray. Many vegetative parts of a plant can be used. The most common methods are leaf cuttings, stem cuttings and root cuttings.

b) Stolons

Stolons are horizontal stems which grow at the soil surface or below ground, they form new plants at the ends or at the nodes. Stolons are often called runners. Imprecisely they are above ground stems that run atop or just under the ground, more specifically, a stolon is a horizontal shoot from a plant that grows on top or below the soil surface with the ability to produce new clones of the same plant from buds at the tip.

Stolons are similar to normal stems except they produce adventitious roots at the nodes and normally run horizontally to the soil surface, instead of up into the air, they also have long internodes with reduced leaves. Plants with stolons are called stoloniferous. A stolon is a plant propagation strategy akin to a rhizome. The complex formed by a mother plant and all its clones connected by or produced by stolons are considered to form a single individual. Runners are above ground stolons and are produced by many plants, with straw berry being a typical example Typically stolons have very long internodes and form new plants at the ends which form a shoot that rises to the soil surface and produces foliage and/or flowers.

c) Layering

Layering is a means of plant propagation in which a portion of an aerial stem grow root while still attached to the parent plant and then detaches as an independent plant. Layering has evolved as a common means of vegetative propagation of numerous species in natural environments. Layering is also utilised by horticulturists to propagate desirable plants. Natural layering typically occurs when a branch touches the ground, whereupon it produces adventtitious roots. At a later stage the connection with the parent plant is severed and a new plantet is produced as a result.

The horticultural layering process typically involves wounding the target region to expose the inner stem and optionally applying rooting compounds. In ground layering,the stem is bent down and the target region buried in the soil.

Layering is more complicated than taking cuttings, but has the advantage that the propagated portion can continue to receive water and nutrients from the parent plant while it is forming roots. This is important for plants that form roots slowly, or for propagating large pieces.

Ground layering

Ground layering is the typical propagation technique in which the original plants are set in the ground with the stem nearly horizontal, which forces side buds to grow upward. After these are started the original stem is buried up to the tip. At the end of the growing season, the side branches will have rooted, and can be separated

Air layering

In air layering, the target region is wounded and then surrounded in a moisture-retaining wrapper such as sphagnus moss, coir dust etc. which is further surrounded in a moisture barrier such as polyethylene film. Rooting hormone is often applied to encourage the wounded region to grow roots. When sufficient roots have grown from the wound, the stem from the parent plant is removed and planted.

d) Division

Division, in horticulture and gardening, is a method of asexual plant propagation, where the plant (usually an herbaceous perennial) is broken up into two or more parts. Both the root or crown of each part is kept intact. The technique is of ancient origin, and has long been used to propagate bulbs such as garlic and saffron.Division is mainly practiced by gardeners and very small nurseries, as most commercial plant propagation are now done through plant tissue culture.

e) Grafting

Grafting is a method of plant propagation widely used in horticulture, where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially.

In most cases, one plant is selected for its roots, and this is called the stock or rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion.

In stem grafting, a common grafting method, a shoot of a selected, desired plant cultivar is grafted onto the stock of another type. In another common form called budding, a dormant side bud is grafted on the stem of another stock plant, and when it has fused successfully, it is encouraged to grow by cutting out the stem above the new bud.

For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive till the graft has taken, usually a period of a few weeks. Successful grafting only requires that a vascular connection takes place between the two tissues. A physical weak point often still occurs at the graft, because the structural tissue of the two distinct plants, such as woods may not fuse. Grafting is successful in dicots but difficult in monocots due to the cambium. So cambium of both stock and scion should be aligned to get a strong union.

Reasons for grafting

- Dwarfing
- To induce dwarfing or other characteristics to the sciosness
- Ease of propagation where rooting is not possible by cutting
- Hybrid breeding
- Hardiness (Weak root system)
- Disease / pest resistance
- Sturdiness (For strong stem)
- Pollen source
- Repairdamage to trunk
- Induction of flowering eg. Growing apple in tropics with preconditioned shoots
- Changing cultivars, for curiosities
- Virus indexing

Cleft grafting

The easiest and most common form of grafting is cleft grafting. The stock is simply split and the scion is inserted. It is best if the stock is 2-7 cm in diameter and has 3-5 buds, and the cleft is around 7cm deep. The scion is cut in a wedge shape and inserted into the tree with the cambium. The bare stock is covered with grafting compound, otherwise the cambium layer quickly dries and the graft fails.

Herbaceous grafting

Grafting is often done for non-woody plants such as tomato, brinjal and The main advantage of grafting is for disease-resistant rootstocks. In Japan an automated process using grafting robots is developed

Uses

Grafting has been important in flowering research. Leaves or shoots from plants induced to flower can be grafted onto uninduced plants and transmit a floral stimulus that induces them to flower.

The transmission of plant viruses has been studied using grafting. Virus indexing involves grafting a symptomless plant that is suspected of carrying a virus onto an indicator plant that is very susceptible to the virus so shows symptoms quickly.

f) Budding

Budding is also a process that consists of engrafting the bud of a plant into another plant. This is a frequent technique for fruit trees, but can also be used for many other kinds of nursery stock. An extremely sharp knife is necessary; specialty *budding knives* are on the market. The rootstock or stock plant may be cut off above the bud at budding, or one may wait until it is certain that the bud is growing.

T-budding is the most common style, whereby a T-shaped slit is made in the stock plant, and the knife flexed from side to side in the lower slit to loosen up the bark. Scion wood is selected from the chosen variety, as young, actively growing shoots. Usually buds at the tip, or at the older parts of the shoot are discarded, and only 2-4 buds are taken for use. The buds are in the leaf axils. They may be so tiny as to be almost unnoticeable.

Holding the petiole of the leaf as a handle, an oval of the main stem is sliced off, including the petiole and the bud. This is immediately slid into the T on the rootstock, before it can dry out. The joined bud and rootstock are held by a winding of rubber band, which will hold it until sealed, yet the band will deteriorate in the sunlight so that soon breaks and does

not pinch new growth, girdling the shoot.The percentage of "take" of the buds depends on the natural compatibility of the stock and scion, the sharpness of the knife, and the skill of the budder. Even the experts will have some buds die.

g) Micropropagation

Micropropagation is the practice of rapidly multiplying stock plant material to produce a large number of progeny plants, using modern plant tissue culture methods.

Micropropagation is used to multiply novel plants, such as those that have been genetically modified or bred through conventional plant breeding methods. It is also used to provide a sufficient number of plantlets for planting from a stock plant which does not produce seeds, or does not respond well to vegetative propagation.

Methods of micropropagation

1) Establishment

Micropropagation begins with the collection of sterile explants (s). This small portion of plant tissue, which may be as small as a cell, is placed on a growth medium, typically a medium containing sucrose as an energy source and one or more plant growth regulators (plant hormones).Usually the medium is thickened with agar to create a gel which supports the explant during growth.

The plant tissue should now begin to grow and differentitiate into new tissues. For example, media containing cytokinin are used to create branched shoots from plant buds.

2) Multiplication

Following the successful growth of plant tissue, the establishment stage may be repeated, by taking tissue samples from the plantlets produced in the first stage. Through repeated cycles of this process, a single cell sample may be magnified to hundreds or thousands of plants.

3) Pretransplant

This stage involves treating the plantlets/shoots produced to encourage root growth and "hardening". It is performed *in vitro*, or in a sterile "test tube" environment.

Root growth does not always occur in the earlier stages in plant cell culture, and is of course a requirement for successful plant growth after the micropropagation procedure. It is performed *in vitro* by transferring the plantlets to a growth medium containing auxins.

"Hardening" refers to the preparation of the plants for a natural growth environment. Until this stage, the plantlets have been grown in "ideal" conditions, designed to encourage rapid growth. Due to lack of necessity, the plants are likely to be highly susceptible to disease and will be inefficient in their use of water and energy.

Hardening typically involves slowly weaning the plantlets from a high-humidity, low light, warm environment to what would be considered a normal growth environment for the species in question.

This stage (pretransplant) is not always performed, instead being incorporated into the last stage by encouraging root growth and hardening *ex vitro*, or in nonsterile plant media.

4) Transfer from culture

In the final stage of plant micropropagation, the plantlets are removed from the plant media and transferred to soil or (more commonly) potting compost for continued growth by conventional methods.

This stage is often combined with the "Pretransplant" stage.

Advantages

Micropropagation has a number of advantages over traditional plant propagation techniques:

- Micropropagation produces disease-free plants
- Micropropagation produces rooted plantlets ready for growth, rather than seeds or cuttings
- It has an extraordinarily high fecundity, producing thousands of propagules in the same time it would take a conventional technique to produce tens or hundreds
- It is the only viable method of regenerating genetically modified cells or cells after protoplast fusion
- It is a good way of multiplying plants which produce seeds in uneconomical amounts (if at all)
- Micropropagation often produces more robust plants, leading to accelerated growth compared to similar plants produced by conventional methods

Disadvantages

Micropropagation may appear to be the perfect means of multiplying plants, but it has associated problems:

- It is *very* expensive, and can have a labour cost of more than 70%
- An infected plant sample can produce infected progeny. This is uncommon, as stocks are usually carefully vetted to prevent this

The greatest limitation is the cost. Most plants will naturally produce seeds, which are normally disease free and will readily grow under good conditions. The number of seeds varies, but is normally acceptable for multiplication and is free. For this reason, many plant breeders will never resort to micropropagation because of the prohibitive cost.

Mechanisation of the process would eliminate most of the labour cost associated, but this has proven difficult so far despite active attempts to develop this technology.

PROPAGATION OF SPICES

BLACK PEPPER

Black pepper develops three types of aerial shoots, namely (a) primary stem with long internodes, with adventitious roots which cling to the standards (b) runner shoots which originate from the base of the vine and have long internodes which strike roots at each node and (c) fruit bearing lateral branches with limited growth.

Cuttings are raised mainly from runner shoots, though terminal shoots can also be used. Cuttings from lateral branches are seldom used since they develop a bushy habit. However, rooted lateral branches are useful for raising black pepper in pots.

i) Production of rooted cuttings

Runner shoots from high yielding and healthy vines are kept coiled on wooden pegs fixed at the base of the vine to prevent the shoots from coming in contact with soil and striking roots. The runner shoots are separated from the vine during February-March, and after trimming the leaves, cuttings of 2-3 nodes each are planted either in nursery beds or polythene bags filled with fertile soil. Adequate shade has to be provided and the polythene bags irrigated frequently. The cuttings become ready for planting in May-June.

ii) Rapid multiplication

An efficient propagation technique developed at Sri Lanka has been modified for adoption in India for quick and easy multiplication of black pepper. In this method, a trench of 0.6 m depth, 0.3 m width and of convenient length is made. The trench is filled with rooting medium comprising of forest soil, sand, FYM in the ratio of 1:1:1. Split halves of bamboo with septa or split halves of PVC pipes of 1.25-1.50 m length and 8-10 cm diameter provided with plastic septa at 30 cm intervals are fixed at 45° angle on a strong support.

Rooted cuttings are planted in the trench at the rate of one cutting for each bamboo split. The lower portions of the bamboo splits are filled with a rooting medium (preferably weathered coir dust-farmyard manure mixture in 1:1 ratio) and the growing vine is tied to the bamboo split in such a way as to keep the nodes pressed to the rooting medium. The tying can be done with dried banana sheath fibers or coir rope. The cuttings are irrigated regularly. As the cuttings grow, the bamboo splits are filled with rooting medium and each node is pressed down to the rooting medium and tied. For rapid growth a nutrient solution of urea (1 kg), super phosphate (0.75 kg), muriate of potash (0.5 kg), magnesium sulphate (0.25 kg) in 250 litres of water is to be applied @ 0.25 litre per vine.

When the vine reaches the top (3-4 months after planting of the cutting) the terminal bud is nipped off and the vine is crushed at about three nodes above the base, in order to activate the axillary buds. After about 10 days, the vine is cut at the crushed point and removed from the rooting medium and each node is cut. Each cutting with the bunch of roots intact is planted in polybags filled with fumigated potting mixture. *Trichoderma* @ 1gram and VAM 100 cc/kg of soil can be added to the potting mixture. Care should be taken to keep the leaf axil above the soil. The polybags should be kept in a cool humid place, or should be covered with thin polythene (200 gauge) sheet to retain high humidity. The buds start developing in about 3 weeks and then the polybags can be removed and kept in shade.

Rapid multiplication (1:40), well developed root system, better field establishment and vigorous growth as a result of better root system are the advantages of this method of propagation.

iii) Trench method

A simple, cheap and efficient technique for propagating black pepper from single nodes of field grown vines has been developed at the institute. A pit of 2.0 m x 1.0 m x 0.5 m is prepared under a cool and shaded area. Single nodes of 8-10 cm length and their leaf intact, taken from runner shoots of field grown vines are planted in polythene bags (25 cm x 15 cm, 200 gauge) filled at the lower half with a mixture of sand, soil, coir dust and cow dung in equal proportion. The single nodes are to be planted in the polythene bags in such a way so as their leaf axil will be above the potting mixture. The polybags with the planted single nodes should be arranged in the pit. After keeping the bags in the pit, the pit should be covered with a polythene sheet. This sheet may be secured in position by placing weights on the corners. The cuttings should be watered at least five times a day with a rose can and the pit should be covered with the polythene sheet immediately after watering. It is advisable to drench the cutting 2-3 times with Fytolan (2g/litre).

After 2-3 weeks of planting, the cuttings will start producing roots which are visible through the polythene bags. After the initiation of roots the frequency of watering may be reduced to 3-4 times a day. After about 1 month healthy shoots start emerging from the leaf axil. At this stage it is advisable to keep the pit open for about 1 hour per day so that the cuttings would harden and will not dry when they are taken out of the pit.

The cuttings can be taken out of the pit after 2 months of planting. Once taken out, they should be kept in a shaded place and watered twice a day. These cuttings will be ready for field planting after about another 2 ½ months. By this method 80-85 % success can be obtained. Foliar application of nutrient solution will enhance the growth of the cuttings.

iv) Serpentine method

In this method the rooted cuttings kept in polythene bags are trailed horizontally and each node is pressed into the polythene bags with potting mixture arranged one after another with midribs of coconut leaves made into "V"shape. Once twenty nodes get rooted in the bag, first 10 will be separated by cutting at the inter nodes. The cut ends will be pushed back into the potting mixture and kept in shade for further growth. The cuttings would be ready after three months for field planting. On an average, 60 cuttings will be obtained in a year by this method from each mother cutting. Serpentine method can be followed throughout the year, it is simple, cheap, quick and suited to small and marginal farmers. Recovery percentage is higher compared to rapid multiplication technique.

v) Vertical column method

The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2m column having one foot diameter made with half an inch platic coated welded wire mesh filled with composted pasteurized coco peat and vermicompost @ 3:1 ratio fortified with bio control agent T.harzianum in hitech polyhouse of fan and pad system with temperature of 25-28^{0}C and relative humidity 75-80 %. Eight to ten cuttings can be planted around each vertical column. The cuttings are allowed to trail on the column and it takes 4-5 months to reach the top and produce more than 20 nodes. Each vine invariably produce laterals within 4-5 months time at 12th to 15th node whereas, vines allowed to grow horizontally on the bed with same medium also produce similar number of nodes but will not produce plagiotropic branch .The advantage of vertical column methods is that three types of cuttings i.e., normal single node cuttings, top shoots with lateral branch and laterals (Plagiotropes) for making bush pepper can be produced(Anandaraj *et al*.,2014).

vi) Trellis method

Comparatively open ares are good for this method. Take trenches of 30 cm width and 50 cm depth and fill with dried and powdered farm yard manure and top soil. Plant rooted cuttings at closer spacing. Irrigate regularly. After the cuttings are established, give NPK @ 10:5:5 . Trail the vines on wire trellis erected at 45-50 ^{0} slope. As they grow further, tie the vines to the trellis. Vines planted in June will grow to a length of 2 m by February by which time they can be cut retaining 3-4 nodes. The vines will again sprout and continue to give cuttings. The vines thus obtained are cut into 2-3 noded pieces and kept for rooting .

Bush pepper

Bush pepper is becoming now a days in homestead farming and urban horticulture. Scarity of labour for harvesting is another factor which has prompted farmers to go for intercropping of coconut and other perennial plantation crops with bush pepper.lateral branches are used for bush pepper production. One year old laterals with 4-5 nodes are planted in polybags filled with potting mixture and kept in mist chamber for rooting. Leaf blades on the cuttings are half cut before planting. Rooting is slow in bush pepper, which may take 2-3 months after which the cuttings are shifted from mist chamber to shade net house.After one month they can be used for planting. Bush pepper can also be made by grafting lateral shoots on *P.colubrinum*. Bush pepper starts yielding from first year onwards. When grown in the field as intercrop in cococnut, spacing of 2m X 2m is to be provided which will accommodate 2500 plants/ha.

GRAFTED PEPPER

To prevent incidence of foot rot and nematode problems, a resistant rootstock *Piper colubrinum* can be used to raise grafted pepper. Since it is a marshy species this technique is useful only wherever irrigation facilities exist. This technique however is useful to get quick yield of black pepper to take advantage of price rise and also to get green pepper throughout the year.

Both rooted cuttings and seedlings of *Colubrinum* can be used as rootstock. It will take six months for rootstock to be ready for grafting. Simple cleft grafting can be done using scions of pepper. Though tongue grafting, double rootstock grafting etc are feasible, semi mature green scions with 2 or 3 nodes are ideal. On *colubrinum*, the grafting is to be done on the semi mature green stem and not on the tip of shoots. Otherwise the graft union will absice at the node near the cut. Grafting can be done through out the year though rainy season with high humidity is the most ideal. All graftings have to be done in a semi permanent shed with 50% shade until union is formed. Union will be formed in 60 days. It is only parenchymatous

union. The polythene wrap around the wound is removed after 3 months. Grafting has to be done at about 60-70 cm above ground level to avoid infection to pepper scion because the splash point of *Phytophthora capsici* is 50 cm.

It is advantageous to grow 5 to 6 grafts per support to get quick coverage of canopies and more yield in first year itself. All the roots that arise from the nodes are to be retained and not removed. Rootstock sprouts can be regrafted every year to get new canopies in case there is a decline in some grafts after several years. Runner shoots will take 2 to 3 years for yield whereas top shoots yield in first year itself. Laterals can be grafted to get bush pepper. An yield of about 13 kg green pepper/ vine have been achieved in farmer's plot in 3rd year.

CINNAMON

Multiplication of cinnamon is by cuttings as well as by air layers

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. The best time is March to May.

Seedlings

Cinnamon can also 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.

Transplanting seedlings into polythene bags

The seedlings are transplanted into polythene bags (30 cm x 15 cm) containing a mixture of soil, sand and well decomposed farm yard manure (in the ratio of 3:3:1), when they are about 15 cm height. The seedlings are ready for planting in the main field when they are one year old. Nowadays selections are available and hence not practiced.

CLOVE

Varieties and planting material

Clove is indigenous to Moluccas Islands (Indonesia) and was introduced to India around 1800 A.D.by the East India Company in their spice garden in Courtallam, Tamil Nadu. 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.

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 radicle, 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 within 3 days. 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. Approach grafting is feasible in clove and the best success is obtained in July- August.

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.

ALLSPICE

Commercial product of Allspice is the dried immature fruits. It is indigenous to West Indies. Jamaica is the main producer of all spice. Its flavor is said to resemble a blend of cinnamon, clove and nutmeg. It is a small evergreen tree; flowers are white and branch trichotomously in the axils of upper leaves. Flowers are structurally hermaphrodite but functionally dioecious. It flowers during March – June and matures in 3-4 months after flowering. Fruit is a two seeded berry. Male trees flower earlier. The common method of propagation is by seeds. Propagation of allspice is similar to clove and the seeds are extracted, washed and sown in sand. Within 15 or 20 days seeds germinate and are transplanted into bags as in clove.

NUTMEG

Varieties and planting material

Nutmeg yields two spices viz., nut and mace. Among the tree spices, it is a major and highly remunerative spice crop. 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 selected a clone A9/4 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. This is named 'Vishwashree'

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 - 1.5m 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.

Production of orthotropic scions

Nutmeg tree exhibits branch dimorphism. The tree produces two different types of shoots. The straight growing orthotropic shoots or the vegetative shoots and the side growing plagiotropic shoots or the fruiting branches. The tree has a tendency to produce large number of plagiotropic shoots and very few number of orthotropic shoots. Attempts to induce orthotrops in nutmeg by physical as well as chemical treatments have not yielded positive results. Unavailability of sufficient orthotropic shoots is a major limiting factor in budding/ grafting of nutmeg. Raising a close planted scion bank will ensure steady supply of straight shoot bud sticks year round.

Top working

Identification of sex in the seedling stage in nutmeg is not possible with the available information. The sex of the trees can be identified only after 6-7 years when they start flowering. Generally, male and female trees are produced in 1:1 ratio . Since one male tree is sufficient for every 10 female trees for pollination, the rest of the male trees available in the plantation can be made productive by converting them to female trees by top working. Top working can be done by grafting. The top worked trees yield from the third year onwards. One or two branches of the female trees can also be top worked with male scions so as to avoid planting of male trees. Unproductive female trees can also be made productive by top working.

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.

CAMBODGE (MALABAR TAMARIND)

The dried fruit rind of cambodge or Malabar tamarind is hard and dark brown in colour. It is rich in acids and possesses marked antiseptic properties. The principle acid in the fruits of Malabar tamarind is identified as hydroxyl citric acid 51-55 %. The tree is dioecious exhibiting male and bisexual types. Cambodge is commonly propagated through seeds: seeds of cambodge are dormant and take a long time for germination.

Grafting

Softwood grafting is found best for propagation of Malabar tamarind. Bush habit will be useful for high density planting and backyard planting in the kitchen garden. To achieve this, orthotropic shoots arising from the main stem or root suckers arising from the base of yielding tree may be used. In Malabar tamarind, June to October is the best time for graft success coinciding with the humid period though grafting is possible throughout the year . Three to four months old scion of 15 cm length of light green colour was found to be the best and neither pre curing nor covering scions with poly covers had any effect in graft success even in summer months under poly shed conditions. It is recommended to use primary branches with whorled leaf arrangement, 6-10 cm long and leaves partly removed as scion. The age of seedling suitable for grafting in Malabar tamarind is 12 months old. Top working of Malabar tamarind is suggested to convert non bearing trees in which the trees are pruned in February – March and the newly emerging shoots are cleft grafted with scions from desired trees during rainy period.

CURRY LEAF

Curry leaf plays an important role as a condiment in the culinary preparation of south Indian dishes. A plant of homestead gardens has recently gained importance as a commercial crop and its cultivated in large scale in many parts of the country. Curry leaf is propagated through seeds and root suckers. However, propagation by seed is solely practiced commercially. Seeds germinate under shade. Unfortunately, the seeds retain their viability only for a short period. Clonal propagation by root suckers is another method in the multiplication of elite genotypes. The main season of availability of curry leaf fruits is July-

August. Seeds are to be collected from 8-10 years old trees. Within 3-4 days of collection of fruits, the seeds should be pulped and sown in nursery beds or poly bags. One year old seedlings are suitable for planting.

VANILLA

Propagation

Vanilla is usually propagated by stem cuttings. Cuttings of 60-120 cm long can be selected as planting material for direct planting in the field. Cuttings less than 60 cm should not be used directly for planting. Such cuttings have to be rooted and raised in the nursery before planting. The stem cuttings after collection should be washed thoroughly and given a dip in Bordeaux mixture 1% or copper oxychloride 2 g/l for killing pathogenic fungi, if any. Then the cuttings are stored in a cool shaded place for 2-3 days for partial loss of moisture, a process which enhances rooting. The cuttings can also be stored upto 10 days if required and can withstand long distance transportation. Plants raised from mature lengthy cuttings come to flowering early. Tissue cultured plantlets can also be utilized for planting. However, sufficiently grown up plantlets should be used.

Planting and after care

Vanilla can be raised either as a monocrop or as intercrop in coconut and arecanut gardens. It is usually trained on trellies or on low branching, rough barked trees like *Glyricidia maculata, Plumaria alba,* Jack (*Artocarpus heterophyllus*), *Erythrina* spp., etc. or on dead standards. In some places arecanut is also used for trailing vanilla. The standards have to be planted well in advance at a spacing of 1.2-1.5 m within rows and 2.5-3.0 m between rows. Approximately 1600 to 2000 standards can be accommodated in a hectare. If dead standards are used, shade should be provided to the vines initially by planting banana or suitable plants. The vanilla plants after trailing to a height of 1.5 –2.0 m should be allowed to trail horizontally on poles/trellies tied to trees or coiled around the branches so as to facilitate hand pollination and harvesting. Flowering will not occur as long as the vines climb upward.

The shade trees should be regularly pruned to maintain a light shade. It is advisable to give an umbrella shape for the supporting trees to provide better shade and protection to the vines. The pruned leaves and branches can be applied as mulch.

Planting of cuttings should be taken up preferably during September/November. The cuttings are planted in shallow pits, filled with humus and mulch, raised above the soil surface to avoid water stagnation. The cuttings should be planted with two nodes below the soil surface and at the rate of two cuttings per standard. It is advisable to provide adequate

shade to the newly planted cuttings. A thick mulch of leaves should be provided immediately after planting. The cuttings sprout within 4-8 weeks.

Inter-cultivation is not generally recommended. However, occasional slashing of weeds is beneficial. Care should be taken not to disturb or damage the roots during cultural operations since they are mainly confined to the surface layer of the soil. Regular mulching combined with irrigation during summer increases growth and yield.

Perennial spice crops such as black pepper, nutmeg , cinnamon, clove, all spice, cambodge ,vanilla and curry leaf can be propagated by seeds as well as by vegetative methods. The best method suited to each crop and may be chosen depending on the multiplication rate, cost effectiveness, skilled labour availability , uniformity in the field establishment, pre bearing period, etc.,. Maintaining pest and disease free mother gardens for collecting cuttings or scion is important. Potting mixer is important for any nursery, the composition may vary with availability of components such as compost, FYM, coirdust, soil, sand etc. Good media should free from pest and pathogen, support young plants in nursery with adequate nutrients, moisture and anchor for good growth. Quality planting material is very essential for successful establishment of plantations and accredited nursery would ensure the quality. All those who involved both government and private in the value chain should put earnest effort to produce and supply high quality material by using efficient production techniques.

6. BLACK PEPPER IN PLANTATION BASED CROPPING SYSTEM

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Black pepper is popularly known as the "**King of Spices or Black Gold"** belongs to the family Piperaceae. Its original home is the dense evergreen forests of Western Ghats in South India. The flavor and fragrance of this oriental spice had a magic spell in human civilization and culture since very ancient days. The King of Spices Black pepper is being cultivated in Andaman and Nicobar Islands. Black pepper is the dried matured berry fruit of the climbing vine. White pepper is also produced from the matured berry by removing the skin and dried to make it more attractive. Black pepper occupies an important place in our food as spices and also has a very high export potential.

Black Pepper in Multiple Cropping Systems

In Andaman & Nicobar Islands, Black pepper can be cultivated as multiple cropping. Multiple cropping is a system in which two or more crops are grown in the same field in a year, at the same time, or one after the other, or in combination of both. The pepper crop is very much prone to the vagaries of monsoon and incidence of pests and diseases, etc. The price fluctuation is so much, that the returns from monoculture of pepper do not compare favorably with those from other commercial crops Such observations emphasize the urgent necessity for optimum utilization of pepper holdings to enhance the level of income per unit cropped area. In this context, it is important to utilize effectively the available space of the pepper holdings for raising additional crops to augment the income from unit area.

Pepper arecanut/Coconut system, where pepper is grown on arecanut /coconut palms, the main crop. Here also pepper grows to heights of 8-10 m. It can be grown on the palms and also can be raised in between the palm rows using live/dead stands if the availability of sunlight is sufficient inside the plantation. Pepper is usually trailed on old coconut palm trunk as a standard. In this case, rooted pepper plants are planted away from the coconut base. As and when the vines grow, they are trailed along the ground and taken on to the trunk of the coconut.

As the vines climb up the trunk, the pepper canopy is restricted to about 4-5 m height from the ground so that climbing on the palm for harvesting may not be hindered. All pepper cultivars are not suitable for inter or mixed cropping. For example, the hybrid Panniyur-1 requires bright sunlight for proper flowering and fruiting. Varieties like Sreekara or Subhakara (selections from cv. Karimunda) are more tolerant to shade and hence are useful for mixed cropping.

Cultivation practices

Climate & Soil

Humid tropical climate with well distributed rainfall, as high humidity is congenial for the crop. An annual rainfall of 2000-3000 cm and a dry spell of 30-45 days before flowering with the *onset* of rain is ideal for its cultivation. The average temperature of 18^0 C to 28^0 C is best suited. Black pepper thrives best on virgin, well- drained soil rich in humus. Pepper is grown in red loam, sandy loam, clay loam and red lateritic sandy clay loam soils with pH of 4.5 to 6.0.

Varieties

There are three leading varieties in these Islands namely Panniyur-I, Panniyur- II, and Panchami.

Panniyur 1: Suited to all regions. Not suited to heavily shaded areas. Average yield is 1242 Kg/ha. Oleoresin is 11.8 %. Piperine is 5.3 %. Essential oil is 3.5 %.

Panniyur 2: Shade-tolerant variety of black pepper. Average yield is 2570 Kg/ha. Oleoresin is 10.9 %. Piperine is 6.6 %. Essential oil is 3.4 %.

Panchami: Late-maturing, suited to all pepper-growing regions. Average yield is 2828 Kg/ha. Oleoresin is 12.5 %. Piperine is 4.7 %. Essential oil is 3.4 %.

Though all the varieties are performing quite well, Panniyur-1 is well adopted by the farmers of this island.

Propagation

Pepper is propagated through shoot cuttings. 2-3 noded cuttings of runner shoots are generally used. The lateral shoots on rooting give rise to bush type black pepper. The runner shoots are separated from vines during Feb-March and after trimming leaves, cuttings with 2-3 nodes each are planted either in nursery beds or in polythene bags filled with fertile soil, so that they would be ready for planting by June- July.

Planting

Black pepper can be cultivated either as a monocrop or as a mixed crop**.** Black Pepper, being a climber needs supporting tree for climbing Arecanut, Erythrina, Jack, Mango, Silk cotton or any other rough barked tree which does not peal out the bark and which is already available in the garden including coconut can be used as standard for pepper in a mixed

homestead farming. But in a monocropping system, live standards should be raised before planting the cuttings in the main field.

Pits of 45 cm long, wide and deep may be made about 60 cm away from the base of the supporting tree on northern side, during Feb- March and filled back with the top soil, dry leaves and compost or farm yard manure. Addition of Organic manure and cattle manure to the pits would develop the basic fertility to encourage quicker growth. The live standards are used at a spacing of 2.7 m x 2.7 m accommodating 2200 vines/ha @ 2 cuttings planted at the base per standard. Plant density in a monocropping system is 1,100 vines/ha but in a mixed cropping system, it is 540–560 vines/ha.

Two rooted vines with at least 4-5 nodes are planted at the centre of the pit, in such a way that one node is within the soil so as to facilitate proper rooting in June-July with the onset of south-west monsoon. The vines may be tied to the stakes slanting towards the standard tree.

Training/Pruning

As the cutting grows, the shoots are tied to standard as often as required. Pepper plants when young, needs shade either natural or artificial. This is normally done in March–April every year. But, too much shade during flowering, defers fruit setting because the raindrops are required to function as the pollinating agent. The young vines should be protected from hot sun during summer by providing shade using coconut leaves. Adequate mulch with green leaf should be given (before the monsoon) after digging around standards at 1m radius. It is, a good practice to bring down the vines after one year and bend them one round and embed in the soil to provide more root zone and also to lessen the fruiting height. Major purpose of this practice is to remove excessive over-growth of the live standards and to give them a proper shape. The effective height of the standards is to be limited to 6 meters.

Manuring & Fertilization

Manuring the soil around the plants twice a year is a good practice i.e. the first half before monsoon in May and second half after monsoon in October to November. NPK at 100:40:140gm per vine per year i.e. 200 urea, 220 gm Rock phosphate and 230 gm Murate of potash per vine per year may be applied in two doses. The first half in April -May with the onset of Monsoon and the second half in Sept-Oct. The fertilizers are applied at a distance of about 3cm all around the vine and at a depth of about 15cm. The soil is forked in after application. One third of the recommended dose is applied during the first year, which is increased to two-third in the second year. and full dose is given third year onwards. 10 kg of cattle manure

compost per vine in May after % years of planting is also recommended. Application of lime @ 500g per vine during April.-May in alternate years is also recommended.

After Care

Carry out digging around the standards and vines at 1 m radius from the base or in the entire plantation, twice during the year, the first at the onset of monsoon and the second towards the end of north-east monsoon. Weeding around the plant is to be done as per necessity. In the early stages, the vines are tied to the standards. Lowering of the vines after 1 year's growth promotes lateral branch production.

The young plant may be completely covered with dry arecanut leaves, coconut leaves or twigs of trees until summer months are over. Mulching the basins of pepper vines during summer months is highly advantageous. Sawdust, arecanut husks and dry leaves are suitable mulching materials. Removal of unwanted terminals, shoot growth and hanging shoots should be done as and when necessary. Prune and train the standards in March-AprIl every year to remove excess over growth and to give them a proper shape. The effective height of the standards is to be limited to 6m. A second pruning of the standards is done in July-Aug, if there is an excessive shade in the garden. After regular bearing for about 20 years, the vines of most varieties start declining in yield. So under planting should be attempted at about 20 years after planting or when a regular declining trend in yield appears. The old and senile vines must be removed 3~5 years after under planting, depending on the growth of young vine.

Irrigation

Frequent irrigation from November-December till the end of March is recommended and afterwards, irrigation must be withheld till monsoon break. This may increase pepper yield by about 50%. Basins should be mulched soon after irrigation to prevent moisture loss.

Harvest & Yield

Black pepper starts yielding from third year after planting. Black pepper has an economic life of over 20 years and after regular bearing for about 20 years, the yield start declining. So, under planting is highly recommended and the old and senile vines must be removed 3–5 years after new under planting, depending on the growth of young vine. The major products are white pepper, canned tender green pepper and bottled green pepper in brine, dehydrated green pepper, and pepper oleoresin and pepper oil.

It flowers during June-July and ready for harvest during December January, when one or two berries in few spikes turn orange or red. Hand picking is the common practice for

harvesting. Berries are separated from the spikes and sun dried for 5- 7 days after their separation from the spike by threshing. Normally, single pole bamboo ladder is used as a support for harvesting. If the berries are allowed to over ripe, there is heavy loss due to berry drop and damage by birds. Harvested spikes are generally collected in clean gunny bags. Spikes which are fallen onto the ground may be collected separately, cleaned and then pooled to the general lot.

To give a uniform lustrous black colour to the finished product and to prevent moldiness of the berries, a heat treatment is recommended. Suitable quantities of separated berries are collected in a perforated basket/ vessel or clean gunny bag. Dip the berries along with the container in-boiling water for one minute, take out drain and spread on a- clean surface for sun drying.

White pepper is produced by collecting fully matured berries (yellow or orange), retting them in clear water for 7 days for removing the outer skin completely and dry the berries after thorough washing and cleaning. Black pepper starts yielding from third year onwards. The average yield per plant would be 5-8 kg of green Pepper, which on drying comes to 25% -30% dry pepper.

Product Stage of maturity at harvest

Canned pepper: 4-5 months

Dehydrated green pepper: 10-15 days before maturity

Oleoresin and essential oil: 15-20 days before maturity

Black pepper: Fully mature and 1-2 berries start turning from yellow to red in each spike

Pepper powder: Fully mature

White pepper: Fully ripe

Post harvest processing

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

Threshing

Threshers with capacities varying from 50 kg/h to 2500 kg/h are available which can thresh quickly and provide clean product.

Blanching

The quality of the black pepper can be improved by a simple treatment of dipping the mature berries taken in perforated vessel in boiling water for a minute before drying.

This processing technique has several advantages

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

Drying

Pepper has moisture content of 65% to 70% at harvest, which should be brought to safer levels of 10% by adequate drying.

The green colour of matured pepper is due to the presence of chlorophyll pigment. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on concrete floor and dried under sun for 3-5 days to bring the moisture content below 10%. Dried black pepper with high moisture content (>12%) is susceptible to fungal attack. Mycotoxins produced by the fungal attack render the pepper unfit for human consumption. In order to achieve a quality dry product, pepper berries are spread on clean dry concrete floor / bamboo mats / PVC sheets and dried in the sun for a period of 4 - 6 days. The average dry recovery varies between 33-37% depending on the varieties and cultivars.

Cleaning and grading

The threshed and dried black pepper has extraneous matter like spent spikes, pinheads, stones, soil particles etc. mixed with it. Cleaning and grading are basic operations that enhance the value of the produce and help to get higher returns. Cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such units consist of a fan / blower and a feeding assembly. The fan is placed at the rear end of the hopper.

Cleaning is achieved by feeding the material through the hopper into a stream of air blowing in perpendicular direction. The lighter fractions (dust, immature berries, pin heads and spent spikes) are blown away. Grading of black pepper is done by using sieves and shifting black pepper into different grades based on size.

White pepper

It is generally prepared by retting (with frequently changing of water) fully ripened red berries for 7-8 days followed by removal of outer skin, washing and drying to a moisture level of 12%. White pepper is also prepared by fermentation using matured green pepper and black pepper.

Packaging

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

Storage

Black pepper is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity may result in mould and insect infestation. Before storage it is to be dried to less than 10 per cent moisture. The graded produce is bulk packed separately in multi layer paper bags or woven polypropylene bags provided with food grade liners or in jute bags. The bags are arranged one over the other on wooden pallets after laying polypropylene sheets on the floor.

7. IMPROVED PRODUCTION TECHNOLOGIES FOR MAXIMISING CINNAMON PRODUCTIVITY

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Cinnamon *(Cinnamomum verum*) (Family: Lauraceae) is one of the earliest known spice which is a native of Sri Lanka. True cinnamon of commerce is the dried inner bark of *Cinnamomum verum* and is used as spice. Sri Lanka is the major producer of cinnamon. Cinnamon was introduced into India by the Britishers in the 18 th century.

Cinnamomum verum is mainly cultivated in Sri Lanka. Cinnamon is also cultivated in Malagasy Republic, Seychelles, India and Madagascar. In India it is cultivated in Kerala, Karnataka, Tamil Nadu, Maharastra, and in Andaman and Nicobar Islands in a limited scale. Sri Lanka is the world's largest producer and exporter of cinnamon. Cinnamon grown in Sri Lanka is considered to be the best in the world.

The commercial products of cinnamon is the dried inner bark which are graded and marketed as quills, quillings, featherings and chips. The other commercial products obtained from cinnamon are cinnamon bark oil, cinnamon leaf oil and bark oleoresin. Cinnamon is widely used as a spice and is employed mainly in food industry for culinary prurposes. Besides flavouring industry, cinnamon is also used in the pharmaceutical and perfume industry. Cinnamon forms a major constituent of the traditional medicines of India and China. Cinnamon is used to treat anorexia, inflammation, menorrhagia, and to treat menstrual disorders. It is also reported to have antioxidant and antimicrobial properties. Leaf oil and bark oil are used in perfumes, soaps, tooth pastes, face creams etc in perfume industry.

Climate and Soils

Being a hardy plant, cinnamon tolerates a wide range of soil and climatic conditions. 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. . The ideal temperature for growing cinnamon is between 20-30^{o} C. The quality of cinnamon is influenced by the soil and the climatic conditions.

Varieties

Efforts have been made to develop high yielding varieties of cinnamon for different regions and at present seven varieties of cinnamon are available for cultivation in various parts of the country. The details are provided (Tables 1-6).

Table.1. Varieties of cinnamon available for cultivation in India

Varieties	Institute /organization from where released	Year of release
IISR Navashree	Indian Institute of Spices Research, Calicut	1996
IISR Nithyashree	Indian Institute of Spices Research, Calicut	1996
YCD- 1	Horticultural Research Station, Tamil Nadu Agricultural University, Yercaud , Salem District	1996
PPI (C) 1	Horticultural Research Station, Tamil Nadu Agricultural University, Pechiparai, Kanyakumari District	2002
Konkan Tej	Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra	NA
RRL (B) C-6	Regional Research Laboratory, Bhubaneswar, Orissa	NA
Sugandhini (ODC-130)	Aromatic and Medicinal Plants Research Station, Kerala Agricultural University, Odakkali, Ernakulam District, Kerala	2000

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

Variety	IISR Navashree	IISR Nithyashree
Pedigree	Seedling selection from Sri Lankan collections	Seedling selection from Indian collections
Areas of adoption	All cinnamon growing areas in India	All cinnamon growing areas in India
Harvest	Three years for first harvest	Three years for first harvest
Average yield	200 kg dry quills / ha	200 kg dry quills / ha
Bark oil (%)	2.7	2.7
Leaf oil (%)	2.8	3.0
Bark oleoresin (%)	8.0	10.0
Bark recovery (%)	40.6	30.7
Cinnamaldehyde in bark oil (%)	73	58
Cinnamaldehyde in leaf oil (%)	15	14
Eugenol in bark oil (%)	6.0	5.0

Eugenol in leaf oil (%)	62	78
Height of tree at 5 years (m)	5-7	5-7
Trunk girth at 5 years (cm)	30	45
Colour of young flushes	Light purple turning to green in 8 – 10 days	Light purple turning to green in 2-4 days
Leaf length and breadth (cm)	13.4/4.69	15.40/5.70
Nature of flowering	Terminal and axillary	Terminal and axillary
Time taken for flowering	4 years	4 years
Shoot regeneration capacity	25.45 shoots/4 plants	18.90 shoots/4 plants
Yield of dry bark per plant (g)	201.1	194.6
Colour of dry bark	Light brown	Light brown
Resistance to major pests and diseases	No major pest or disease attack was noticed	No major pest or disease attack was noticed
Special characteristics	A selection with high shoot regeneration capacity. Higher cinnamaldehyde and oleoresin in bark.	A selection with high shoot regeneration capacity. Gives quality quills. Bark oil, leaf oil and oleoresin contents high, giving good aroma and taste.

Table 3. Characateristics of cinnamon varieties released from Tamil Nadu Agricultural University

Variety	YCD- 1	PPI (C) 1
Research station	Horticultural Research Station, Yercaud , Salem District	Horticultural Research Station, Pechiparai, Kanyakumari District
Year of release	1996	2002
Pedigree	OP progenies	OP progenies obtained from IISR
Areas of adoption	High ranges of Tamil Nadu at an altitude range of 500-1000 m above MSL	Suitable for high rainfall area and lower elevations ranging from 100-500 m in Tamil Nadu

Harvest	Three years for first harvest	Four years for first harvest
Average yield	360 kg dry bark/ha	973 kg fresh bark/ ha
Bark oil (%)	2.8	2.9
Leaf oil (%)	3.0	3.3
Bark recovery (%)	35.3	34.22
Colour of young flushes		Purple turning pale green in 4-7 days
Shoot regeneration capacity	19.2 shoots/year	32 shoots/year
Resistance to major pests and diseases	Resistant to major pests and diseases	Resistant to major pest and diseases
Special characteristics		Drought tolerant, high yielding

Table 4. Characateristics of cinnamon variety Konkan Tej

Variety	Konkan Tej
Research station	Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra
Year of release	NA
Pedigree	OP seedlings
Areas of adoption	Konkan region in Maharastra
Average yield	378.30 g fresh bark/ plant
Bark oil (%)	3.20
Leaf oil (%)	2.28%
Bark recovery (%)	29.16
Cinnamaldehyde in bark oil (%)	70.23
Cinnamaldehyde in leaf oil (%)	75.5
Eugenol in bark oil (%)	6.93

Table 5. Characateristics of cinnamon variety Sugandhini

Variety	Sugandhini (ODC-130)
Research station	Aromatic and Medicinal Plants Research Station, Kerala Agricultural University, Odakkali, Ernakulam District, Kerala
Year of release	2000
Pedigree	Sri Lankan type obtained from a farmer in Wayanad. Single tree selection
Areas of adoption	Central zone of Kerala
Harvest	18.34 kg fresh leaves/tree/year
Average yield	1.2 kg fresh /tree/year
Bark oil (%)	0.94
Leaf oil (%)	1.6
Bark recovery (%)	51
Cinnamaldehyde in bark oil (%)	45

Table 6. Characateristics of cinnamon variety RRL (B) C-6

Variety	RRL (B) C-6
Research station	Regional Research Laboratory, Bhubaneswar, Orissa
Pedigree	OP seedling progenies
Leaf oil (%)	0.8
Eugenol in leaf oil (%)	94

Propagation

Propagation of cinnamon is by cuttings as well as through air layering. 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 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.

Cinnamon can also be propagated through seeds. In such cases variability is observed among the seedlings. Normally 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.

Planting/ Planting Density

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 air layers are used. In each pit 3-4 seedlings or rooted cuttings or air layers 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.

Training/ Pruning

The cinnamon tree attain a height of 10-12 meters if left to grow without coppicing. But when cinnamon is cultivated, the trees have to be coppiced or cut back periodically to harvest the spice. When the plants are two years old they are cut back to a height of 25 cm from the ground during June- July. The stump is then earthed up to encourage side shoot production. The side shoots so produced are cut back during Septemnber to November, in the fourth or fifth year for extraction of cinnamon bark depending upon the thickness of the shoot. This process is repeated after every harvest. This process will help the plant to assume the shape of a low bush of about 2 to 2.5 m height with lot of shoots for harvest. Coppicing is done in cinnamon in alternate years.

Nutrition

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.

Irrigation

Cinnamon is commercially cultivated as a rainfed crop. But an annual rainfall of 200–250cm is ideal. In the initial 2–3 years, watering is given during summer months twice a week. The quantity of water depends upon the soil moisture level and growth of plants. However, 8 to 10 liters of water can be given during summer months in the initial years. Irrigation can also be provided through drip or sprinklers depending upon the availability.

After care/ culture

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.

Management of Diseases and Pests

Diseases

Leaf spot and die back

Leaf spot and die back disease are 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 the 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%.

Insect pests

Cinnamon butterfly

The cinnamon butterfly (*Chilasa clytia*) is the most serious insect 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 arrow head shaped spots on outer margins; the other form has black wings with elongated bluish white markings. Fully-grown larvae are dark brown with pale yellow 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 is more common during the monsoon period and generally nursery seedlings are seriously affected. The adult is a minute silvery grey moth with a wing span of 5 mm. 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.

Quality Improvement

Spice importing country has developed quality requirement specifications which is adopted for import and export of spices. American Spice Trade Association (ASTA), United States Food and Drugs Administration (USFDA), European Spice Association (ESA), British Standard Institution (BSI), International Organization for Standardization (ISO) Essential Oil Association (EOA) etc. are agencies providing spice quality regulations. The quality specifications has to be maintained to avoid rejection of the product from export market. Quality of cinnamon is determined by its physical and chemical characters, presence or absence of foreign materials, pesticide residue, heavy metals, sulphur dioxide, solvent residues and retention of chemical principles like volatile oil, alkaloids, oleoresins etc. Post harvesting processing has a major role to play in producing quality product. Hence, emphasis has to be given for post harvest processing for production of quality products which satisfies the cleanliness and quality specification for cinnamon.

Mechanization

No mechanization is used for harvesting or peeling of cinnamon. However, tractors are used for initial field operations and for transporting the coppiced shoots. Generally, cinnamon is sundried. But artificial dryers are used for drying cinnamon. These dryers are either electric, solar or fuel operated. For extraction of cinnamon bark oil, bark oleoresin and leaf oil mechanization is adopted.

Harvesting

Coppicing for bark extraction can be commenced from the fourth or the fifth year of planting depending upon the growth of the plant. The harvesting practices differ slightly from country to country but the basic principles are the same.The shoots are harvested from September to November. 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 and carried to the peeling shed.

Post Harvest Management

Processing

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 shoots cut in the morning are peeled on the same day. The rough outer bark is first scrapped off. Then the scrapped portion is polished with a brass, wooden 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 curled pieces of peeled inner bark are next assembled into compound quills or pipes by placing one quill inside the other. The best and longest quills are used outside and the inside is filled with smaller pieces of bark. The compound quills are then rolled by hand to press the outside edges together and the ends are neatly trimmed with a pair of scissors once the required length of 107 cm is attained.

The compound quills are dried in shade and sun alternately till they dry sufficiently. A moisture content of 12% is recommended for dried quills.

Grading

The best grade of cinnamon is quills. Quills are long compound rolls of cinnamon bark measuring more than 107 cm long. The lower grades of cinnamon exported are quills, featherings and chips.

Quillings: The small pieces of the bark (5–20 cm long), left after preparing the quills are graded as quillings.

Featherings: The very thin inner pieces of bark or twisted bark are graded as featherings.

Chips. Chips are trimmings of quills or the bark of coarser canes that are scraped off, instead of peeling. The bark that is scraped off without removing the outer bark is known as *unscrapped chips* and that scrapped after removing the outer bark are *scrapped chips*.

Cinnamon powder: The different grades of bark are powdered to get cinnamon powder.

Standards

The quality of the product is dependant on the thickness of the bark, their appearance and the aroma and flavour. The quills are graded from '00000', being the finest quality, to '0' the coarsest quality. Any pieces of bark less than 107 cm long is categorized as quillings.

According to the Sri Lankan system of grading the cinnamon quills are graded into four groups (Table 7).

Alba (Less than 6 mm in diameter); *Continental*; *Mexican*) and *Hamburg* grades. These groups are further divided into specific grades, as follows

Fine/continental grades (6–19 mm diameter*)*

C- 00000 special (Thinnest)(6 mm); C-00000 (10 mm); C-0000 (13 mm); C-000 (16 mm) C-00 (17 mm); C- 0 (thickest) (19 mm).

Mexican grade (16 mm diameter)

M00000 special, M00000 and M0000 depending number of quills per kg. Mexican grade is intermediate in quality between Fine and Hamburg grades.

Hamburg grade (23–38 mm diameter)

H-1 grade (23 mm); H-2 (25 mm); H-3 (38 mm).

Table 7 . Classification of cinnamon quills, type Sri Lanka

Commercial designation of the grades and qualities	Diameter of quills (mm) (max)	Number of whole quills (1 050 mm) per kg (min)	Extent of foxinf1 % max. 2	Minimum length of quills in a bale 3 mm	Pieces of tubes and broken pieces of the same quality per bale% (m/m) max
Alba	6	45	Nil	200	1
Continental C 00000 Special C 00000 C 0000 C 000 C 00 C 0	 6 10 13 16 17 19	 35 31 24 22 20 18	 10 10 10 15 20 25	200	1
Mexican M 00000 Special M 00000 M 0000	 16 16 19	 22 22 18	 50 60 60	200	2
Hamburg H1 H 2 H 3	 23 25 38	 11 9 7	 25 40 65	150	3

Marketing

The dried quills are tightened into small bundles, each bundle containing about 30-40 quills. The edges are then trimmed making them into ready for marketing. For wholesale export the quills are packed in compact cylindrical bales of 50 kg. Whole cinnamon should be packed in clean, sound and dry containers and stored in cool dry place to prevent loss of volatile oil and aroma, for marketing the flavour of cinnamon shall be fresh and characteristic of the spice of the origin concerned. Cinnamon, whole, should have fresh aroma, and delicate and sweet flavour characteristic of the spice. The material should be free from foreign odour including mustiness. The cinnamon, whole, should be free from living insects and moulds and practically free from dead insects, insect fragments and rodent contamination visible to

the naked eye. The proportion of extraneous matter like dust, stones, earth, stem, leaves, and outer bark of the shoots of cinnamon plant shall not exceed the limits prescribed in Table 2 for the relevant grades, when determined in accordance with the method given in of IS 1797: 1985.

Packing

Whole cinnamon

Whole cinnamon shall be packed in clean, sound and dry containers made of a material, which does not affect the product or its flavour.The different commercial classes are usually packed as follows:

- Cinnamon, type Sri Lanka: in cylindrical bales of about 45 kg:
- Cinnamon, type Seychelles and type Madagascar: on bales of about 50 kg;
- Cinnamon, type Seychelles quills and quillings : in wooden boxes of about 100 to 150 kg.

Cinnamon powder

Cinnamon powder shall be packed in the same type of containers as specified for whole cinnamon. In addition, the containers shall protect the cinnamon powder against moisture and loss of volatile matter Following particulars like (a) Name of the product and grade designation; (b) Variety or the trade name; (c) Net mass; (d) Date of packing;(e) Producing country (f) Name and address of the manufacturer or any other details required by the purchaser shall be marked or labeled on the container.

Value Addition

In addition to cinnamon various other products are obtained from this tree namely, bark oil, leaf oil, bark oleoresin, cinnamon powder, root bark oil. Bark oil is extracted by steam distillation. The bark oil is graded based on the cinnamaldehyde content. Bark oil is a pale yellow to dark yellow liquid with a strong, warm, sweet, spicy odour and a sweet pungent taste. The major constituent of bark oil is cinnamaldehyde. Leaf oil is obtained by steam or water distillation of leaves. The leaf oil is rich in eugenol and is a yellow to brownish liquid with a warm, spicy odour. Oleoresin is prepared by extracting cinnamon bark with a variety of organic solvents. The quills and other broken bark pieces are powdered and used as cinnamon powder.

8. IMPROVED PRODUCTION TECHNOLOGIES FOR MAXIMISING CLOVE PRODUCTIVITY

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The clove of commerce is the aromatic, dry, fully grown, but unopened flower buds of the clove tree (*Syzygium aromaticum* (L.) Merrill & Perry (Synonymn: *Eugenia caryophyllata* Thunb., *Eugenia caryophyllus* (Sprengel) Bullock & Harrison). The word clove was derived from the French word *clou* which means nail, as the dried clove appears like tiny nails. Dried fully mature but unopened flower buds are the spice of commerce. Besides clove, the clove oil obtained from bud, stem and leaves and the oleoresin from bud and stem also has commercial value. The essential oil of clove is rich in eugenol, which has medicinal properties.

Origin and distribution of clove

Clove is a native of Moluccas, in Indonesia. It is grown in Indonesia, Zanzibar, Madagascar, Sri Lanka, India, Reunion Island, Seychelles, Mauritius and Jamaica. Clove was introduced into India around 1800 A.D. by the East Indian Company in their spice garden in Courtallam, Tamil Nadu. From there, the clove cultivation extended to the high ranges of Nagercoil in Kanyakumari District of Tamil Nadu, Thiruvananthapuram and Kollam to the Mekkara hills in Thirunelveli District. At present, the important clove growing states in India are Kerala (Quilon, Trivandrum, Calicut, Kottayam districts), Tamil Nadu (Nilgiris, Kanyakumari, Nagercoil, Ramanathapuram, Tirunelveli and Kanyakumari districts), Karnataka (South Kanara District), Maharashtra (Ratnagiri District) and Andamans.

Production

Indonesia is the major producer of clove followed by Zanzibar and Madagascar. Indonesia produces about 60% of the clove. UAE, Japan, UK, Singapore, Kuwait, Saudi Arabia, Vietnam USA, India West Germany and France are the major importing countries.

Clove is an important spices used all over the world for its flavour and medicinal values. Food processing industry uses both whole and ground form of cloves in various preparations. Clove oil is used in perfumeries, pharmaceuticals and flavouring industries. Clove oleoresin is used in the food processing industry. It is used to treat flatulence, indigestion and nausea. In Indonesia, the major part is used for making *kretek* cigarettes. The clove oil is used in microscopy and is also a local anesthetic for toothaches. It is a strong antiseptic and preservative. The major constituent in clove oil is eugenol and it has immense use in medicine and perfume industry.

Climate and Soils

Clove requires a warm humid climate having a temperature of 20 to 30^{0}C. It thrives well in areas receiving a well distributed annual rainfall of 150-300 cm. In India, clove grows from sea level up to 1500 m above sea level and also in areas having proximity to sea. A cooler climate with well distributed rainfall is ideal for flowering. Hot summer or very cold winters are not ideal for clove as clove do not flower under such conditions.

Clove grows well in rich loamy soils of the humid tropics and can be grown successfully in the red soils. The site selected for cultivation of clove needs good drainage since the crop cannot withstand water logged conditions. Sandy soil is not suitable.

Varieties

PP1 (CL-1)is a high yielding clove variety released from Horticultural Research Station, Pechiparai, Tamil Nadu Agricultural College. Clove plantations in India are reported to have originated from a few seedlings obtained originally from Mauritius and hence much variability is not seen in the population mainly due to the self pollination nature of the crop.

Propagation and Rootstock

Seed propagation is commercially practiced in clove. High yielding trees are selected and marked during the flowering season. Seeds are collected from selected high yielding trees for propagation. The seeds become available from June to October. 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. The seeds loose their viability if sored for long time after harvest.

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.

Approach grafting of clove on its own rootstock is a vegetative propogation method adopted in clove but is not commercially practiced.

Planting/ Planting Density

Clove can be grown as a pure crop or as an intercrop in coconut, arecanut or coffee . 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 7 m. Eastern and northeastern hill slopes, well drained valleys and river banks are ideal for clove. If planted as an intercrop, the spacing has 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. In order to give a cool humid microclimate, intercropping with banana is ideal.

Training/ Pruning

Training and pruning are not recommended in clove plantations. Pruning is not effective in inducing low branching and is not common in any areas. Occasional thinning, however, helps in preventing overcrowding of branches in full-grown trees. Diseased and dead shoots are systematically removed without injuring trees.

Nutrition

Manuring and after cultivation

Clove trees are to be manured regularly and judiciously for their proper growth and flowering. 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. Mulching of trees with fallen leaves and application of river-silt are also beneficial.

Irrigation

Irrigation is necessary for clove but water logging has to be avoided. Watering is essential in the initial stages in the absence of rains. Irrigation should be given during summer months. Applying 8-10 litres of water daily either through drip or through basin irrigation during the months of January - May is essential for proper growth.

After care/ culture

Provide shade for seedlings in the initial years. Weed the basins as and when necessary. Banana can be grown to provide shade during the initial establishment or even artificial shade regulation mechanisms can be adopted till the plant establishes. Mulching of plant basins with dried leaves or any other mulching material is an essential practice for clove cultivation. Weeding is also an important intercultural operation and must be carried as and when required to keep the field weed free.

Management of Diseases and Pests

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. Fully grown larvae are creamy white with a black head and measures about 8.5 cm in length. To control the damage caused by the pest, 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 paste 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 (*Mycetaspis personata*) 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 dimethoate(0.05%) is effective for the management of scale insects.

Quality Improvement

For clove not much of research has been done on quality improvements. But for maintaining the export quality standards farmers take precaution for producing quality produce as detailed in Tables 2,3 and 4.

Mechanization

Normally clove is hand picked asn no mechanization is available in clove harvest. However, dryers are used for drying clove, machines are used for powdering and for oil and oleoresin extraction. Mechanization is adopted to a certain extent in land preparation for planting clove.

Post Harvest Management

Harvesting and processing

Clove trees start flowering from the fifth year of planting under good soil and management conditions. Flower buds are produced on young flush. It takes about 4 to 6 months for the buds to become ready for harvest. 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 and as they turn from green to slight pink. At this stage, they are less than 2 cm long. The opened flowers are not valued as a spice. Timely harvest of flower buds are essential to maintain the quality of the cured produce. Delay in picking also leads to pollination of flowers and fruit development. Picking is done by hand by climbing the tree or using ladders. Bending of branches or knocking off of bud-clusters with sticks is not desirable, as rough handling of trees affects the yield during succeeding years.

A clove inflorescence contain on an average 12-20 flower buds. The harvested flower buds are separated from the clusters by hand and spread in the drying yard on mats for drying. It takes normally 4 to 5 days for drying. Cloves are generally dried in sun or in artificial dryer. 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. A 15 year old tree gives an average of 6 kg fresh clove. The yield progressively increase as the age of the tree increases. The economic life of a clove tree is considered as 60-65 years. A good high yielding tree of 40 years grown under ideal condition and under proper management condtions gives an average yield of 60 kg fresh.

Inorder to produce quality produce care has to be taken to maintain hygienic conditions while drying, packing and storing clove. The cloves has to be dried immediately after harvest. Delayed drying causes fermentation and results in poor quality product. The clove is generally dried in sun or in artificial driers. The clove has to be raked and turned frequently for uniform drying. A well dried product would have a dark brown colour. It takes about 4 to five days for drying. Good quality cloves should be whole, unbroken and stalkless and must not contain any woody, and brittle cloves and should have a strong aroma and spicy odour and characteristic flavour. The product should be free from living insects and moulds, and shall be practically free from dead insects, insect fragments and rodent contamination. The ISO specifications are detailed in Tables 2, 3 and 4. The pesticide residues and metallic contaminants in the product shall also not exceed the limits as prescribed in the Prevention of Food Adulteration Act, and the Rules.

The clove buds are dried and cleaned free of any extraneous matter before they are stored. They are stored in air tight, moisture proof containers away from sun light. The produce has to be checked frequently for any damage or moisture inside the container. If moisture is observed they have to be dried again to a moisture level of 10 % and re packed.

The storage room should be clean, dry, cool and free from any pests. Strong smelling detergents, paints etc. should not be stored along with clove as it would affect the aroma and flavor of clove.

Table 2. Classification of whole clove (ISO 2254)

Grade	Headless clove(% Max.)	Tendrils, mother of cloves(% Max.)	Khoker cloves (% Max)	Extraneous matter (% Max.)
1 Special (hand picked)	2	0, 5	0,5	0,5
2	5	4	3	1
3	Not specified	6	5	1

Table 3. Chemical requirement of whole clove (ISO 2254)

Characteristic	Requirment	Test method
Moisture, (Max.%) (mass fraction)	12	ISO 939
Volatile oil, ml/100 g on dry basis,min. grade 1 &2	17	ISO 6571
Volatile oil, ml/100 g on dry basis,min. grade 3	15	

Table 4. Chemical requirement for ground (powdered) cloves (ISO 2254)

Characteristic	Requirment			Test method
	Grade			
	1	2	3	
Moisture, (%)(mass fraction), Max.	10	10	10	IS0 939
Total ash, %(mass fraction) on dry basis, Max.	7	7	7	IS0 928
Acid-insoluble ash, % (mass fraction) on dry basis, max	0,5	0,5	0,5	IS0 930
Volatile oil, %(mass fraction) on dry basis, Min.	16	13	14	IS0 6571
Crude fibre,%(mass fraction), Max.	13		13	IS0 5498

PACKING AND MARKETING

Cloves, whole and ground, shall be packed in clean, sound and dry container made of metal, glass, food-grade polymers, wood or jute bags. The wooden boxes or jute bags shall be suitably lined with moisture-proof lining which does not impart any foreign smell to the

product. The packing material shall be free from any fungal or insect infestation and should not impart any foreign smell. Each container shall be securely closed and sealed.

Marketing

The following particulars shall be legibly and indelibly marked or labelled on each container of cloves, whole and ground:

Name of the material, trade-name or brand name, if any; Name and address of the manufacturer/ packer; Batch or Code number; Net mass; Date of packing; Year of harvest;

Best before……. (month/year);

9. GENETIC RESOURCES, CROP IMPROVEMENT AND PRODUCTION TECHNOLOGY OF NUTMEG

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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. 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 is from Indonesia. Grenada is the second largest producer of nutmeg and mace in the world. In India the major areas of nutmeg cultivation are Tamilnadu, Kerala, Karnataka, Goa, Maharashtra and Andaman and Nicobar Islands.

Species diversity

The primitive family Myristicaceae, has about 18 genera and 300 species. The members of the family are pantropical, being associated with the rainforests of Asia, Africa, Madagascar, South America and Polynesia. India has four genera namely *Horsfieldia, Gymnacranthera, Knema* and *Myristica* and altogether 15 species. Table 2. Indicates the wild and related spices of Myristicaceae occurring in India. The members occur in the evergreen forests of Andaman and Nicobar Islands, Meghalaya and the Western Ghats. *Myristica* with 120 species is the largest of the genus and New Guinea has the largest number of species.

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

Ecosystem diversity

The *Myristica* swamps are dominated by members of Myristicaceae. Krishnamoorthy (1960) reported *Myristica* swamp, for the first time, as a special type of habitat from

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

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

Cultivar diversity

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

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

Progeny evaluation aims in analyzing breeding behaviour of certain elite trees for sex ratio and prepotency so that such promising trees are selected for seed/scion collection. Significant differences were observed among the populations for plant height, number of main shoots, number of years for flowering, fruit weight and ratio of mace weight to seed

weight. The phenotypic coefficient of variation is more than the genotypic coefficient of variation, indicating the role of environment in the expression of these characters.

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

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

Table 1. Genetic resources of nutmeg conserved at Indian Institute of Spices Research, Calicut

Crop	Area surveyed	Important species
Nutmeg	Thenmala, Cheekilodu, Balussery, Mannuthy, Sugandhagiri, Munnar (Kerala); Nagercoil, Kolli and Shevroy Hills (Tamil Nadu); Ratnagiri (Maharashtra) Andaman and Nicobar Islands	*Myristica amygdalina* *M. andamanica* *M. attenuate* *M. beddomeii* *M. fatua var. magnifica* * *M. fragrans* *M. malabarica* *M. prainii* *Gymnocranthera canarica* *Knema andamanica*

Promising accessions

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

Quality lines

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

Accessions with high oil yield in nut and mace, high butter content, high oleoresin in nut and mace, high myristicin and elemicin , low myristin and elimicin etc. has been identified from the germpalsm available at Indian Institute of Spices Research and the details are given in Table 3.

Table 2. Members of *Myristicaceae* occurring in India

Members of Myristicaceae	**Distribution**
Myristica amygdalina Wall.	Nagercoil
M. andamanica Hook. f.	Andaman Islands
M. attenuate Wall.	Western Ghats
M. beddomeii King	Western Ghats
M. dactyloides	Western Ghats
M. gibbosa Hook. f. & Thoms.	Khasia Mountains
M. glabra Blume	Silhet (Assam), Tinnevelly (Tamil Nadu), Andaman Islands
M. glaucescens Hook.f. & Thoms.	Tinnevelly, Andaman islands
M. irya Gaertn. Fruct.	Tinnevelly, South Andaman islands
M. kingii hook. F.	Sikkim Himalaya
M. longifolia Wall.	Sikkim, Himalaya, Assam, and the Khasia Hills
M. magnifica Hood. f.	Western Ghats, parts of Tinnevelly, and
M. malabarica Lamk.	S. Karnataka
M. prainii King	Andaman Islands.
Gymnacranthera canarica Warb	Karnataka, Kerala.
Knema attenuate Warb.	Western Ghats
K. andamanica spp. *nicobarica* *K. andamanica* spp. *andamanica*	Nicobar, Andaman Islands.

Table 3. High yielding accession of nutmeg

Category	Accession	Remarks
Essential oil in nutmeg	A9-18	16.5%
Essential oil in mace	A9-18	26.1%
Butter	A11-12	44%
Oleoresin in nutmeg	A9-30 A9-116	5.3%(acetone extract) 23% (ethanol extract)
Oleoresin in mace	A4-22	32.2% (acetone extract)
High myristicin & elemicin in nutmeg oil	A4-17, A4-20, A9-4-12, A9-4-13, A9-4-15	
High myristicin & elemicin in mace oil.	A4-17, A9-4-1, A9-4-3, A9-4-8, A9-4-11	
High myristicin in both nutmeg and mace oils.	A4-17	
Low myristicin and elemicin levels in nutmeg oil	A4-22, A9-69, A9-71, A9-95 and A9-102	
Low myristicin and elemicin levels in mace oil.	A9-1, A9-44, A9-71 and A9-95	
Low myristicin, low elemicin and low safrole coupled with high sabinene in both nutmeg and mace oils.	A9-71 and A9-95	

Conservation of germplasm

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

Rare/threatened species

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

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

Production technology of nutmeg

Climate and Soil

Nutmeg thrives well in warm humid conditions in locations with an annual rainfall of 150 cm or more. It grows well up to about 1300 m above mean sea level. Areas with clay loam, sandy loam and red laterite soils are ideal for its growth. Both dry climate and water logged conditions are not suitable for nutmeg cultivation.

Planting material and propagation

As nutmeg is cross pollinated, considerable variations are observed in the crop. The plants differ not only for all aspects of growth and vigour, but also for sex expression, size and shape of the fruit and quality and quantity of mace. Another important problem in nutmeg cultivation is the segregation of seedlings into male and female plants resulting in about 50 per cent unproductive male trees. Though there has 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 is to adopt vegetative propagation either by top working male plants or using budded or grafted plants.

Preparation of land and planting

Planting in the main field is done at the beginning of the rainy season. Pits of 0.75 m x0.75 m x 0.75 m size are dug at a spacing of 9m x 9m and filled with organic manure and soil about 15 days earlier to planting. For planting plagiotropic grafts, a spacing of 5m x 5m 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 nutmeg is grown as a monocrop. Nutmeg can be best be grown as an intercrop in coconut gardens that are more than 15 years old where shade conditions are ideal. Coconut gardens along riverbeds and adjoining areas are best suited for nutmeg cultivation. Irrigation is essential during summer months.

Manuring and fertilizer application

Manures are applied in shallow trenches or pits dug around the plants. The recommended dose of fertilizers is 20g N (40 g urea), 18g P_2O_5 (110 g super phosphate) and 50g K_2O (80g 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 1000g k2O (1670 g muriate of potash) per year for a fully grown tree of 15 years or more. FYM should be applied @ 25 kg for 7-8 years old trees and 50 kg for grown up tree of 15 years.

Plant protection

Diseases

Die back

The disease is characterized 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 end pasted with Bordeaux mixture 1%.

Fruit rot

Immature fruit split, fruit rot and fruit drop are serious in a majority of nutmeg gardens in different parts of the country. Immature fruit splitting and shedding are noticed in some trees without any apparent infection. In case of fruit rot, the infection starts from the pediciel as dark lesions and gradually spreads to the fruit, causing brown discolouration of the rind resulting in rotting. In advanced stages, the mace also rots emitting a foul smell. *Phytophthora sp* and *Diplodia natalensis* have been isolated from affected fruits. However, the reasons for

fruit rot may be pathological and physiological. Bordeaux mixture 1% spray may be sprayed when the fruits are half mature to reduce the incidence of the diseases.

Shot hole

The disease is caused by *Colletotrichum gleosporoides*. . Necrotic spots develop on the lamina, which are encircled by a chloratic 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 diseases.

Insect pests

The black scale (*Saisettia nigra*) and white scale (*Pseudauacaspis cockerelli*) are the pests noticed in nutmeg. The scale insects feed on plant sap and severe infestations may cause the shoots to wilt and dry.

Harvesting

The female nutmeg tree starts fruiting from the sixth year though the peak period is reached after 20 years. The fruits are ready for harvest in about 9 months after flowering. The peak harvesting season is during June-August.

The fruits are ripe and ready for harvesting when the pericarp splits open. After harvest the outer fleshy portion is removed, and mace is manually separated from the nut. The nut and mace gradually becomes yellowish brown and brittle when drying is completed. The fleshy pericarp can be used for making pickles, jams and jellies.

Mechanical drying

Freshly harvested mace can be blanched in water at 75^{o}C for 2 minutes to retain the scarlet colour. This is followed by hot air drying at 55-35^{o}C which takes 3-4 hours fir drying to a moisture level of 8-10%. However nut can be dried in 14-16 hours using hot air technique.

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

are the most endangered and fascinating habitats/ecosystems, they have good potential for developing ecotourism. If myristica swamps can be associated with sacred groves traditional conservation practices can be adopted.

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10. ORGANIC CULTIVATION OF GINGER AND TURMERIC IN ANDAMAN & NICOBAR ISLANDS

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Worldwide concerns regarding food safety, environmental degradation and threats to human health have aroused interest in alternative sustainable agricultural systems (Carter et al., 1993). "Land degradation" is considered to be one of the world's greatest environmental challenges as per the UN millennium ecosystem assessment. Globally, 40% of the arable land is seriously degraded and 11% of this is situated in Asia (Suja and Sreekumar, 2014). The major challenge faced by world agriculture is the production of food for a population of nine billion by 2050, with the anticipated climate change (Branca et al., 2013). There is an urgent need for transformations to increase the productive capacity and stability of smallholder agricultural production systems. Modern day spices production mainly depends on the use of chemicals based inputs such as pesticides, fertilizers, herbicides and high input technologies which has undoubtedly increased production and labour efficiency, but there is a growing concern about the adverse effects on soil productivity and environmental quality.

The land quality for food production ensures future peace. "Organic farming" is a viable option that enables sustainable production, maintenance of soil health, protection of human health and conservation of environment. It envisages non-use of synthetic chemicals, reduced use of purchased inputs and maximum use of on-farm-generated resources. It is soil-building mechanisms to keep the soil alive. Organic spices cultivation offers great scope in sustainable natural agro-ecosystem resource management towards improving the rural livelihoods in India. Several organizations have launched programs towards promotion of organic spices practices. These are largely directed at addressing the concerns and needs of the stakeholders in the farming to market supply chain involving supply and technical services production-post harvest handling- marketing. There is the need for empowering the farmers within formation and access to a wide range of organic crop production inputs and protection inputs. It is also important to ensure that these inputs, which are produced and availed by community initiatives and also by private sectors, are of dependable quality so as to safeguard the interests of the farmers.

Importance of spices in Islands

India, considered as the-Land of Spices is one of the major spice producing and exporting country in the world, contributing about 20-25% of the world trade in spice. There is a good export demand for Indian spices because of high quality with the maximum

content of essential oil, oleoresin and active principles. Spices are grown widely in Andaman & Nicobar Islands also. Tropical humid climate prevailing in these island are suitable for organic production of Black pepper (*Piper nigrum)*, Chilli (*Capsicum annum)*, Cinnamon (*Cinna*momum *zeylanicum*), Nutmeg (*Myristica fragrans*), Clove (*Syzygium aromaticum)*, Turmeric (*Curcuma longa)* and Ginger (*Zingiber officinale)* in the islands. Currently, the total area under different spices in India and Andaman islands are 33, 17,280 ha and 1675 ha with a production of 61, 08,280 MT and 3220 MT respectively (NHB, 2014-15). In Andaman and Nicobar islands among the spices, maximum area is under Black Pepper (600 ha) followed by Chilli 400 ha and Ginger 215 ha, while maximum production was in Ginger 1910 t followed by Chilli 610 t , and Turmeric 470 t (NHB,2014-15). The world demand for organically produced foods is growing rapidly in developed countries in Europe, in the USA, Japan and Australia. The current estimated share of organic foods in these countries is approximately 1 to 1.5 per cent which is expected to increase to 10 per cent in the next couple of decade. The market size of organic spices in the US is 30,000 tonnes, Europe 21,000 and Japan 6,000. The worldwide food trends are changing with a marked health orientation. Since organic foods are free from chemical contaminants, the demand for these products should steadily increase in near future.

Why Organic Spices?

Pesticides pose dangers to the biodiversity; health and well-being of humans, animals and plant life and are detrimental to soil micro-flora, micro fauna and soil health. Chemical pesticides used in Black Pepper, Turmeric and Ginger etc are toxic, non renewable, non degradable, lethal and stay in the environment for many years. In the long run, they become a cause ecological imbalance, unsustainable development and disharmony between human beings and environment. The organic cultivation takes into consideration of the local resources, the status of the environment and community involvement. Products that are certified and sold as 'organic' fetch a premium price compared with conventional products. Hence, for a country like India where small and marginal farmers are the majority, organic farming would be the right choice for exploiting the interests of the potential market. Organic farming also expected to offer more employment opportunities since it is more labor intensive. Spices crops currently occupy a special niche in organic agriculture in India, as there is considerable potential demand for organically grown products in the global market.

Importance of organic spices production

- ❖ Spices produced with the use of inorganic fertilizers and chemicals are harmful to human health and environment due to presence of heavy metals, toxic chemicals.

- The economic efficiency of chemical fertilizer is not more than 50% and the remaining is lost by leaching and volatilization.
- The growth and yield of important spices in India has been declining, and hence to sustain the yield and quality organic cultivation should be preferred.
- Plant uses nutrients from organic sources through mineralization and billions of beneficial microorganisms available in the soil are saved under organic cultivation.
- Excess and indiscriminate use of inorganic fertilizer has already deteriorated the soil health with deficiency of macro and micronutrients.
- Use of bio-pesticides like *Trichoderma viridi, Bacillus thurengiensis*, and others botanical pesticides (Neem), bio-control agents (*Trichogramma, Cryptolaemus, Chrysoperla* etc.) are capable of controlling pests and diseases. These bio-pesticide are eco-friendly and good for the environment as well as soil health
- The production and productivity of spices under organic farming may be less in the initial years but the yield could be increased progressively after 2-3 year under organic farming.

Conversion requirements to organic spices farming

Organic farming means a process of developing a viable and sustainable agro ecosystem. The time between the start of organic management and certification of crops is known as conversion period. When traditional agricultural methods fulfill the principles of these standards, no conversion period is required. When claiming virgin land for organic agriculture, no conversion period is required. The whole farm including livestock should be converted according to the standards over a period of time. If a farm is not converted all at once, it should be done on a field-by-field basis, whereby full standards are followed from the start of conversion on the relevant fields.

Strategies for Organic Spices Cultivation

The following strategies are to be adopted for organic spices cultivation

- Crop rotations and diversification are key principles in organic crop production system
- Diversity of crops both in time and space prevents pest and disease buildups and provides opportunity to the grower against market fluctuation to any one crop.
- In an annual cropping system, legumes are included to improve soil fertility. Allelopatheic crops that exude toxins from their roots can suppress weeds and insect/ pests.

- ❖ Pest and weed free fields are neither possible always nor economically and ecologically desirable. Hence, one should aware about the threshold levels of weeds, pests and rodents through experience as an ongoing process.
- ❖ In a perennial system, cover crops are grown to conserve soil moisture, improve soil fertility and provide habitat for beneficial insects.
- ❖ Varietal selection should look beyond maximum yield and consider insect and disease resistance, nutritional quality, flavour and responsive to lower inputs of nutrients and water.
- ❖ Proper time of planting and use of trap crops can minimize pest problem.

Organic production of Ginger and Turmeric

Ginger and turmeric is cultivated in many states in India. Ginger, one of the oldest known spices, is esteemed for its aroma and pungency. Dry ginger has good demand abroad especially in the Middle East markets. India is the largest exporter of dry ginger. Ginger of commerce constitutes both fresh and dry rhizome. Ginger is used in the production of ginger beer, ginger wine, cordials and carbonated drinks in confectionery, pickles and pharmaceutical preparations. Turmeric is one of the most valuable ancient sacred spices of India. In turmeric curcumin the yellow colouring pigment present in the rhizome has high medicinal value. Turmeric powder and water are used as cosmetics. Turmeric is considered a carminative, tonic, blood-purifier, vermicide and an antiseptic. It is used in folk medicine for intestinal disorders, worms, anemia, measles, asthma, sore throat, cough and cold, diabetes, sprains, skin disorders, etc., both externally and internally. Being an exhaustive crop, it may not be desirable to grow ginger and turmeric in the same field year after year. Therefore, it is essential to convert the whole farm as organic with ginger/turmeric as one of the crops in rotation. These crops cannot withstand water logging and hence soils with good drainage are preferred for its cultivation. Organic production practices for turmeric and ginger is summarized as below.

Criteria	Turmeric	Ginger
Conversion period	Minimum 2- 3 year	Minimum 2 years
Buffer zone	25-30 m	5–10 m should be left all around to separate the plot from conventional farms
Growing season and Land preparation	March April, Prepare raised beds of 1-1.5 m width, 15 cm height and convenient length or bed or ridges and furrow	
Varieties suitable	Allepey supreme, Prabha, Pratibha	Jorhat, Maran and Nadia
Propagation and seed rate	Whole or split mother rhizome or finger rhizomes are used for planting. Seed rhizome @ 2,500kg/ha is optimum. Each rhizome bits of 20–25g size may be used for planting.	For planting use rhizome bits of 15–20g and 4–5 cm length in size. A seed rate of 1,200–1,800kg/ha may be used
Seed treatment	Hot water treatment of rhizome bit at 52 ^{o}C for 10 minutes or 45^{o}C for 30 minutes. Treatment with *Trichoderma* and VAM formulation	Store seed rhizome with *Glycosmis pentaphylla* leaves, Seed treatment with *Trichoderma* and VAM formulation. Solarization of rhizome bits in moist 200 gauge polythene cover in the morning sun at 9-11 am
Mulching	The crop is mulched immediately after planting with green leaves (Gliricidia leaves) or any other locally available material @ 12-15 t. It may be repeated for a second time with the same quantity of green leaves after weeding and earthing up.	The first mulching is to be done with green leaves (Gliricidia leaves) or any other locally available material @ 10 - 12 t/ha at the time of planting. It is to be repeated @ 5 t/ha at 40th and 90th day after planting.
Weeding and earthing up	First weeding and earthing up should be given 50–60 days after planting and the next after 40 days.	Two weedings are generally given to the crop. The first weeding is done just before the second mulching and repeated depending on the intensity of weed growth. If necessary, weeding is to be repeated for the third time

Application of manure	A basal dose of farmyard manure @ 40 tonnes/ha may be incorporated at the time of land preparation	Application of well rotten FYM @25-40 t/ha or compost @ 5-6 t/ha may be made as a basal dose while planting the rhizomes in the pits. Enriched compost giving a start to phosphorus and potassium requirements may be highly useful. In addition, application of neem cake @ 2 t/ha is also desirable.
Pest management	Mechanical collection of larvae from bore hole and destruction at 15-day interval, spray 0.5% neem formulation / bacterial bioside (Dipel) formulation at 15-day interval and mulch with *Virtex negundo* and *Lantana* camara leaves.	
Root-knot nematode	Application of Neem cake @ 2t /ha	
Management of Soft rot	Planting on raised bed. Provide 30 cm deep drain at regular interval to check soft rot. Use of tolerant varieties	Planting on raised bed. Provide 30 cm deep drain at regular interval to check soft rot. Select seed rhizomes from disease free areas since this disease is also seed borne. Solarisation of soil done at the time of bed preparation can reduce the fungus inoculum. Remove the affected clumps carefully along with the soil surrounding the rhizome to reduce the spread. *Trichoderma* may be applied at the time of planting and subsequently if necessary. Restricted use of Bordeaux mixture (1 %) in disease prone areas may be made to control it.
Foliar Disease	Provide 25% shade by planting *Sesbania*, spray with 1% Bordeaux mixture, Plant short duration varieties because all short duration varieties are resistant to foliar disease	Provide 25% shade by planting *Sesbania*, spray with 1% Bordeaux mixture
Harvesting and processing	Harvest at after 9 month	Harvest at after 7-9 month.
Yield	On an average, a yield of 25–30 tonnes/ha of fresh rhizomes may be obtained.	The average yield is 15–25 tonnes/ha

Do's and Don'ts in IPM

- ❖ Grow only recommended varieties.
- ❖ Don't grow varieties unsuitable for the region.
- ❖ Seed rhizomes should be free from any infection or infestation. Biocides like *Trichoderma* may be used while planting seed rhizome.
- ❖ Don't treat the seed rhizomes with any chemicals.
- ❖ Remove weeds by hand weeding before each mulch and biofertilizer application.
- ❖ Don't forget weeding before mulching and bio fertilizer application.
- ❖ Use bio fertilizer as per soil test recommendation.
- ❖ Don't mix micronutrients with bio fertilizers and incorporate in the soil.
- ❖ Proper drainage facilities must be provided to drain off stagnant water. Best choice of land should be with a gentle slope.
- ❖ Don't allow water to be stagnant.
- ❖ Visit the field periodically to check for pests or disease incidence.
- ❖ Don't use chemical pesticides. Install light traps for collecting and monitoring shoot borer adult moths, if such infestation is observed.

Harvesting and post harvest operations

Ginger is ready to harvest in about eight to ten months depending upon the maturity. Clumps are lifted carefully with a spade or digging fork and rhizomes are separated from dried leaves, roots and adhering soil. The average yield of fresh ginger per hectare varies with varieties ranging from 15 to 25 tonnes. For making vegetable ginger, harvesting is done from the 6th month onwards. The rhizomes are thoroughly washed in water twice or thrice after harvest and sun-dried for a day. For preparing dry ginger the produce is kept soaked in water overnight. Rhizomes are then rubbed well to clean them. After cleaning, rhizomes are removed from the water and the outer skin is removed with a bamboo splinter or wooden knife having pointed ends. Iron knife is not recommended, as colour will be faded. In order to get rid of the last bit of the skin or dirt, the dry rhizomes are rubbed together. The peeled rhizomes are washed and dried in the sun uniformly for one week. Rhizomes are to be dried to a moisture level of 11 % and they are stored properly to avoid infestation by storage pests. Storage of dry ginger for longer periods is not desirable. The yield of dry ginger is 16-25 per cent of the fresh ginger depending upon the variety and location where the crop is grown.

Turmeric takes 7–9 months for harvesting. Drying up of the aerial portion indicates maturity. On an average, a yield of 25–30 tonnes/ha of fresh rhizomes may be obtained. The harvested rhizomes are washed well to remove adhering soil. The fingers are separated and cooked in boiling water for 1hr under slight alkaline condition (100g of sodium bicarbonate or sodium carbonate in 100 litres of water) and sun-dried on bamboo mat or drying floor for 10–15 days. For boiling turmeric, usually copper galvanized/iron or earthern vessels are used. It takes 40–60 minute of boiling to reach the correct stage (soft). The cleaned fingers (50kg) are taken in a perforated trough of convenient size made of GI or MS sheet with extended parallel handle. The fingers are then immersed in a paddle. The alkaline solution is poured into a pan so as to immerse the fingers. It is boiled till they become soft. Mother and finger rhizomes are generally cured separately. The dry recovery varies from 15–30% depending on variety, location and cultural practices. The dried turmeric is subjected to polishing either manually by rubbing it on concrete flooring or mechanically in power operated drums. Turmeric powder is added to the drum either as powder or as emulsion for giving bright colour to the rhizome. Cured turmeric is sorted as finger, round 'split', and marked under its varietal/trade name such as Alleppey, Erode, Duggirala, Nizamabad, Rajapuri and Cudlapah

Preservation of seed rhizomes

The rhizomes to be used as seed material should be preserved carefully. The indigenous practices like spreading layers of leaves of *Glycosmis pentaphylla* called in Malayalam 'panal' being followed by farmers can very well be adopted for this purpose. In order to get good germination, the seed rhizomes are to be stored properly in pits under shade. For seed materials, big and healthy rhizomes from disease-free plants are selected immediately after harvest. For this purpose, healthy and disease-free clumps are marked in the field when the crop is 6-8 months old and still green. Seed rhizomes are stored in pits of convenient size made inside the shed to protect from the sun and rain. Walls of the pits may be coated with cow dung paste. Seed rhizomes are stored in these pits in layers along with well dried sand or saw dust (i.e. put one layer of seed rhizomes, then put 2 cm thick layer of sand or saw dust). Sufficient gap is to be left at the top of the pits for adequate aeration. The pits can be covered with wooden plank with one or two small holes for aeration. Seed rhizomes in pits needs to be inspected once in twenty days to remove shriveled and disease affected rhizomes. Seed rhizomes can also be stored in pits dug in the ground under the shade of a tree provided there is no chance for water to enter the pits. In some areas, the rhizomes are loosely heaped over a layer of sand or paddy husk and covered with dry leaves in a thatched shed.

Organic farming is an alternative for sustainable and safe food production. It is a system for the well being of the soil, environment and all flora and fauna inhabiting the earth. Hence, this system is to be implemented in the production of spices so as to make the natural aromas and flavors used throughout the world. Organic spices farming imply growing of spices crops without chemical fertilizer, herbicide, and pesticides. Organic farmers rely on crop rotation, green manures, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control insect/pests as far as possible and practicable. In view of declining trend in export of certain spices like black pepper, cardamom, clove and nutmeg etc. due to the emergence of new competitors like Vietnam, Guatemala, and Sri Lanka coupled with change requirements of emerging market of organic spices, the organic production technology need to be popularized to sustain the quality. In A&N Islands already one of the island namely Havelock Island has been already declared as organic Island and in near future the efforts are on the way to promote organic agriculture in entire A& N Islands. Hence, organic cultivation of spices are very much suitable for Island condition due to its fragile ecosystem which enables not only the restricted use of chemicals but also preserves the soil health and environment in the tropical Islands, besides the quality of spices and we can brand and export "Andaman Organic spices" in near future.

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11. EMERGING OPPORTUNITIES FOR NEWER SPICES IN ANDAMAN AND NICOBAR ISLANDS

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The tropical islands of Andaman and Nicobar are bestowed with unique flora of ecological and economic importance. Of 2,426 species of flowering plants occurring in the islands, about 300 species are reported to be endemic (Murugan et al., 2016), while many others were deliberately introduced by settling communities from different parts of the country for their own consumption (Singh et al., 2016). Several species of horticultural importance have also been introduced by ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair and developmental agencies for promoting commercial cultivation, thereby adding up to their diversity in the islands. Never the less most of these species have been successfully established and naturalized in various parts of the islands.

Though a large number of species are cultivated in the islands for food, medicine, fodder or other use, they have rarely reached the status of 'crops' in the absence of systematic efforts (Goldschmidt, 2013). Identification of scope for commercial scale cultivation, development of suitable production and post-harvest technologies, development of improved varieties, assessing market demand, creation of processing opportunities etc. are important steps in this process. Spices are one such commodity for which both native and introduced diversity is available in the islands. A number of species are being used by the native/ settler communities as spices and are being grown sometimes in the backyard at present. In present report, some of the native and introduced species that could be promoted for cultivation on backyard, small or large scale have been discussed. These species would help in crop diversification and also for getting additional returns to the island farmers.

Mango ginger

Two species namely *Curcuma-mangga* and *C. amada* are commonly known as mango ginger as their rhizomes bear aroma of raw mango. The former species is found distributed in various parts of the islands while, the latter is native to Eastern India. Considering the natural distribution of *C. mangga* in the islands, there is considerable scope for cultivation of this species. Traditionally, its rhizomes are used in the preparation of pickles, as spice, as vegetable, salad, sauce and candy. The spice is medicinally valued and extracts have been reported to possess anti-cancer activity (Malek et al., 2011). Essential oil obtained from

rhizomes grown in Andaman islands was known to contain β myrcene, which is commonly used in production of high value aroma and flavor products.

Experiments conducted at ICAR-CIARI, Port Blair revealed that the crop could be raised using seed rhizomes of 20-25 g size for producing raw material meant for aromatic and pharmaceutical industries. While if the produce is meant for processing and value addition, use of seed rhizomes of 15-20 g size was recommended. About 0.4-0.5% essential oil was reported from the rhizomes. Crop could be grown under rainfed conditions and matures in seven to eight months of planting. Suitable agro-techniques are being developed for island condition. Also, identification of superior types is under progress in both the species as it could be helpful for getting produce of optimum quality. Considering the unique flavor, the spice could be a choice for the restaurants for preparation of exotic cuisines of South Asian origin. About 600 to 700 g of yield was obtained from each plant and hence, this could also be grown in the home gardens for household consumption. The existing coconut and arecanut gardens could be utilized for large scale cultivation of mango ginger.

Pepper wood

Pepper wood, locally known as *Choi Jhaal*, is a perennial climber belonging to the black pepper family. This species is naturally distributed in the forests of North and Middle Andaman, South Andaman and Little Andaman islands. Bengali settler community employs the inner wood segments in culinary preparation to impart pungency and unique flavor. This is one of the popular ingredients of their non-vegetarian curries. Stems are cut into pieces of *ca*. 20-25 cm, bundled and sold in local markets of North and Middle Andaman. Price of the produce in Middle Andaman and Little Andaman market has increased from Rs. 150/- per kg during 2015 to Rs. 300 to 450/- per kg in 2017, indicating its increasing popularity. Earlier most of the produce was harvested from the wild; however due to increasing popularity of this spice and good market price, a few farmers have started cultivating it in their backyards. Nevertheless, interaction with local farmers suggested that even now some produce is harvested from the wild and thus the natural stock is decreasing. Some farmers in Middle Andaman have also introduced the species from West Bengal and they opine that the produce possess better quality than that obtained from local types.

The vines could be propagated by stem cuttings and planted taking support of trees in the backyard. Being shade tolerant, the species could be easily incorporated in the existing plantation based cropping systems in the islands. Famers generally harvest the vines after three to five years depending on the plant growth and market demand. About 5-6 kg of produce is generally obtained from three years old vine; however, with increasing age the

vines grow luxuriantly and good yields could be obtained from older vines. Experiments conducted at authors' institute revealed differences in the antioxidant capacity and phenolic content from woods of different sizes and hence optimum harvesting stage need to be identified. In order to promote its cultivation as a commercial crop, rapid multiplication techniques need to be standardized. Also the diversity present in the natural populations and introduced populations could be analyzed to identify fast growing types with superior biochemical contents. The species cannot sustain water logging and death of vines was noticed in Little Andaman due to foot rot, which could be addressed by identifying disease tolerant types. The species could be a profitable crop mainly for the home-gardens, upland regions of the islands and palm based cropping systems.

Malabar tamarind

The species was introduced in the islands by the settler community from Kerala, ICAR-CIARI and UT Department of Agriculture. Dried rind of Malabar tamarind/ *kodampuli* (*Garcinia gummi-gutta*) is an important acidulant spice used mainly in South Indian cuisines. Acidic fruits are consumed either in fresh or pickled form. Fruit rind is known to possess hydroxycitric acid, which is highly prized for anti-obesity property. Though generally cultivated for its fruits, the plant has multifaceted uses in paint manufacturing industry, as medicine, source of edible fat etc.

Malabar tamarind is a dioecious species and considerable diversity for morphological and biochemical parameters has been reported from Western Ghats of India. It has been conserved in the germplasm block of the institute, wherein itflowers during February – March and fruits are harvested during May to July. Heavy bearing is noticed in the plants, indicating suitability of *kodampuli* under island conditions. A morphotype with good rind recovery has been reported from the germplasm block of the institute, which could be multiplied through vegetative means. Efficient multiplication technique needs to be standardized under island condition. The dried rind of unripe and ripe fruits was made into powder and products were found to be storage stable during five months study under ambient conditions (CIARI, 2016). Dried rinds are generally brought from mainland and sold in Port Blair market. Large scale cultivation of this crop could help the farmers in getting good profits. Excess of the produce could also be sent to mainland markets, wherein there is good demand for it. For meeting local demands, a few trees could be promoted in the home-gardens.

Native acidulant spices

Souring agents have been regarded as one of the important ingredients of many vegetarian and non-vegetarian Indian cuisines. Like Malabar tamarind, other native *Garcinia*species could also be utilized as acidulant in the preparation of various cuisines. Some of the *Garcinia* species are locally called as *cow phal*. Rind of *G. cowa* and *G. xanthochymous* are sometimes dried and stored for use in the curries by local people(Ellis, 1990). Till date ca. 18 species have been reported from the islands, out of which seven are endemic in nature. Some of these species could also possess hydroxycitric acid and hence, detailed studies are required. *G. cowa* and *G. xanthochymous* could be promoted for backyard cultivation and the produce could be sold in the local markets. This could meet the dual purpose of conservation of these species and livelihood security to the local inhabitants. Value addition and postharvest processing could not only help in fetching better prices in the market but also assist better management of harvested produce (Waman and Bohra, 2016).

Spondias dulcis L. is commonly known as *amra* in local languagesand has been reported to occur in wild as well as homestead gardens of the islands (Singh et al., 2002). Mature unripe and ripe fruits are generally sold during July- August in the local markets. Usually, mature fruits of *amra* are used as acidulant in preparation of various dishes mainly fish and vegetable curries by Bengali and Tamil communities. Commonly the species is preferred in preparations of foods that require mild sourness, wherein strong acidulants are not preferred. Fruits grown in the islands had 0.38 % titratable acidity (citric acid equivalent) with 35.49 mg/100g of ascorbic acid of and 108 mg/ 100 g GAE of total phenolic content (Bohra and Waman, 2017). The species can tolerate variety of soils (Singh *et al.,* 2012)and hence could be promoted for cultivation in home gardens.

Sour Carambola (*Averrhoa carambola*) and bilimbi (*Averrhoa bilimbi*) are two well-known members of Averrhoaceaefamily, which were introduced by the settler communities and have naturalized under island conditions (Singh *et al*., 2002). Both the species are used as fresh fruits as well as in the form of value added products such as pickle. These species are rich in oxalic acid and are sometimes employed as acidulant spices. Both the species are sometimes sold in the local markets.Owing to good regeneration capacity and multiple seasons flowering under island condition, carambola could be grown as backyard crop and could also be maintained as a potted plant for terrace garden.

Culantro

Culantro (*Eryngium foetidum*) is commonly known as broad dhaniya or Burmese coriander. The species is hardy and is popularly consumed in the islands and North Eastern

states of the country. The species is cultivated by some farmers and produce is sold in the local market with a handsome price of Rs. 300/- to 400/- per kg. The species can perform well under average management conditions and could be effectively cultivated in the interspaces of existing coconut gardens. An improved selection CARI- Broad Dhaniya -1 has been identified at the authors' institute. The species is short duration and could also be cultivated in home and terrace gardens.

Andaman and Nicobar islands harbor a large number of species, which could be exploited on commercial scale. The species discussed in the chapter have been grown in the islands since considerable period and exhibited good performance. Systematic efforts have been initiated in some of these species to make their cultivation profitable. In the era of crop diversification, cultivation of such species could help the farmers in getting better income from their farms.

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12. CHILLI: A POTENTIAL SPICE CROP FOR ANDAMAN AND NICOBAR ISLANDS

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Chilli or hot pepper (*Capsicum annuum*) is the most valuable commercial spice-cum-vegetable crop grown in India. Chilli is reported to be a native of South America and is widely distributed in all tropical and sub tropical countries including India. It was first introduced in India by Portuguese towards the end of 15th Century. Now it is being grown all over the world except in colder parts. Different varieties are grown for vegetables, spices, condiments, sauces and pickles.

Chilli occupies an important place in Indian diet. It is an indispensable item in the kitchen, as it is consumed daily as a condiment in one form or the other. Among the spices consumed per head, dried chilli fruits constitute a major share. Currently, chillies are used throughout the world as a spice and also in the making of beverages and medicines. If some varieties of chillies are famous for red colour because of the pigment 'capsanthin,' others are known for biting pungency attributed to 'capsaicin.' India is the only country which is rich in many varieties with different quality factors. Chillies are rich in vitamins, especially in vitamin A and C. They are also packed with potassium, magnesium and iron. Chillies have long been used for pain relief as they are known to inhibit pain messengers, extracts of chilli peppers are used for alleviating the pain of arthritis, headaches, burns and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol.

The world area and production of chilli is around 19.89 million hectare and 33.52 million tonnes, respectively. Major chilli growing countries are India, Myanmar, Bangladesh, Pakistan, Thailand, Vietnam, Romania, China, Nigeria and Mexico etc. The bulk share of chilli production is with Asian countries. The largest producer of chillies in the world is India accounting for 13 million tonnes of production annually followed by China with a production of around 3 million tonnes. Out of the total (33.52 million tonnes) world chilli production, 38.78 percent is contributed by India followed by China (8.65 percent). India also leads in the context of maximum area covered under chilli cultivation. In India, chillies are cultivated on 8,01,500 ha with a total production of 1.3 mt of dry fruits and 6800 MT of fresh fruits. Average yield of dry chilli harvest was around 1.6 t/ha compared to those of 8.5 t/ha for green chilli (F.A.O. 2012).

In India the states of Andhra Predesh, Karnataka, Maharastra, Oddhisa and Tamil Nadu account for more than 75 per cent of the area and total production of chilli. India stands

first in chilli cultivation covering 45 per cent of chilli growing areas of the world. There is a tremendous demand for Indian chillies in the international market that provide wide scope to increase the export and earn good foreign exchange. Chilli continued to maintain the lead in the spice export basket. Chilli market types prevalent in india can be broadly grouped into 1. Fresh market 2. Fresh processing 3. Dried spice and 4. Industrial extracts. India has immense potential to grow and export different types of chillies required to various markets around the world.In India, chillies are produced throughout the year. Two crops are produced in kharif and rabi seasons in the country.

In Andaman and Nicobar Islands, chilli is used as fresh green spice for preparation of different dishes. Chilli has very good market potential in the local market of this island. Almost entire demand of chillies (green chillies, dried fruits and powder)are met through its transport from mainland India. In the islands, it is normally grown during December to April in kitchen garden. However, it can be profitably cultivated at large scale as it has very good demand in the local market.

Performance of Chilli landraces and genotypes in the islands

The islands have rich diversity of Capsicum with the existence of *C. annum, C. frutescens and C. chinense* (Abraham *et al*., 2008). There are 26 landraces of Capsicum found in different places of the islands (Shrawan Singh *et al*., 2013). It is presumed that these species were introduced during or after the second half of 19th century to meet up demand of settler communities. Jaisankar *et al* (2015) studied the performance of 12 chilli genotypes and recorded average fruit yield of 2-4 t/ha under island ecosystem. The maximum yield of green chillies (17.7 t/ha) was obtained in variety Surakta followed by variety JCA-283 (17 t/ha) (Kishan Swaroop and Surayanarayana, 2004). This shows that the chilli crop can be successfully grown in the islands.

Suitability of island ecosystem for chilli cultivation

The climate of ANI is typified by tropical conditions with little difference between mean summer and mean winter temperatures. The annual rainfall varies from 2900 to 3100 mm representing perhumid climate. The length of growing period is more than 210 days. The relative humidity varies from 68 to 86 % and the maximum and minimum temperature is 32°C and 22°C, respectively which is suitable for chilli cultivation. The soil of the Andaman and Nicobar Islands is medium to deep, red loamy soils including marine alluvium derived soils along the coast. These are slightly to strongly acidic in nature and are moderate to low (40 - 70 %) in base saturation (Ganeshamurthy *et al*. 2002). Acidic soils are not suitable for cultivation. However, it will grow well in soil with pH between 5.5 and 7.0. Mostly, green

chillies are brought from mainland and sold at Rs. 150-200 per kg in the retail market as local production is not sufficient to meet the demand of local people and tourists. Hence, the farmers can fetch good price if it is grown locally.

Package of practices for chilli under island ecosystem

Climate requirement

Chilli is a plant of tropical and sub tropical regions. It grows well in warm and humid climate and a temperature of 22-30°C. Excessive rainfall is detrimental to the crops, because it brings about defoliation and rotting of plants. Hence, it can be cultivated during dry season in the islands.

Soil requirement

They can be grown over a wide variety of soils however they thrive their best on sandy and loamy soils, clayey loamy soils under irrigation conditions. Soil should have high organic matter content with the facility of good drainage and aeration. For excellent plant growth, the ideal soil pH for growing chilli is 5.8 to 7.0. Acidic soils for cultivating this crop may be avoided since they are not suitable for higher production and quality yield.

Varieties

The varieties *viz*.,Pusa red, Kalyanpur red, Pant C1, Pant C2, Arka Abhir, Pusa Jwala, Panjab lal and Arka Suphal and the F_1 hybrids such as Arka Sweta, Arka Megna, Arka Harita, Arka Khyati are developed by public institutes for cultivation in India. Many private seed industries are extensively marketing different chilli hybrids Viz., Wonder hot, Delhi hot, NS 1101, NS 1701, Sitara, Roshini, Tejeswini, Devanur deluxe, Sankranti and ARCH 82.

Land preparation

Land is prepared by giving 3-4 deep ploughings and clod crusting after each ploughing. After bringing the soil to fine tilth, level the field to avoid water stagnation. Compost or FYM at the rate of 15-20 tonnes/ha as basal dressing should be applied. However, the manuring should be done for about 15 to 20 days before the sowing of seedlings. Ridges and furrow should be formed at 60 cm.

Seedling production and transplanting

Chilli is propagated by the seed. For raising nursery seeds of high yielding varieties with tolerance to pest and diseases must be used. Normally, seed rate of 400-500 g /ha for varieties and 200 g/ha for hybrids are used. Seedling of chilli is produced using protrays under protected structures and transplanted after 30 days after sowing with the ball of earth.

Transplanting at a spacing of 60 x 45 cm for varieties of selections and 75 x 60 cm for hybrids are generally adopted.

Irrigation

Chilli can't withstand heavy moisture. Hence, irrigation should be given only when necessary. As chilli is a shallow rooted crop, it needs uniform and constant moisture in the root zone. During dry season, low moisture in soil at blossom development and fruit formation causes the flower and fruit drop. Hence, irrigation at weekly interval is necessary for getting good yield. Again irrigation depends on soil type and weather condition. Drip irrigation is beneficial for enhancing water productivity and avoids fungal diseases.

Inter cultural operations

Whenever needed, depending on the weed growth, weedings may be taken up. Earthing up is carried out after second weeding. Stake the chilli plant to prevent lodging especially when plants have full load of fruits. Mulching is best option for weed control, moisture conservation and uniform root establishment.

Manures and fertilizers

Chilli crop very well responds to manures and fertilizers. For large scale cultivation, it is better to conduct soil test to find out nutrient status and further fertilizer application. For growing chillies under rainfed conditions, apply 50 kg of Nitrogen, 25 kg of Phosphorous and 25 kg of Potash. Give the half dose of Nitrogen at the time of planting seedlings on the main field. Whereas the remaining half dose of Nitrogen should be given after about 4 to 5 weeks of planting seedling. For growing chillies with the facility of irrigations, apply 100 kg of Nitrogen, 50 kg of Phosphorous and 50 kg of Potassium per growing hectare. Manuring should be done in four equal splits. The 1st split at the time of planting seedling. And, the 2nd one at 4th week of planting seeds and the 3rd and 4th splits to be given at 10th and 12th week of planting seedling to obtain higher yield.

Pest management

Sucking pest such as Aphids, thrips and mites are the major problem in chilli cultivation. For controlling the pests IPM technology may be followed.

Disease management

Serious disease of seedlings observed on nursery bed is damping off. Treat seeds properly with Pseudomonas fluorescens @ 15 gm/kg seeds, 1 day before sowing. Avoid Waterlogging. It can be controlled by regularly spray with fungicides. For controlling, leaf

spot, Spray Agrimycin @ 200 ppm along with copper oxychloride (0.3 %). Anthracnose can be controlled by spray of Mancozeb @ 2.5 gm/ litre.

Harvest

The maturing age depends on the cultivar, chosen for production. Generally, it takes about more than two months for fruits to become fully ripen after the flowering season starts. Harvesting also depends on the market need. For selling freshly harvested in local, harvest fully grown immature green chillies. For making powder, harvest the fully matured riped fruits. Harvesting should be done on alternate days to obtain higher yield for few months and to meet the market need. However, it is quite important to store them at proper place to maintain the pungency and red colour. Since having much perishable nature they require attention while harvesting and after harvesting. The collected fruits should be stored in proper place and transported to local market. Also, harvesting at proper maturity leads to higher production as yield.

Post-Harvest processing

The post harvesting in the chilli production includes the Drying, Grading, Packing and preserving at a suitable place. It is helpful maintaining the quality and quantity of fruits to earn higher market rate and also reduce post harvest losses.

Yield

Yield depends on cultivar, soil type, and fertility and management conditions. However, on an average, yield of about 2 to 2.5 tonnes of dried chillies could be realized from 10-15 tonnes of green chillies.The yields may be higher under irrigated conditions over rainfed condition.

Problem of insect- pest and diseases, lack of technical know-how, non availability of inputs, and scarcity of labour are the some major problems of chilli cultivation in these islands. However, chilli cultivation is profitable in this island due to high market price. Farmer can get net income of more than a lakh rupees through this crop.

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13. WEED MANAGEMENT IN SPICE CROPS OF ANDAMAN & NICOBAR ISLANDS

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Spices are integral components of Andaman and Nicobar Islands farming that contribute substantially for the well being of the farmers through providing additional income. All the perennial spices (black pepper, tree spices i.e. nutmeg (*Myristica fragrans* Houtt), clove (*Syzygium aromaticum*(L) Merril& Perry), cinnamon (*Cinnamomum verum* Bercht&Presl), allspice (*Pimenta dioica* L.) and annual crops of ginger and turmeric in the islands are cultivated as understory crops (intercrops) of plantations (coconut, arecanut etc. in homestead farming concept)and fruit tree crops. However, chilli: *Capsicum annum*L. (grown for both dry and green chillies) and coriander: *Coriandrum sativum* L. (grown for above ground biomass i.e. tender stems and leaves), other important spice crops of the islands are grown under sole stands.

Weed menace in spices

Spice crop productivities are substantially reduced by various biotic (insect pests, diseases and weeds) and abiotic (water, nutrients etc.) stresses. Among the biotic stresses, weeds are the most important ones as they pose entirely a different sphere of competition with crop plants when compared to others. Weeds in general grow along with the crops (except parasitic weeds) unlike diseases/insect pests that are present on crop plants itself. Weeds compete with the crop plants for both above ground (solar radiation, space) and below ground resources (nutrients, moisture and space). Further, weeds by acting as alternate hosts to insect pests and disease causing organisms aids in their proliferation and thus their losses to crop plants. Andaman and Nicobar Islands are bestowed with heavy and continuous rains from May-September months that results in ample soil moisture supplies. Under soil moisture adequacy, weeds compete for light and nutrients. The post South-West monsoon (especially during December- March/April) period with low rainfall results in gradual build up soil moisture stress. In such scenario, weeds compete intensely with the crops for moisture first; and often weeds get upper hand over crop plants. Further, in a moisture stressed soil, the nutrient solubility is hampered and thus their availability and uptake by crops. Hence, weed induced crop yield losses gets compounded in post-rainy season than rainy season.

Studies of Dagar *et al.*(1991) have resulted in identification of 28 weed species in plantation crops in the Islands that holds true for perennial spices, turmeric and ginger as they are grown as intercrops of the plantations. The weed flora of chillies and coriander

are much wider than above spice crops owing to their cultivation in sole stands. The weed flora of spice crops is diverse and includes both grassy and broad leaved weeds. Among broad leaved weeds, *Mikaniacordata* (Burm.f.) was found rampant in spice crops, especially cinnamon (Gangwar and Singh, 1987) in the islands. Unmanaged weeds were found to incite enormous yield penalties in all spice crops; hence their management assumes prominence for economic yield realization. The information on yield penalties of weeds on spice crops in the islands is not available as no such studies were made. Depending on the management practices adopted, weeds cause losses as high as 90% in unweeded spices.

Weed management in spices

Weed management in spices in the Islands are predominantly based on preventive and cultural methods with rare intervention through curative methods i.e. herbicide use (biological control has little or no relevance). The weed management options for spice crops of islands are detailed below.

Preventive methods

Preventive methods are indirect methods of managing weeds that are done prior to sowing of the crop and are aimed at reducing the weed density in the subsequently sown crops. Thus they are relevant to turmeric, ginger, chillies and coriander crops only in the islands. The weed preventive methods useful for spices are detailed below.

Use of weed free seed is the most important preventive weed management technique contributing to reduced weed seed sowing in the chilli nurseries / field and coriander fields. Manuring and fertilization of crops in the islands lays greater reliance on organic manures which could form an important source weed seeds if used when their decomposition is incomplete.A due attention needs to be given to verify the organic manures (FYM, poultry manures, vermicompost etc.) for their decomposition status before application. Soil solarisation with transparent polythene sheets during summer for 40 days was found effective in killing the weed seeds in addition reducing the rhizome rot disease and nematode infestations in ginger and turmeric crops. In islands, March-April months are ideal periods for soil solarisation and could be helpful for ginger and turmeric cultivation. This technology could also be useful for adoption on nursery beds of chillies.

Tillage is the most common weed preventive strategy adopted by farmers. Tillage for sowing / planting of the spice crops (ginger, turmeric, chilli, coriander) results in killing of the germinating weed propagules and existing vegetation and thus gives opportunity for crops to germinate in weed free situation. In islands, rapid progress has been made in land

preparation with gradual replacement of the traditional bullock drawn country ploughs with tractor or power tillers. In a fields infested with thick mat of weeds, land preparation becomes difficult and in such cases, spray of herbicides like glyphosate or paraquat could come handy in killing the thick mat of weeds from rainy season. In ginger and turmeric crops, the land preparation includes 4 to 5 times ploughings or soil digging thoroughly with receipt of early summer showers to bring the soil to fine tilth. In chillies and coriander land preparation to attain fine tilth through 2 ploughings is sufficient. In perennial spices, tillage is done before start and end of rainy season to clear the weeds surrounding the spice crops.

Cultural methods

Crop sowing time, establishment method and density

The sowing window for best performance of annual spices and not for the weed could form an important weed prevention strategy. Chilli and coriander crops sown in post rainy season were found to have lower weed menace than their rainy season cultivation due to appearance of fewer number of weed flushes.

Transplanting of seedlings give a distinct advantage to spice crop like chill over weeds. In recent times, transplanting technology (30-40 days old seedlings) has been evolved for discounting high seed cost in turmeric and ginger that have inherent benefit of giving advantage to these slow growing crops over weeds. This technology could be adopted in the Islands as well. Sowing / transplanting of the above annual crops in rows was also found useful in weed management as the inter rows can be easily cleared of weeds with animal drawn or machine drawn inter cultural operations.

Plant density was also found to regulate the crop competitiveness with the weeds. Optimum plant stand maintenance in turmeric, ginger, chillies and coriander was found to effective in not providing free space for weeds for establishment and subsequent growth& proliferation to effect crop performance substantially.

Intercropping

Homestead farms of coconut / areca nut with spices, fodder crops etc. as under storey crops (intercrop), have been found to limit the space (light) available for weeds and have less intense weed pressures than open field conditions. The frequent harvest of fodder crops and or grazing of animals in homestead farms was found to regulate weed menace.

Mulching

Mulching is done by farmers for soil and water conservation purpose also provides weed management by acting as a physical barrier for weed seed germination and also by

reducing the sun light availability for germinated weeds. In ginger and turmeric, mulching with green leaves and straw @ 10-12 tonnes /ha just after planting is recommended for effective weed control and for early sprouting. Repeated green leaf mulching (at 45 and 90 days after planting using 5 t/ha green leaves), immediately after first weeding & application of fertilizers and earthing up will restrict the weed growth. In tree spices and black pepper grown in homestead farms, mulching with coconut leaves, coconut husk & shells around the plants was found effective in providing weed management services in addition to moisture conservation functions.

Selective input application

Selective input application (water and fertilizers) to crop helps in weed management by stimulating crop growth. Spot application of fertilizers to spices by hill placement will starve the weeds of nutrients and thus help in weed management. Similarly, water application through drip system also helps in weed control by restricting water supplies to hills only. The weeds growing away from crops will dry up and get eliminated gradually and this is more so in post rainy season. Fertigation (application of water soluble fertilizers through drip irrigation) by limiting both nutrient and water supplies to weeds also limits their germination as well as growth. The state department efforts to promote drip irrigation in high value crops like spices may give boon to the fertigation efforts.

Cover cropping

Cover crops have potential to suppress the weed growth and thus become a tool of weed management.As soil moisture is not a limitation in islands during rainy season (May-November), cover crops may not compete and stress the crop for water. At flag end of rainy season (October-November), cover crops may be killed to derive subsidiary benefits of nitrogen supply to spice crops.In coconut plantations, legume cover crops *Atylosias carabaeoides*, and *Pueraria phaseoloides*(Dinesh, 2004), *Mimosa* and *Stylosanthes* (Singh and Gangwar, 1989) proved promising based on their contribution to soil organic C, N, and microbial activity in addition to weed management of spice crops. Live mulches crops like *Glyricidia* on farm boundaries / bunds also provide weed suppressing effects in homestead farms.In turmeric growing of cover crops *Desmodium trifloium*(L)DC, *Calapagonium mucunoides* Desv, and *Centrosema pubescens* Benth was found promising for not only smothering the weeds but also for reducing the *Phytopthora* infections (Ramachandran *et al.,* 1991). Thus cover crops could be used for weed management in homestead farm spice crops.

Curative methods of weed management

Curative methods of weed management comprises of intercultural (manual weeding by hoeing or animal or mechanical harrowing) and herbicide (post-emergence and non-selective) use. Though potent herbicide options are available for spice crops weed management, the non-availability of herbicides use with limits its adoptability in the islands.

Manual, animal and mechanical methods

Hand weeding with suitable implements (khurpi, spade) at critical period of crop-weed competition and or during rain free periods of the cropping season is the most common practice resorted by farmers in the islands. In post-rainy season, hand weeding is most effective method for managing weeds than the rainy season. In ginger and turmeric, initial five months after planting are critical period for crop-weed competition. Two- three hand weedings are required depending on the intensity of weed growth during this period. First hand weeding should be done just before second mulching at 40-45 days after planting (DAP).The subsequent hand weedings depending on the intensity of weeds can be scheduled at 90-120 DAP coinciding with earthing up. Earthing up done at 45 and 90 DAP in ginger and turmeric to prevent exposure of rhizomes and provide sufficient soil volume for free development of rhizomes also provides opportunity for removal of weeds. In chilli, first one month after sowing / transplanting is critical period of crop-weed competition, hence one hand weeding within one month after sowing / planting in chilli is essential. Subsequent hand weedings (1-2) depending on intensity of weeds should be done at 3 weeks interval. In corinader, repeated harvestings of biomass are done at a 3-4 weeks interval. Weeds if removed properly before taking first harvest, the intensity will be less in subsequent cuts. However, a weeding within a week of harvest is desired for effective weed management.

In tree spices, 3-4 weedings are required per annum in the initial two years of establishment. From third year onwards, 2 weedings or diggings (May-June & October-November) are sufficient. Ring weeding with spade around trunks is followed widely in tree spices. The removed weeds when used as mulch aids in moisture conservation and nutrient recycling (upon decomposition). No separate weeding is required for black pepper that is usually grown on support of coconut, areca nut and other fruit trees and the weeding done for these support trees takes care of black pepper weeds.

Use of animal drawn intercultural implements for weed management is promising for sole turmeric, chillies and coriander crops. Power operated weeders are also becoming available that can be explored for weed management.

Herbicide options for weed management

The herbicidal method of managing weeds involves the prevention of weed growth and or destroying the already growing weeds in the crop. According to the method of treatment (time of use), the herbicides are mainly classified into two types viz., pre-emergence (soil treatment) i.e. after sowing but before germination of the crop and post emergence (stem and leaf treatment) i.e. after germination of crop.

Pre-emergence herbicides

Pre-emergence herbicides provide weed free environment for the crop during germination and seedling stage (up to 25 days from date of application) by killing the germinating weed seeds. In arable spice crops of coriander, chillies, turmeric and ginger, pre-emergence herbicides use is possible. Fluchloralin @ 1.5 kg a.i /ha as pre plant incorporation or pendimethalin @ 1 kg a.i/ha as pre-emergence spray are recommended. In chillies, pre-emergence application of Alachlor @ 2 kg a.i /hawas also found to provide effective weed management. Atrazine 0.5 kg a.i/ha or metribuzin @ 0.75 kg a.i/ha orsimazine@2.0 kg a.i/ha (pre-emergence) were also found effective for weed management in turmeric and ginger. In turmeric / ginger integration of herbicides with one hand weeding (40- 45 DAS) and or straw mulching (10 t/ha) was found to provide best weed control over herbicides or hand weeding alone.

Post-emergence herbicides

In tree spices and black pepper, non-selective herbicides {glyphosate (systemic) and paraquat (contact)} can be sprayed for killing the existing weeds from time to time. However, the spray should be a directed one towards weeds only (any spray fluid falling on crops leaves also could kill them). The weed free conditions attained with use of herbicides on steeply sloped lands in the Islands may lead to soil erosion. Hence, ring application of herbicide around trunks of spice plants is advised. Glyphosate and paraquat herbicides can be sprayed on lands for killing the existing weeds prior to land preparation will ease the job of seed bed preparation for crops like chillies and coriander during post rainy season. Though post-emergence herbicides are available for use in chilli, they are not available in the Islands, hence, not listed.

For effective weed management through herbicides, the following points needs due attention. The herbicide has to be applied at the appropriate time at the recommended dose using required spray fluid (500 – 600 litres/ha). Separate sprayer should be used for spraying herbicides and the sprayers used for herbicides spray should not be used for spraying insecticide or fungicide. For spraying herbicide, a special type of nozzle either deflector

or fan type has to be used. Proper soil moisture at the time of application of herbicide is essential. Walking in the field after spraying herbicide should be avoided, because in walked space because of removal of herbicide, weed control will be reduced.

Despite of significant advances made in the country with respect to use of herbicides as a component of integrated weed management tool and for reducing drudgery of manual weeding, the progress on use of herbicides in the islands is limited even today due to lack of technical knowhow as well as due to non-availability of herbicides.

Organic weed management

The tree spices including black pepper, and turmeric and ginger grown in homestead farms are on organic mode. Preventive and cultural methods of weed management recommended above can be used in organic farms.

It is to conclude that weeds incite enormous yield penalties in spice crops of the islands. A combination of preventive and cultural methods will take care of weeds in these crops. However, in light of decreasing manpower for farm operations including weeding, the wages are becoming higher continuously. This calls for herbicide interventions. There is need to test the herbicide options available in the main land in the Island ecosystem to provide economic weed management alternative to farmers. The use of rotary weeders and package for organic weed management in spices needs to be evolved.

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14. PROTECTED STRUCTURES USED IN PRODUCTION OF SEED SPICES

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In agriculture sector, the use of new agro-chemicals and intensive crop cultivation techniques are adopted to boost the production. But for the past few years, periodical explosions of whiteflies, bollworms, pod borers, defoliators, coccids, cutworms, plant hoppers etc., have emerged as direct disease transmitters and crop damagers in different regions of the world and have made agriculture less remunerative and highly risk prone. Without using any crop protection product or technique, the crop yields may be declined drastically. The entire effort of farmers and agriculture experts will be of no use in absence of crop protection techniques. This has aroused the need of crop protection techniques and products that can help to prevent the crop from damages and reduce the amount of risk involved in agricultural sector.

Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially/ fully as per the requirement of the plant species grown during their period of growth. With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged.

Need of protected structures

- ❖ Better Quality of Produce
- ❖ Higher Productivity
- ❖ Nursery Raising and Hardening of Plants
- ❖ Better insect & disease control resulting in reduced use of pesticides
- ❖ Off-season Cultivation
- ❖ Efficient use of Resources

Advantages

- ❖ The yield higher than that of outdoor cultivation depending upon the type of greenhouse, type of crop, environmental control facilities
- ❖ Reliability of crop increases under greenhouse cultivation
- ❖ Off-season production

- Disease-free and genetically superior transplants can be produced continuously
- Efficient utilization of chemicals, pesticides to control pest and diseases
- Water requirement of crops very limited and easy to control
- Maintenance of stock plants, cultivating grafted plant-lets and micro propagated plant-lets
- Hardening of tissue cultured plants
- Production of quality produce free of blemishes
- Most useful in monitoring and controlling the instability of various ecological system
- Modern techniques of Hydroponic (Soil less culture), Aeroponics and Nutrient film techniques are possible only under greenhouse cultivation.

BIS standards for protected cultivation

S. No.	Application	Component Description	IS Code
1.	Mulching	Surface covered cultivation – plastics mulching – code of practice	IS 15177:2002
2.	Greenhouse	Plastic film for Greenhouses – specifications	IS 15827:2009
		Recommendations for Layout, Design and Construction of Greenhouse Structures.	IS 14462 : 1997
		Recommendations for Heating, Ventilating and cooling of Greenhouses	IS 14485 : 1998
		Steel Tubes for Structural Purposes	IS 1161 : 1998
3.	Agro Shadenets	Shadenets for Agriculture & Horticulture Purpose	IS 16008:2012
4.	Protection Nets	Plant protection nets	IS 10106:part 1: section 6:1992
5.	Vermi-Bed	Agro Textiles- High Density Polyethylene (HDPE) Woven Beds For Vermi-culture-Specification	IS 15907:2010

(NCPAH, 2014)

Types of Protective Structures

Following are the various protective structures which are used to increase the crop production and quality of the produce.

(1) Net houses: These are used to reduce adverse effect of scorching sun and rains in vegetables, ornamentals and herbs.

(2) Plastic low tunnels: These are used to raise early nurseries of vegetables and flowering annuals.

(3) Green houses: These are framed structure covered with a transparent material in which crops could be grown under controlled environment. The environmental conditions refer to light, temperature, air composition and nature of root medium.

(4) Glasshouse: Glass is used as a Glazing material in the green house. Glass houses are fitted with the help of wooden or metal frame. The glass houses are constructed in all shapes and sizes and are quite effective for winter cultivation but due to increase in day temperature in summer, it becomes unfit for cultivation during summer. High initial cost, difficulty in construction and frequent damage of glass panels by strong winds has limited its use in both the regions. The variation in temperature between outside and inside conditions is 20 to 25º C.

(5) Walk in Tunnel: It is most popular type greenhouse which is small semi spherical structure frame made of materials like wood or plastic, iron , G.I. pipes and covered with polyethylene or fiber reinforced plastics. Maximum numbers of walk in tunnel type green houses have been installed in Kashmir valley region. The various sizes of tunnel type green houses that were being utilized by the farmers and installed by different development departments are 40 sq. m (4 m x 10 m), 80 sq. m (5 m x 16 m) and 54 sq. m (9 m x 6 m).

(6) Trench: This is a very simple, cheap and common greenhouse structure especially for the Ladakh region of the state and, thus, has unlimited potential in the region. The various sizes of the trenches are (9 x 3 x 0.9 m) and (10 x 4 x 1 m) respectively.

(7) FRP Greenhouse: The glazing material used in the green house is fiber reinforced polyester. The normal dimensions of the green house are (30 x 9 m) with a centre height of 3.04 m and a side height of 1.82 m. The initial cost required for fabrication of the greenhouse is high but the comparative life of the green house is much more than other.

(8) Double layered Polycarbonate Greenhouse: The glazing material used in the green house is double layer polycarbonate. The normal dimension of the green house is 16.8 x 9.1 m with a center height of 3.3 m and a side height of 1.8 m. The variation in temperature between outside and inside conditions is 20º C.

(9) Polyench Greenhouse: This type of greenhouse combines the trench and green house technology for achieving more temperature inside green house during peak winter. The glazing material utilized in the green house is polyethylene, FRP, double layer and triple layer polycarbonate. The normal recommended dimensions of the green house are (18 m x 4.5 m x 0.8 m).

Seed spices under protected cultivation

Seed spices important group of spices cultivated in arid and semi-arid region of the country. Scope of protected cultivation techniques in seed spice crops grown in the harsh climatic conditions of semi-arid and arid regions of the country. The issues regarding the use of other techniques like advanced nursery raising techniques, mulching, use of low cost protected cultivation technologies feasible and technically suitable for seed spice crops.

i. Plug tray seedling production technology

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

plug tray nursery raising technology was found suitable for all these crop viz., fennel, dill, ajwain and celery, whereas, the plastic made and coco peat filled bed technology was only suitable for fennel, dill and celery except, ajwain.

ii. Plastic mulching

The technique of mulching is a foolproof method to suppress the weed growth in the commercial crop sown area. Mulching layer also reduces the evaporation loss that occurs in open fields. Seed spices being grown in arid and semi-arid areas, rabi crop faces tremendous pressure of water management. The best combination of the mulching practice is with plug tray nursery raised seedling and drip irrigation for better resource management. Crops like celery are sown in the North West plains of Punjab where the cold period and water availability status are high compared to that of the areas lying in the western arid and semi-arid zones of Rajasthan and Gujarat. It has been observed by experimentation at NRCSS, Ajmer that, celery grows well when sown as transplanted crop under mulching with drip fertigation. The yield levels realized in the experiment shown tremendous potential of the technology in introducing the celery crop as a future seed spice for few tracts of western hot/humid zone of the country. Similarly, this technology is also equally suitable for fennel, dill and ajowain in arid and semi-arid regions of the country**.**

iii. Temporary plastic walls for protection of seed spices against frost

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

it can be advantageous, considering acreage of the crops and significant damage by frost is reported yearly in one or the other parts of the country.

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

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

v. Transparent plastic covered high-tunnel technology for seed spices cultivation

Transparent plastic covered temporary high-tunnels are also suitable and effective for seed spice cultivation limited to tall crops like fennel and dill. The height of the structure at the center from the ground is normally nine feet. This type of structure provides protection not only against frost but against unseasonal rains and hailstorms. It also helps in vernalization and other advantages are as those stated in transparent plastic covered walk-in-tunnel technology. (Singh & Singh, 2015)

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

The technique of insect proof net covered temporary walk-in-tunnels are as same as above, the only difference is that the basic covering material used is UV stabilized nylon net of 40 mesh. This provides a more open type micro-climate compared to plastic covered as the temperature difference between the outer and inner structure is not much due to free air movement through the holes of the net mesh. The basic advantage of the technology is prevention against hailstorms and insects. The size of the mesh is smaller than the size of hailstorm and insects, which does permit the entry of these abiotic and biotic elements. Crop like cumin, when it is to be grown in organic system, efficient pest management strategy is by implementing insect proof net covered walk-in-tunnel completely closed from all sides for complete restriction of aphids and other insects.

vii. Shade net covered walk-in-tunnels technology for off-season

The present technology is a very simple approach to make the crops to be raised during off-season for green leafy purpose. Seed spices, specifically coriander and fenugreek are grown during rabi, are also having importance for their green leaves. Coriander leaves are an integral part of Indian cooking system and are needed round the year for adding taste. Leaves being the most perishable part have a limitation of transportation from one corner to other. During the peak summer months (May to July) the availability of coriander leaves is highly influenced and there is a sharp rise in the rates per kg leaves sold during summer. The present technology of shade net covered walk-in tunnel is an intervention found to be most suitable for the farmers of arid and semi-arid regions of the country where the summer temperature goes beyond 45°C coupled with hot waves. Mostly 50-60% shading intensity shade net covered walk-in-tunnel can be coupled with low pressure drip irrigation system to obtain good quality coriander leaves. During summer months, problem of early bolting occur in open field, even genotypic differences are noticed for bolting under open and shade net conditions. Presently, large areas are sown by temperate type coriander by farmers for leaves. A study was conducted at NRCSS, Ajmer to screen the genotypes for adaptability under shade net walk in tunnels for leaf yield and aromatic quality.

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

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

working efficiency under the structure. Crops like fennel can be raised in high tunnels to protect it from climatic vagaries (Singh & Singh, 2015).

The country has an exciting future in production and marketing of spices to meet the emerging global needs and domestic consumption. The export market is becoming ever more competitive and stringent and favours ´zero´ defect spices for marketing.

Protected cultivation technology is an area that has immense potential to be exploited by spice industry. The resuls obtained from various studies suggest that protected cultivation is a feasible technology and a handy tool particularly for farmers for production of Quality planting materials, growing off season crops *viz*. coriander, fenugreek, fennel etc.

15. PLUG TRANSPLANTS PRODUCTION IN RHIZOMATOUS CROPS

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Horticulture sector has been the main stay of Indian agriculture with a contribution of about 30 per cent to the agricultural GDP from about 14 per cent of area and 40 per cent of total export earnings in agriculture. Horticulture growth in the country is mainly depends on the production and supply of genuine seeds and elite quality planting materials. During the crop year 2015-16, the country produced about 58,05,000 tons from 31,00,000 hectares of area under spices. Of the total production, nearly 9.5% was exported. Share of export in total production varied from a mere 0.6% in tamarind to about 72% in nutmeg and mace. It is imperative that production of quality seeds and plants can be taken up by creating the state-of-the-art nursery complex to meet the future demand of Horticulture sector of our country.

India was regarded by the rest of the world as the magic land of spices. India, the home of spices, is the largest producer, consumer and exporter of spices. Sixty three spices are reported to be produced in this country. For centuries, India held a virtual monopoly in spice production and trade. While black pepper (the King of spices) and cardamom (the Queen of spices) originated in this country, it is also a major production center for many others like ginger, turmeric, chillies and tree spices (nutmeg, cinnamon and garcinia). In Andaman and Nicobar Islands, black pepper, clove, nutmeg and cinnamon are *grown* under multitier cropping system. Turmeric, ginger, coriander and black pepper are the important spice crops grown under larger area.

Turmeric and ginger are important major spices contributing to the national economy of our country. Turmeric of commerce is the processed rhizome of *curcuma longa* L. and ginger of commerce is the rhizome of *Zingiber officinale* Rosc both belonging to the family Zingiberaceae. These crops are propagated vegetatively using rhizome. The area under turmeric in Andaman and Nicobar Islands is 92 hectares with the production of 642 tonnes (Spices Board). The area under ginger in Andaman and Nicobar Islands is 200 hectares with the production 1800 tonnes. For turmeric, a quantity of 2500 kg of rhizome is used as planting material to plant in one hectare of land similarly for ginger, a quantity of 1500 - 1800 kg of rhizomes is used as planting material to plant in one hectare of land. Protray raised rhizome bud transplants help in reducing the seed rate considerably, also they are suitable for mitigating the climate change and these propagules are suitable for high tech precision farming both under open and poly house condition.

The majority of the farmers are still following traditional and conventional method of propagation *viz*., whole rhizome is used as seed material. The conventional method of propagation has a number of drawbacks, *viz*. two months dormancy period of rhizomes, only one plant can be obtained from each rhizome; and a sizeable percentage of the produce has to be put aside as seed material. To overcome these problems and to produce good quality planting material with reduced cost, rapid multiplication of turmeric and ginger through single bud rhizome sprouts in protrays has been standardized. In this method, single bud rhizome is utilized to produce transplant in protray. This one month old transplant is used as planting material for turmeric and ginger cultivation. The modern technology recommends rhizome buds as seed material with high success rate of growth. This will reduce the cost of the seed material and also increase the yield.

Turmeric Plug Transplant production

Turmeric is a sterile triploid plant that is vegetatively propagated by means of underground rhizomes. The rate of rhizome multiplication in this plant is very low (only six – ten times) with yield ranging from 15 to 25 tons/hectare (Balachandran *et al.,* 1990). A considerable amount (10 – 20%) of rhizomes of the total yield is required for the next cropping year (Shirgurkar *et al*., 2001). Maintenance of such a huge amount of seed rhizomes for annual planting is expensive and labour intensive. Various studies conducted to determine the most suitable planting material have revealed that generally mother rhizome is the most suitable planting material. However, in case of var. `Tekurpeta' transplanting of 30 day old sprouts were equally productive. The mother rhizome is cut into two, each having at least one sound bud; fingers cut into 4-5cm long pieces can also be used as planting material (Nair in Nair *et al.,* 1989). The conventional method of propagation has a number of drawbacks, *viz*. two months dormancy period of rhizomes, only one plant can be obtained from each rhizome; and a sizeable percentage of the produce has to be put aside as seed material. To overcome these problems and to produce good quality planting material with reduced cost, rapid multiplication of turmeric through single bud rhizome sprouts in protrays has been standardized at Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Single bud rhizome of turmeric has been used as planting material as a cost effective technology of turmeric planting. In this method, single bud rhizome is utilized to produce transplant in protray. This one month old transplant is used as planting material for turmeric cultivation.

Advantages in single bud rhizome method of planting

1) Less requirement of planting material – 0.750 tonnes per ha.
2) Reduced cost of production (less quantity of seed rhizome)

3) Good crop establishment (98-100 percent)
4) Early rhizome development (starts from three months after planting)
5) Production of quality planting material
6) Suitable for planting in the raised beds as well as ridges and furrows
7) Extended period of planting is possible.
8) 15% yield increase over direct rhizome planting

Due to unavailability of better quality and high yielding seed rhizomes to cater current requirements of the growers, the production of turmeric transplants through rapid multiplication technique is the only way to meet out the demand of seed rhizomes. Based on the advantages of the turmeric transplant derived from rhizome bud can be selected as the planting material for turmeric cultivation which will augment the turmeric cultivation with good propagating materials and also increase the farm income. Consequently, it provides not only as a simple technique for adoption, but also accounts high success rate.

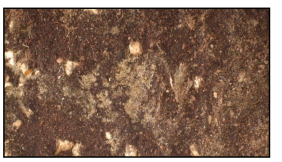
RAPID MULTIPLICATION OF TURMERIC USING SINGLE BUD RHIZOME (Stepwise procedure)

Drying of seed rhizomes (1- 1½ months after harvest)

Rhizomes are cut into small pieces with single bud (5 to 7 grams)

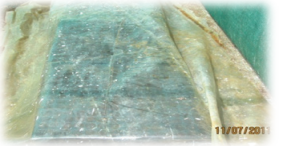
Seed rhizome treatment (Carbendazim @ 2 g/l + Monocrotophos @ 1.5 ml/l)

Covering the single bud rhizome with cocopeat (0.5% humic acid treated)



Sowing of sprouted single bud rhizome in protray (Cocopeat (100 g) + *Pseudomonas fluorescens* (1 g)


Covering the protrays with polythene sheet (seven days)



Removal of polythene sheets after sprouting
Regular watering of protrays kept under 50% shade

Spraying of humic acid (0.5%) after emergence of leaf

Rhizome sprouts are ready for transplanting (30-35 days)


Vigorous shoot & root growth


Transplanting of turmeric rhizome sprouts


Comparison of growth on Direct planting Vs Transplanting of turmeric

Growing Phase	Direct planting method	Transplanting method (turmeric bud rhizome)
1. Sprouting phase	 20 DAP	 Plants have 3-4 leaves (1 month old)
2. Vegetative phase		
(i) One month after planting	 2-3 leaves/plant	 6-7 leaves/plant
(ii) Tillering stage	 3 MAP	 1½ – 2 MAP 

3. Rhizome development phase	Starts from 5 MAP 	Starts from 3 MAP 
4. Rhizome maturation phase	 7 – 9 MAP	 6 – 7 MAP

Ginger Plug Transplant production

The use of rhizomes is a routine vegetative propagation method for ginger and many rhizomes are required because the efficiency of vegetative propagation is low. In addition, during storage and cultivation, rhizomes used for vegetative propagation are susceptible to diseases that cause tissue senescence and degeneration. Heavy losses have been reported because of infection with *Ralstonia solanacearum* (formerly *Pseudomonas solanacearum*), soft rot (*Pythium aphanidermatum*), and nematodes (*Meloidogyne* spp) (Hosoki and Sagawa 1977; de Lange *et al*. 1987). Ginger rhizomes degenerate after long-term propagation, and it is difficult to breed new cultivars through normal crossing because of poor flowering and seed set (Zhao 2002) and because the diseases are mainly transmitted by rhizomes propagated every year production of disease-free clones is necessary in order to get a successful ginger cultivation. Single bud rhizome technology and micro propagation by using tissue culture technique can be a proper alternative to produce disease-free clones of ginger plant. There is a scarce in disease free quality planting material of ginger. Hence, a technique on production of ginger transplants using single bud rhizome as an alternative way to produce quality disease free planting materials.

Advantages

- ❖ Less requirement of planting material
- ❖ Reduced cost of production due to less quantity of seed rhizome
- ❖ Good crop establishment
- ❖ Early rhizome development

Production of ginger transplants in protrays

Selection of healthy ginger rhizome for seed purpose

↓

Treating the selected rhizomes with mancozeb (0.3%) and quinalphos (0.075% for 30 min and storing in well ventilated place.

↓

One month before planting the seed rhizomes are cut into single buds with small piece of rhizome weighing 4-6g.

↓

Treating the single bud sprouts (mancozeb 0.3% for 30 min before planting)

↓

Filling the portrays (98% well) with nursery medium containing partially decomposed coir pith and vemicompost (75:25) enriched with PGPR/ Trichoderma 10g/kg of mixture

↓

Planting the ginger bud sprouts in protrays

↓

Maintaining the protrays under shade net house

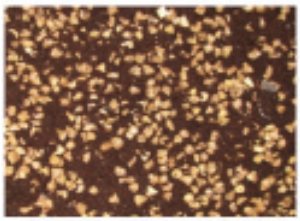
↓

Adopting need based irrigation with rose cane or by using suitable sprinklers

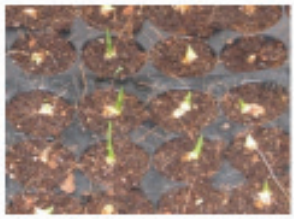
↓

Plants will be ready within 30-40 days for transplanting

Ginger Protray: from nursery to field



Buds kept for germination



Transfer of germinated buds to protray

Growth in protray

Transfer to field/Polybag

Plants transferred to polybags

New tiller formation

Field view

Tiller development in polybag

Tiller development in field

Different stages of ginger transplants growth in protrays

- This is a very simple technique which can be easily followed by farmers.
- As disease free planting material is produced, the usage of chemicals can be reduced thereby we can avoid environment pollution.
- At the same time this technology is the most cost effective technology for the establishment of turmeric with high success rate.

Thus the technology can be effectively used for large scale multiplication of rhizomatous crops.

Turmeric Plug Transplants Nursery

Ginger Plug Transplants Nursery

16. STATUS AND PROSPECTS OF POST HARVEST PROCESSING OF SPICES IN THE BAY ISLANDS

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Spices are valued for their distinctive flavors, colors and aromas and are among the most versatile and widely used ingredient in food preparations and processing throughout the world. In Andaman and Nicobar Islands, the congenial climate favours the cultivation of spices under many multi-tier cropping systems by the farmers which include black pepper (130 tonne), clove (5.25 tonne), cinnamon (5.25 tonne), zinger (1900 tonne) and nutmeg (4.75 tonne) etc spanning over nearly 700 km (North-south). Spices, the predominant flavouring, colouring and aromatic agents in foods and beverages, are now gaining importance for their diversified uses in these Islands. In the present scenario, the anti-diabetic, anti-hypercholesterolemic, anti-carcinogenic, anti-inflammatory effects of spices have paramount importance, as the key health issues of mankind nowadays are diabetes, cardio-vascular diseases, arthritis and cancer. In these Islands, a considerable percentage of post harvest losses are taking place due to lack of organized production-processing linkages, limited processing infrastructure and technologies and inadequate packaging and storage facilities etc. posing major constraints. The quality loss occurring in the spices sector can be extremely serious as the farming community is less aware of them. If these losses are reduced, the supply could be increased by 10-15% without cultivating additional area or incurring additional expenditure on seeds fertilizers, irrigation and plant protection measures.

Status of post harvest processing

The most post-harvest technologies in Andaman and Nicobar islands followed by now for spices are still the traditional labour intensive practices. Spices are traditionally dried in open sun on floors smeared with cowdung or on bamboo mats. The drying time required varied from 32-45 hours. Quality analyses of these samples revealed that in terms of physical quality, they do not qualify the specified standards. In this regard, a survey was conducted to reveal the post harvest practices by the spice grower in the Island. Out of 45 respondents, the analysis of results indicated that about 7-8% of total spice growing areas (1662 ha) are organized and rest are subsistence type of cultivation. Most of the spices are harvested during rainy season (relative humidity, 75-95% and temperature of 30-33^{o}C) which resulted into heavy loss due to decay as well as humid climate favours for incidence of pest and diseases that again damage the produce. After harvest, mainly women take part in picking/harvesting, grading, drying, peeling and packaging of various spices which are labour intensive and

drudgery-laden operation. For the tree spices, farmers regularly conduct processing after harvesting. All the farmers do partial cleaning. But washing is seldom practiced before drying. Unscientific cooking of rhizomes is also done as a regular pre-treatment, as farmers are aware that it will not get dried without cooking. Spreading on unclean surfaces also without any supervision is commonly observed. Physical quality analyses showed that commercially dried turmeric rhizomes/berries/clove/cinnamon packets did not bear AGMARK standard. Nearly, 70% of farmers prefer sun drying method (fig. 1) followed by both shade and sun drying (25%). So, the lack of quality consciousness and poor handling of the commodity during post harvest period is the primary factor for quality deterioration. About 53% of the farmers sell to local market (Fig 2) followed by Dept. of Agriculture (33%), tourist (6%) and others (9%).

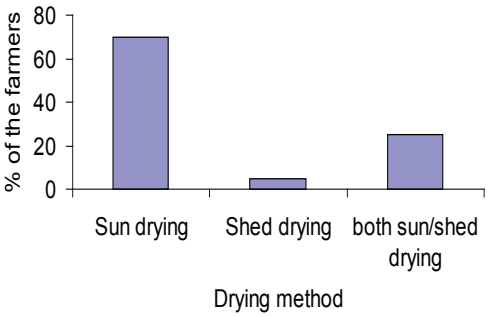

Fig 1 Variation of drying methods

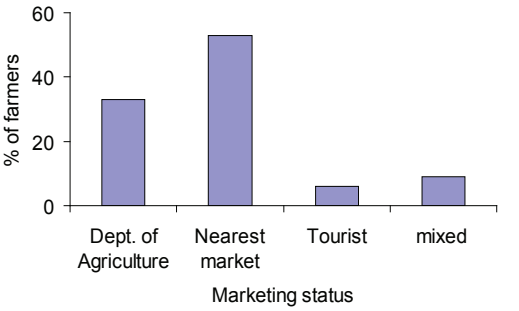

Fig 2 Variation of marketing status

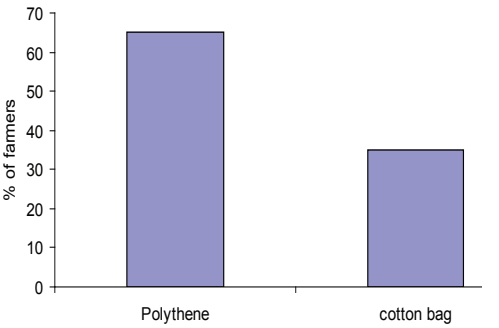

Fig 3. Variation of packaging materials

The Farmers living nearer to Port Blair are getting advantages of selling dried spices due to arrival of huge tourists than other spice growing Islands where farmers are gradually stopping spices cultivation.

After drying, about 65 % of the farmers use polythene bags (fig 3) to store and sell the dried product followed by cotton bags (35%). More than 85% of the work is done by the farmers themselves so that it is not possible to take care all the post harvest operations. Moreover, there is no organized market for the spice in the Island which forced farmers to sell produce according their own choice that resulted into imbalance price variation.

After critically examining the status, it may be identified and enunciated that progress in the development of post harvest technologies (based on sound scientific footings) is substantial and it is very much imperative inculcate the habit or culture of post harvest processing for value addition in farmers, horticulturists, marketers, small entrepreneur and enterprising houses etc.

Constraints in post harvest processing of spices

- Heavy rainfall and high humidity
- Lack of systematic spice plantations, poor spices database, subsistence type of cultivation.
- Due to high rainfall and steep slopes, the rate of runoff is very high than the rate of percolation, the crops suffer water scarcity in the slopes resulting in poor quality and lower yield in summer.
- Only traditional sun drying is mostly practiced by the spice grower.No mechanical drying facility.
- Inefficient supply cum demand chain management
- Lack of coordination between the research-extension-farmer and market
- Inadequate storage, quality control and testing infrastructure.

Moreover, spices are harvested manually in these Islands where these are commonly exposed to many contaminants before, being dry enough to prevent microbial growth. For example, the traditional methods of drying spices are to spread them out on the ground to dry under the sun. However, this practices potentially exposes them to the risk of contamination. Dried spices contain high levels of microbial contamination, depending on whether they received a form of treatment or not. So, post-harvest attention is essential if the spices of higher production are to be fully exploited. The processing sector has a vital role in farm income enhancement, poverty alleviation, food security, and sustainable agriculture in these Islands.

Post harvest processing of spice

1.Cleaning and washing

After harvest, the fibrous roots of spices such as ginger and turmeric attached to the rhizomes should be trimmed off and soil is removed by washing. Rhizomes should be soaked in water overnight and then cleaned. The skin can be removed by scrapping with sharp bamboo splits or wooden splice. Use of metallic knives should be avoided since they may discolour the rhizomes. Peeling or scraping reduces drying time, thus minimize mold growth and fermentation. However scraping process tends to remove some of the oils constituents which are more concentrated in the peel. By removing the outside corky skin the fiber content also decreases. In case of black pepper, cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such units consist of a fan/ blower and a feeding assembly. However, for cinnamon, clove and nutmeg, after harvest the spices are subjected to drying to reduce the moisture content to a safe level. Cleaning and drying procedures should be done as fast as possible after harvest to ensure minimum loss from microbial contamination, mold growth and fermentation. Mechanical washers, slicers, and solar or hot air driers may help minimize contamination from dust during post harvest handling operations.

2. Boiling/Blanching/Cooking

It is a requisite to gelatinize the starch for a more uniform drying, and to remove the fresh earthy odour to the root spices (ginger and turmeric). The aim is to uniformly coloring the material throughout the rhizome. Boiling is done in metal or mud pots along with water for 45 min to one hour, until froth appears at the surface and the typical turmeric aroma is released. Boiling process is continued till foams and white foams start coming out. These come out with a special quality of flavour. Rhizomes are tested by pressing with fingers. For the curing process, it is important to boil batches of equal size rhizomes since different size material would require different cooking times. Practically, fingers and bulbs are cured in separate batches, and bulbs are cut in halves. It is recommended to use perforated containers that allow smaller batches of 50 to 75 kg, which are immersed in the boiling water; by using this method, the same water may be used for cooking several batches. Benefits of curing turmeric include reduction of the drying time, and a more attractive product (wrinkle free) that lends itself to easier polishing. In the developed method, bulbs are treated with 0.1% Soda (Sodium Carbonate, Sodium bicarbonate or Ammonium Carbonate) and water solution. The time required for this process is 30 minutes to 6 hours.

3.Drying

Drying is one of most important operation practiced since a long time with the basis aim of getting dried product having moisture content to a level that could not available for the microorganism to grow in it. For drying of spices, some of the drying methods are described below.

a) Sun drying

During sun drying, heat is transferred by convection from the surrounding air and by absorption of direct and diffuse radiation on the surface of the crop. The converted heat is partly conducted to the interior increasing the temperature of the crop and partly used for effective migration of water and vapour from the interior to the surface. The remaining amount of energy is used for evaporation of the water at the surface or lost to ambient via convection and radiation. The evaporated water has to be removed from the surrounding of the crop by natural convection supported by wind forces. Due to the hygroscopic properties of all agricultural products, during sun drying the crop can either be dried or rewetted. Especially during night time when ambient temperature in general is decreasing, causing a simultaneous increase of the humidity, remoistening effects can occur either by condensation of dew or by vapour diffusion caused by osmotic or capillary forces.

Approximately 4 KWH/m² of solar energy is needed to use these techniques successfully. The best outputs are obtained in regions with a humidity of 40% to 60% and average temperatures of 14º to 18ºC. In the Islands, harvesting of turmeric and ginger is done during December to February where the chance of rainfall is very low and so, sun drying is the viable option for drying of rhizome. Simply sun drying after cleaning and washing removes outer skin. Cooked fingers or bulbs are dried to a moisture level of 5% to 10%. Sun drying may take 10 to 15 days, and the rhizomes should be spread in 5-7 cm thick layers to minimize direct sunlight that results in surface discoloration. Sometimes, rhizomes can be first soaked in water for 2 to 3 hours, then steeped in a solution of 1.5 to 2.0% lime (calcium oxide) for 6 hours, then drained and sun-dried. This procedure should be used when a light bright color is desired. Sun-drying peeled ginger takes 7 to 9 days to reach a moisture content of 7.8% to 8.8%. The despiked berries, clove, cinnamon and nutmeg should be spread on concrete floor and dried under sun for 3-4 days, to bring the moisture content from 56-58% to the safe level of 6-7% (wet basis). The average dry recovery varies between 33-37% depending on the varieties and cultivars.

In this method ,the samples are exposed to direct sun light and consequently the spice pieces heat up and internal temperatures rise without regulation which destroys colour,

vitamins and flavor giving rise to low quality product. Again, sun drying suffers from high product losses due to inadequate drying, fungal growth, encroachment of insects, birds and rodents, etc. The condition is significantly worse in Island climate with high rainfall and humidity. In order to mitigate the problems faced by the spice grower, CIARI has initiated research on alternate source of energy for drying of spices. As the Inlands is in tropical region with quantum of solar energy available, this could be efficiently harnessed and utilised for the drying of spices.

b) Solar drying

Solar drying renders rapid, more homogenous and cleaner product over sun- drying method. When drying with hot air, care should be taken to adjust air flow and temperature. Drying should not exceed the critical temperature of 60 ºC to avoid flesh darkening and discoloration.The objective of solar dryer is to supply the product with more heat than is available under ambient conditions, thereby increasing sufficiently the vapour pressure of the moisture held within the spices and decreasing significantly the relative humidity of the drying air and thereby increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content.

Solar dryer technology

A solar dryer (Fig. 4) has been designed, developed and evaluated with locally grown spices for getting quality spices. It consists of collector panel (2 no's), solar photo-voltaic cell (for providing power to the blower), blower (for aiding hot air from collector panel to the drying chamber) and drying chamber where vertical stacks of adjustable trays are placed to dry the produce. The maximum temperature achieved by the drier depends on the outside climatic conditions.

Fig. 4. Solar dryer (Garacharma farm)

The maximum temperature inside the solar dryer reached 65.7°C on January compared to outside air temperature of 34.8°C. The minimum temperature was recorded to be 44.3°C on partially cloudy day. There is provision of fan to maintain uniform temperature inside the drying chamber. The CIARI designed solar dryer takes only 11 hours for cinnamon, 18 hours for black pepper and 26 hours for drying for clove to reduce the initial moisture content of 56-62 % to safe moisture content of 5-7 % (wet basis). In comparison to sun drying, solar drying save on an average 30% of total drying time (Fig. 5) with better quality spices.

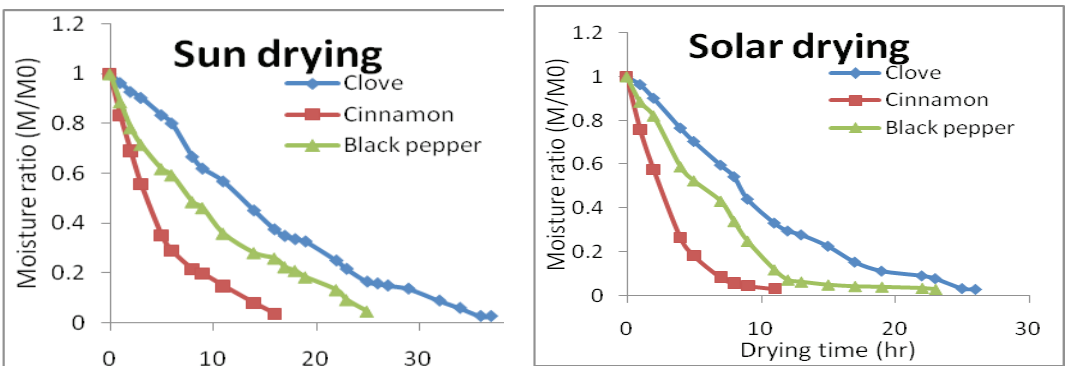

Fig. 5 Variation of moisture ratio with drying time in sun drying and solar drying

c) Cabinet dryer

This consisted of vertical stack of metallic trays (fig. 6) in a close housing for the spices to be dried inside the chamber. This is operated by electrical energy and the blower is provided for making homogeneous drying of spices to the safe level based on the presetted temperature. The food is spread out on trays at an acceptable thickness so that the product can be dried uniformly. Heating may be produced by hot air stream across the trays, conduction from heated trays, or radiation from heated surfaces. In a tray dryer, more products can be loaded as the trays are arranged at different levels. The key to the successful operation of the tray dryer is uniform airflow distribution over the trays. The tray dryer may be applied to a solar dryer or any conventional dryer that uses fossil fuel or electrical energy. Good airflow distribution will ensure the final moisture content of the dried products on the trays are uniform. For the spices (clove, cinnamon and dried in cabinet dryer at 40°C, 55°C and 70°C at 50, 100 and at 150 rpm of blower indicated that it takes about 10 hrs to dry to safe moisture content of 4-5 % at 70°C whereas the same could take 16 hrs and 27 hrs at 55°C and 40°C respectively. For black pepper, it takes 11 hrs approx. to dry to safe moisture content of 4-5 % at 70°C whereas the same could take 16 hrs and 25 hrs at 55°C and 40°C respectively. Similar kinds of observations were also found for cinnamon. Though

cabinet dryer is expensive than solar dryer but it reduces the drying time so that the chances of microorganism to grow in the spices drastically reduces, enabling quality grade products.

Fig.6 Cabinet dryer

d) Polishing

It is a requisite for the root spices like dried rhizomes and turmeric where these are to be rubbed against ground or below the foot to take out the hard layer over them for removing small roots. By this process colour of turmeric becomes bright or shining. Later on removed roots, light garbage and thin layerings are cleaned. Machine is also used for polishing. For this a drum having 0.9m diameter and 0.6m length is used. It is kept horizontally on a shaft and operated by a handle. Average capacity of this machine comes to 32 kg per batch. Dry turmeric 32kg approx. is filled and polishing is done at least for 7 minutes. During this period water is also sprinkled which causes improvement in the colour of turmeric.

e) Colouring

Exporting of root spices like turmeric is given special colour by mixing yellow so that powder and processed materials can give better look and quality. Colouring is done by two methods. One is dry colouring and the other wet colouring. In the first process dry powder of yellow colour is sprayed on boiled turmeric and rightly mixed. Powder is known as middle crome. In the wet colouring process the solution is prepared in water which is sprayed on rhizomes and mechanically mixed. After colouring is complete for one week these are dried. Later on these rhizomes are kept in sacks and closed for exporting.

f) Grinding or Powder making

Grinding is a simple process involving cutting and crushing the rhizomes into small particles, then sifting through a series of several screens. Depending on the type of mill, and the speed of crushing, the spice may heat up and volatiles be lost. In the case of turmeric and

black pepper, heat and oxygen during the process may contribute to degradation of curcumin and oleoresin. Cryogenic milling under liquid nitrogen prevents oxidation and volatile loss, but it is expensive and not widespread in the industry. Ground spices are size sorted through screens, and the larger particles can be further ground. Most quality control laboratories use the U.S. Standards (U.S.S.) screen size system. However, there are other systems that use a different numbering, and comparisons between specifications may be difficult.53 For instance, the U.S.S. screen numbering goes from 4 to 80 mesh screens (i.e. 4 to 80 openings per inch), while the Mill screen system goes from 4 to 55 mesh with different increments than the U.S.S. system. Traditionally dried and polished turmeric are cut into pieces and beaten in mortar and pestle. Hammer mill may also be used for grinding. Powder should be so fine that it passes through 300 micron sieve and nothing is left over the sieve.

g) Grading and packaging

Grading of spices mainly black pepper is done by using sieves and shifting it into different grades based on size. The major grades of black pepper are of size 4.8 mm (Special extra bold), 4.2 mm (Garbled extra bold), Malabar Garbled (MG grades 1 and 2) and Malabar Ungarbled (MUG grades 1 and 2). Similarly, grading of cinnamon and cloves should be done with the regulation of AGMARK standard. Proper care should be taken during the grading and packaging to supply quality material. Spices such as black pepper, clove and connamon should be packaged separately and labelled. Mixing different types of pepper is not good from a commercial point of view. Eco friendly packaging materials such as clean gunny bags or paper bags may be adopted and the use of polythene bags may be minimized. Recyclable/ reusable packaging materials shall be used wherever possible. Similarly, bulk rhizomes may be packed in jute sacks, wooden boxes or lined corrugated cardboard boxes for shipping. Well dried cloves (8-10% moisture) can be stored in gunny bags without damage by fungus and insects for 1 or 2 years.

The following terms are used to describe the various forms of dried rhizome.

Peeled, scraped, uncoated: whole rhizome with the corky skin removed

Rough scraped: whole rhizome with the skin partially removed

Unpeeled or coated: whole rhizome with skin intact

Black ginger: whole rhizomes scalded before being scraped and dried

Bleached: whole rhizome treated with lime or diluted sulfuric acid

Splits and slices: unpeeled rhizomes, split or sliced

h) Storage

Spices are is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity may result in mould and insect infestation even it is dried. The produce is bulk packed separately in multi layer paper bags or woven polypropylene bags provided with food grade liners or in jute bags. The bags are arranged one over the other on wooden pallets after laying polypropylene sheets on the floor. After packaging, fresh ginger should be stored at 10-12ºC and 90% relative humidity in cold room. A "zero energy" cool chamber which maintains the temperature 6 to 7ºC below than outside temperature can be used in the producing areas where cold storage are not available. Besides this storage of fresh ginger in polyethylene bags with 2% ventilation prevents dehydration and mould development. Dried rhizomes, slices, or splits should be stored at 10-15˚C in cold room. If cold storage facility is not available, extraction or distillation of dried ginger should be done rapidly because after three months at room temperature storage the oil content decreses considerably. Gamma-irradiation of dried rhizomes at doses of 5-10 KGy prevents mould and bacteria growth. Ethylene oxide @ 50 ppm can be used as a fumigation treatment of rhizomes. In case other spices, the packaged products should be stacked in jute bag/nylon bags followed by transportation and marketing.

Lack of awareness and actual skills on post-harvest technologies of spices have caused significant losses starting from the harvesting of the produces, drying and storage. Effective processing mainly drying technologies offer many possibilities which can be utilized for augmenting the farm level income by the farmers. After plantation crops, spices are the second most cash crops that need attention for its proper processing and maintenance. In future, the Island may earn its name as a hub of spice production like other spice growing countries in the Asian subcontinent. This could be possible through effective organizational set up to provide marketing support and other essential services to the farmers which alone will sustain their interest in the activities undertaken. Apart from this, research and development efforts are also needed to identify and popularize spices cultivars for specific purposes to cope with need of different products to render better services to the stake holders.

It is possible to evolve appropriate technologies which can establish agricultural based rural industries. The farmer whose role has been reduced to producer can be transformed into producer cum processor and thus getting more dividends for hard labour, input, kind of risk taken and generating resource for socio-economic advancement keeping pace with the modern times.In addition, successful establishment of solar drying system could certainly help in enhancement of revenue generation to the progressive farmers/farm women/rural youths who are using open yard for drying of spices.

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17. VALUE ADDITION IN SELECTED SPICE CROPS

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Value addition is defined as a process in which a high price is realized the same volume of a primary product by means of processing, packing, upgrading the quality or other such methods. In simple terms, it denotes to make things valuable or important in terms of economic gain, time and money saving in preparation, quantity and quality improvement or modification of raw ingredients for specific desirable characteristics. Value addition is any step in the production process that improves the product for the customer and results in a higher net worth vis-a-vis reduced post harvest losses. Value addition have many advantages such as they are simple to carry, have long-lasting flavors, with low bacterial contamination, higher income from food industry, they are used as preservatives and also in pharmaceutical industry.

The farm level processing operations are of utmost importance for value addition and product diversification of spices. It is essential that various operations like washing, threshing, blanching, drying, cleaning, grading, storing and packaging ensure proper conservation of the basic qualities like aroma, flavor, pungency, color etc. Each of these operations enhances the quality of the produce and the value of the spice.

Value Added Products from Spices

1. Ginger

Ginger is very important commercial crop grown for its aromatic rhizomes which is used both as a spices and medicine. Ginger is used both as a fresh vegetable and as a dried spice. Ginger contains polyphenol compounds such as gingerol and its derivatives that accounts for its characteristic aroma and therapeutic properties. The crop is ready for harvest in about 8 months after planting when the leaves turn yellow and start drying up gradually. Fresh ginger is perishable in nature and is spoiled due to improper handling, growth of spoilage microorganisms, changes during storage etc. Keeping in mind the low shelf-life of fresh ginger and inadequate facility for their modern storage leading to distress sale, value addition could be a viable alternative which will fetch remunerative price to the growers. The fresh ginger immediately after harvest should be washed to remove dirt, residues of farm chemicals and other foreign materials. Different value added products from ginger are described below.

i) Ginger Powder

Dried ginger is powdered to a fine mesh-60 (250 microns) to be used in various end products. Ginger rhizomes contain 4-6% of volatile oil and there is a great chance of losing the oil when powdered. Hence it is to be properly packed immediately after powdering.

Ginger Powder

ii) Ginger Pickle

Ginger is washed with plenty of water using a brush to remove all soil residues. It is then peeled and again washed in clean water. Ginger is cut vertically in 2mm thick slices. It is then blanched in boiling water for 15 minutes and hot water is drained out. This process should be repeated four times. Ginger slices are then mixed with 1 % salt, it is then packed in glass jars and lemon juice or vinegar is added until the slices are completely immersed. The glass jar should be kept under sun for at least one week. By the end of one week, ginger slices will become sour and turn pink in color.

iii) Ginger Preserve (salty)

Fresh ginger which is harvested at 170 -180 days after planting should be used for preparing salted ginger. Ginger is washed with plenty of water to remove all soil residues.It is peeled and again washed in clean water. Ginger should be cut vertically in 2mm thick slices. It is then blanched in boiling water for 15 minute and hot water is drained off. This process is repeated for seven times. Ginger slices are then mixed with 10 % salt. Salt is allowed to be dissolved and then heated on a medium flame. It is then stirred every now and then until salt crystals stars appearing on the ginger. After the process is complete, ginger slices are removed from the heat and cooled before packing.

Ginger preserve

iv) Ginger Preserve (Sweet)

The cut slices are kept in a lye (sodium hydroxide) solution for 30 minutes, then washed in clean water and kept in a saturated salt solution for 24 hours. Every eight hours, water is drained off and replaced with fresh and clean water for two days. Blanching is to be done as per pickle and this process is repeated for seven times. Sugar (60% by weight) is dissolved in clean water, and the syrup is filtered through a thin cloth. Then, ginger slices are mixed with the sugar solution. It is then kept for one day. Next day, when it has released its moisture, the ginger is taken from the sugar solution. Then sugar solution is boiled until the volume becomes half and it is removed from the heat and cooled. When the solution becomes cool, ginger is kept in it for one day. This procedure is repeated for three times. After three days, the mixture is put on the low medium heat, stirred continuously until the solution becomes thick and small sugar crystals starts appearing on the ginger. It is then removed from the heat and cooled before packing.

v) Ginger Oil

Ginger oil is characterized by pale yellow colour, warm, spicy and woody flavour with slight lemony notes. Dry ginger on distillation yields 1.5 to 2.5% volatile oil. The main constituent in the oil zingiberene contributes to the aroma.

Ginger oil

2. Black Pepper

Black pepper is produced from whole, unripe but fully developed berries. The harvested berries are piled up into heaps to initiate browning. Then they are dried on suitable drying floor after detaching the berries from the stalk by threshing. Drying the berries for 3-5 days reduces the moisture content to 10-12%. Different value added products from black pepper are as follows:

i) Ground Pepper (powdered pepper)

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

Ground pepper

ii) Cryoground pepper powder

To reduce loss of volatile compounds during the preparation of pepper powder using conventional grinding where the temperature rises as high as 90°C, cryogenic grinding is preferred. Cryogenic grinding helps in retaining more volatile oils besides reducing oxidation, improving fineness and posing minimum distortion in the natural composition of powder. The usual practice during the cryogrinding is to inject liquid nitrogen (-80°C) into the grinding zone. A temperature controller maintains the desired product temperature by suitably adjusting the nitrogen flow rate. The exhausted gas is recirculated for precooling of the spice.

iii) Pepper Oil

The characteristic aroma of black pepper is due to the presence of volatile oil which ranges from 2-5% and can be recovered by steam or hot water distillation. To recover essential oil from black pepper, it is flaked with the help of roller mills grounded into coarse powder and distilled in a stainless steel extractor. The steam comes in contact with the ground pepper particles and vaporizes the oil present in the oil cells. On cooling, the oil is separated from water.

Pepper oil

iv) Oleoresin

Oleoresins is the concentrated product of all the flavor components (aroma, taste, pungency and related sensory factors) and it is obtained by cold extraction of ground pepper using solvents like hexane, ethanol, acetone, ethyl acetate etc. Flake the pepper to a thickness of 1 to 1.5 mm and it is then packed in stainless steel extractors for extraction with the organic solvent. Normally, solid to solvent ratio of 1:3 is employed.

v) Green Pepper Based Products

Fully mature green pepper is dried under sun for 5 days to obtain whole black pepper.However, a variety of green products are made without drying process.

Dehydrated green pepper

a) Dehydrated Green Pepper

Slightly immature green pepper is selected for producing dehydrated green pepper. Freshly harvested

cleaned pepper berries is blanched in boiling water for 15 minutes till the enzymes responsible for blackening the pepper are inactivated and polyphenols washed out of the berries. Then, berries are cooled immediately and dried in a cabinet drier at 70°C. Dehydrated green pepper is easy to store and transport, and when it is soaked in lukewarm water it will regain its fresh green color and shape. Because of its pleasing flavor and aroma there is a distinct preference among conscious consumers for green pepper to black pepper.

b) Green Pepper in Brine

Green pepper in brine

Green pepper pickle

Freshly harvested green berries are used for preparing pepper in brine. Wash and clean the berries and dip it in brine solution having concentration of 17 % salt with added vinegar of around 0.6%. Pepper is washed three times in a period of 45 days and each time the brine solution is changed so that they are properly matured and then packed in HDPE food grade cans or as required with sufficient quantity of freshly prepared brine solution of the same concentration just sufficient to immerse the pepper. Major applications of green pepper in brine are in making sauces, meat processing industries and in the food service sector.

c) Green pepper pickle

Green pepper pickle is popular in many states as an appetizer. When mixed with shredded fresh ginger, it becomes more tasty and piquant. Peppercorn is washed and then dried by wiping gently with a towel, making sure the stalks are intact. In a pan, bring the water to a boil and add the salt and turmeric powder. It is then simmered for a couple of minutes and then taken off the heat. The brine solution is cooled down. Lemon juice is added and stirred well. The glass bottles are sterilized and it is then poured into the bottles. The bottles are closed and kept at room temperature. After a week, the pickle is ready to be served. This pickle does not require refrigeration. The peppercorn stalks will change to a somewhat dull and dirty greenish color after being in the brine. This is normal and doesn't change the quality of the pickle.

d) Mixed green pepper pickle

Mix the green pepper berries with lime pickles, mango pickles, mixed cauliflower and carrot pickles, brinjal pickles, bitter gourd pickles with or without green chilies and sliced fresh ginger. They are quite popular but however their preparation is mostly limited to domestic scale.

Mixed green pepper pickle

vi) White Pepper Based Products

White pepper is the white inner corn obtained after removing the outer skin or pericarp of pepper berries. The traditional method of preparation of white pepper is by retting. Retting converts only ripe and fully mature green berries to white pepper. White pepper is preferred over black pepper in light colored preparations such as sauces, cream soups etc. where dark colored particles are undesirable. It imparts modified natural flavor to food stuff.

a) White Pepper Powder

White pepper powder is processed in the same way as the black pepper powder, except the starting material is white pepper. White pepper powder can also be produced from black pepper by selective grinding followed by sieving.

3.Turmeric

Turmeric is used in diversified forms as a condiment, flavouring and colouring agent and as a principal ingredient in Indian culinary as curry powder. It has anti cancer and anti viral activities and hence finds use in the drug industry and cosmetic industry. Turmeric is ready for harvest in about 7-9 months depending upon the variety, when the leaves of the plant turn yellow and starts drying. After harvest rhizomes are cleaned of other extraneous matter adhering to them and the roots are removed and then boiling. Then the rhizomes are boiled to obviate the raw odour to reduce the drying time and to gelatinize the starch resulting in a more uniformly coloured product. Finally, it is dried under sun

Turmeric

or using mechanical dryers. The major colouring principle of turmeric is curcumin. The curcumin content in different varieties varies from 3 to 9%. It is a mixture of three pigments, curcumin, demethoxy curcumin and bis-de methoxy curcumin. It is preferred in the food and pharmaceutical industry as a natural colorant.

i) Turmeric Powder

Washed turmeric rhizome are dried in a solar dryer or cabinet dryer at 45-50°C followed by powdering to a fine mesh-60 (250 microns). This powder is used in various food products. Turmeric rhizomes contain 4-6% of volatile oil and there is a great chance of losing the oil when powdered. Hence it is very crucial that the packing is done immediately once turmeric is powdered.

Turmeric powder

ii) Turmeric Oil

Dried rhizomes and leaves of turmeric are used to extract the volatile oil industrially. Oil can be obtained by soxhlet apparatus or stem distillation system. Dried rhizomes contain 5-6% and leaves contain about 1-1.5% oil. It is generally extracted by steam distillation.

Turmeric oil

4. Nutmeg

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

Nutmeg

i) Nutmeg Powder

Nutmeg powder

Nutmeg powder is obtained by grinding completely dried nutmeg into fine powder. It is used in various food preparations like sweets, bakery products, curry powders culinary preparations.

ii) Nutmeg Oil

Nutmeg oil

The essential oil from nutmeg has various applications from food preparations to pharmaceutical industries. The oil can be obtained by steam distillation. Which varies from 5-15%. The essential oil is highly sensitive to light and temperature, therefore it is recommended to store the oil immediately in cool dry place. It yields a colorless, pale yellow or pale green oil with characteristic odor of nutmeg.

iii) Nutmeg Butter

Nutmeg butter

Nutmeg contains 25-40% oil and this can be obtained by pressing the crushed nuts between the plates in the presence of steam. Nutmeg butter is a highly aromatic, orange colored fat having the consistency of butter at ambient temperature.

iv) Mace Oil

Mace oil is obtained by steam distillation of dried aril and yields 4-17% oil.It has numerous medicinal properties like rheumatic problems, intermittent fevers, mouth sores, insomnia, flatulence, diarrhea etc.Mace oil is a colorless liquid having characteristic flavour. Due to its high demand in pharmaceutical industries, mace oil is highly priced than nutmeg oil.

5. Cinnamon

Cinnamon is a spice which is used for its anti inflammatory properties which helps in reducing the risk of various diseases, it also have anti diabetic effect,anti ageing properties and loaded with antioxidants. Cinnamon is obtained by drying the central part of the bark after the third year of planting. It is harvested from the branches which have attained greenish brown color indicative of maturity and when the bark peels of easily. The shoots are cut for bark extraction and the rough outer layer is first scraped off with special knife. The scraped

portion is polished with brass rod to facilitate easy peeling. A longitudinal slit is made from one end to the other end and the bark is peeled off.

Cinnamon

i) Cinnamon Oleoresin

The dry cinnamon bark powder on treating with solvents like acetone, hexane, ethyl acetate yields a viscous mass that attribute to the total taste and aroma of cinnamon. The oleoresin content varies from 7-10%. The oleoresin is dispersed on sugar and salt and used for flavoring processed foods like confectionaries, bakery products etc.

ii) Cinnamon Bark Oil

It is essentially extracted by the steam distillation of cinnamon and the oil percentage varies from 0.5 to 2.5%. It is used in flavoring bakery foods, sauces, pickles, confectionary, soft drinks, dental and pharmaceutical preparations and in perfumery.

Cinnamon oil

iii) Cinnamon leaf oil

Cinnamon leaf oil is produced by steam distillation of leaves yielding 0.5 to 0.7% oil. The major constituent is the eugenol (70-90%) while the cinnamaldehyde content is less than 5%. The oil is used in perfumery, flavouring and also as a source of eugenol.

Clove

6. Clove

Clove is the small, reddish brown unopened flower bud of the tropical evergreen tree *Syzygium aromaticum*. The trees begin to yield from 7-8 years after planting.

i) Clove Bud Oil

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

ii) Clove Steam Oil

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

Clove oil

iii) Clove Leaf Oil

Clove leaves on distillation yield 2-30% oil dark brown liquid which on rectification turns pale yellow and smells sweeter with a eugenol content of 80-85%.

iv) Clove Oleoresin

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

18. EXPORT STANDARDS OF MAJOR SPICE CROPS

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India is one of the largest producer, exporter and consumer of spices in the world, contributing about 20-25% of the world trade in spices. Out of 109 spices listed by ISO about 75 are produced by India. There is a good export demand for Indian spices because of high quality with the maximum content of essential oil, oleoresin and active principles. Indian spices exports have been able to record strident gains in volume and value. Spices exports have registered substantial growth during the last five years, registering a compound annual average growth rate of 10% in rupee terms and 5% dollar terms of value and India commands a formidable position in the World Spice Trade. During 2016-17, a total of 9, 47,790 tons of spices and spice products valued Rs.17664.61 crore has been exported from the country as against 8, 43,255 tons valued Rs.16238.23 crore in 2015-16 registering an increase of 12% in volume, 9% in rupee terms As compared to the total export target of spices fixed for the period 2016-17, the total export of Spices has exceeded the target in terms of both volume and value. Compared to the target of 8,70,000 tons valued Rs.15725.12 crore for the financial year 2016-17 the achievement is 109% in terms of volume and 112% in rupee and 109% dollar terms of value

Why spices grade and quality?

The developed countries give top priority to the health of their citizens. The laws with respect to items of spices are meant to protect the consumers from spices of inferior quality, or those which are likely to be contaminated by impurities or poisonous substances. Therefore any spices item that we export, be it pepper, cardamom or ginger, it is important that the product conforms to the quality standards demanded by the importing country Sudarshan *et al* (2005). In the context of thousands of people getting infected with foodborne diseases or even dying of food poisoning, it is only just and reasonable that countries which depend on imported spices stuffs should take such extreme precautions. Spices materials that have become rotten, spoiled, infected with micro-organisms or contaminated by other impurities are either destroyed by the import inspection authorities or sent back to the exporting country. This not only results in loss of market but also damages the exporting country's reputation

Quality Assurance

Even though India has been in the forefront for export of spices for several centuries, it was not until the mid-80s that the word 'quality' assumed importance. The imposition of quality standards by importing countries resulted in efforts for quality assurance. The steps were taken by the Spices Board to develop and inculcate good post-harvest management right from the stage of harvesting particularly in seed spices (Sivadasan *et al* 2005). The right stage of harvest decides the quality, viz., size, colour, fibre content, volatile oil, chewing quality (fennel), splitting (coriander), etc. Clean drying proper winnowing to remove dirt, chaff, plant parts, birds' droppings, rat excreta, hair, etc., followed by storage in hygienic and well-ventilated godowns ensures a good product. At the international level there is a stringent quality standard which has to be met by exporting countries. The specifications of American Spices Trade Association (ASTA) and the International Organisation for Standardisation (ISD) guidelines, with mutually agreed terms are followed. Japan and many other countries use the ASTA specifications; India, Malaysia, Spain, Indonesia, Sri Lanka and Hungary have their own quality standards for exporting spices. ASTA specifications are for unprocessed spices imported into the USA, and they regulate the cleanliness of these spices. ASTA specifications place limits on extraneous matter (insects, insect excrement, stones, stems, sticks, moulds, etc.) and set standards in sampling and testing procedures. Imported spices not meeting these specifications are reconditioned at the port of entry, while local spices need to be reconditioned (using fumigants) before they are processed for use in a product. USA is the most important buyer of our spices and their products. American spice trades Association (ASTA) is the authority which defines various quality parameters of spices import to USA.

1. Minimize the risk for introduction of filth throughout the supply chains.
2. Prevent environmental contamination, cross contamination and post process contamination during processing and storage
3. Use validated microbial reduction technique
4. Perform post treatment testing to verify a safe product.
5. Test to verify a clean and wholesome manufacturing environment

Table: 1 ASTA cleanliness specifications of major spics crops

Name of the spice	Whole insects dead by count	Excreta mammalian by mg/lb	Excreta Other by mg/ lb	Mould % by weight	Insect defiled / infested % by weight	Extraneous/ foreign matter % by weight
Black Pepper	2	1	5.0	SF (6)	SF (6)	1.0
White Pepper	2	1	1.0	SF (7)	SF (7)	0.5
Cardamom	4	3	1.0	1.0	1.0	0.5
Turmeric	3	5	5.0	3.0	2.5	0.5
Ginger	4	3	3.0	SF (3)	SF (3)	1.0
Chilies	4	1	8.0	3.0	2.5	1.0
Clove	4	5	8.0	1.0	1.0	1.0
Nutmeg Broken	4	5	1.0	SF (4)	SF (4)	0.5
Nutmeg whole	4	0	0.0	SF (5)	SF (5)	0.0
Mace	4	3	1.0	2.0	1.0	0.5
Cinnamon	2	1	2.0	1.0	1.0	0.50
Coriander	4	3	10.0	1.0	1.0	0.5
Cumin seed	4	3	5.0	1.0	1.0	0.5

Cleanliness Specifications Footnotes

(1) Clove stems: Less than (<) 5% allowance by weight for unattached clove stems over and above the tolerance for other Extraneous Matter is permitted

(2) White pepper: "Percent Black Pepper" will be reported separately for economic purposes and will not represent a pass/fail criteria

(3) Ginger: More than 3% mouldy pieces and/or insect infested pieces by weight

(4) Broken Nutmeg: More than 5% mould/insect defiled combined by weight

(5) Whole Nutmeg: More than 10% insect infested and/or mouldy pieces, with a maximum of 5% insect defiled pieces by count

(6) Black Pepper: 1% mouldy and/or infested pieces by weight

(7) White Pepper: 1% mouldy and/or infested pieces by weight

In India, quality standards are established for unprocessed and processed spices that particularly regulate moisture content, volatile oil, total ash, acid-insoluble ash, starch and extraneous matter. Grades are also established with specifications. Many spices, such as turmeric, black pepper, ginger and chilli peppers, have individual grade specifications that differentiate them from similar spices. Even curry powders are graded based on the amount of spices and salt they contain. Similar specifications are established for spices in many other countries.

Grinding and sterilizing procedures decrease the volatile oils in spices. Excessive heat volatilizes and dissipates the essential oils in ground spices, and high humidity tends to cake them (Jayashree *et al* 2012b). Exposure to light, humidity variations, air and certain metals can discolor many spices such as paprika, turmeric or the green leafy spices. Dry, ground chilli peppers turn from a natural green or red colour to an olive or dirty reddish-brown colour when exposed to light. Flavour and aroma losses, as well as insect and rodent infestation, occur when spices or spice extracts are stored in tightly closed containers in cool, dark, dry conditions below 4.4°C and 60% humidity. Some spices need storage at low temperatures of about 2-5°C to prevent mould infestation (capsicum peppers), colour deterioration (paprika) and to avoid rancidity (in high fixed oil seeds, such as sesame seeds). Colder temperatures also help preserve the volatile oil flavour and aroma, freshness and sanitary quality; refrigeration slows microbial growth (Thankamini *et al* 2003). Whole spices tend to have better shelf life than ground spices. Ground spices for minimally processed foods such as salad dressings, condiments or 'sprinkle on' seasonings should be well cleaned and sterilised.

High levels of moisture in ground or whole spices indicate mould and microbial growth. During storage, insects breed on spices in varying degrees, depending upon storage conditions, where they are harvested, transportation contamination and the extent of cleaning. Filth levels include foreign materials such as insect fragments (moths, mites, and beetles), small stones, metal fragments and glass pieces. Insects and mould growth can change the colour and, to some extent, the flavour of the spice.

1. Black pepper*:* The Indian Government, through the Ministry of Agriculture and Food, has prescribed the obligatory grading and standardization of agriculture products under the label "AGMARK. The quality of black pepper is largely determined by berry size, colour, light berry content, damaged berries, moisture content, microbial load, presence of foreign matter, insect infestation etc (Amala *et. al,* 2003). These factors are essentially determined by harvesting, processing and handling practices at growers level and grading and storage practices adopted at the traders or exporters level. They provide a compulsory quality control and pre-shipment inspection apart from meeting the requirements of importing countries. For

export, American Spice Trade Association (ASTA) or European Spice Association (ESA) or International Pepper Community (IPC) or International Organization for Standardization (ISO) specifications are the commonly adopted standards in the international trade.

Table: 2 The Agmark, ASTA and ESA specifications for cleanliness and quality of Black Pepper

S.No	Particular	Agmark (India)	ASTA	ESA	Japan	Malaysia	IPC
1	Organic extraneous matter (% m/m) max	0.8					
2	Inorganic extraneous matter (% m/m) max	0.2	1			1	1
3	Light berries (% m/m) max	5				2	2
4	Pinhead and broken berries max	4					550
5	Bulk density (g/L) min	490					
6	Moisture % (max)	11	12	12	11	10	12
7	Total ash (% m/m) max	6		7			
8	Non volatile ether extract % (min	6					
9	Volatile oil % (mL/100 gram)	2.5		2			
10	Piperine content (% m/m) min	4					
11	Whole insects dead (by count)		2			$\leq$ 2 in sample	
12	Excreta mammalian (mg/lb)		1			0	
13	Other excreta (mg/lb)		5				
14	Mold (by weight)		6		0	1	
15	Insects defiled /infested % by weight max		5		0	1	
16	Acid insoluble ash (% w/w) max			1.5			

Uncontrolled application of chemical pesticides at various stages of plant growth results in accumulation of their residues in spices, sometimes to a levels beyond acceptable limits.

With the growing concern on the carcinogenic properties of various pesticide residues, the importing countries are tightening the tolerance limits. Pesticide residue continues to be a serious problem in all the spices for export (Balakrishnan 2007). Pesticide residue tolerance limits for black pepper is given below (Table 3)

Table: 3 Pesticide residue tolerance limits fixed by some black pepper importing countries and India (MRL in milligram per kilogram)

Pesticide	Agmark (India)	US	Netherlands	UK	Germany	Spain
Acephate	0.2	4.0				0.1
Azinphos-methyl	0.5					
Chlorpyriphos	1.0	1.0	0.01		0.05	0.05
Cypermethrin	0.1				0.05	0.05
Diazinon	0.1		0.05	0.05	0.02	0.05
Dichlorvos	0.1		0.05		0.1	
Dicofol	0.1	5.0	0.05	0.05	0.02	0.02
Dimethoate	0.5	2.0	0.01	0.05	0.5	0.05
Disulfoton	0.05				0.02	
Ethion	5.0	1.0	0.01		0.05	0.1
Fenitrothion	1.0		0.05	0.05	0.05	0.05
Malathion	1.0	8.0	0.05	0.08	0.05	

Microbiological requirements for 'clean' spices include counts for total bacteria, yeast, mould, coliforms and food pathogens such as *Escherschia coil* and *Salmonella.* High microbial counts are caused by contamination during growing and post-harvest handling. Spore- forming bacteria, such as the *Bacillus* species or *Aerobacter aerogenes* found in the soil can be transferred to the spice during the drying process, particularly to 'under the ground' spices such as turmeric, ginger, galangal or garlic. The type and amount of moulds and bacteria on a spice depends upon the type of spice and the conditions under which it is harvested and dried. *Staphylococcus* and *Streptococcus* species of bacteria predominate, but pathogenic bacteria tend not to exist on spices. Spices that show strong antimicrobial properties tend to have low counts of microbes. Moulds, such as *Aspergillus,* that produce the toxin Aflatoxin and *Penicillium,* are found on certain species including red pepper, fenugreek and ginger, so there are specification limits for these toxins. Moulds tend to multiply during the drying process and storage. The control of insects and microbes is important in receiving quality spices. Spices need to be free of microbes so as to reduce the initial bacteria or

mould content in processed foods. Spice extractives and sterilised spices tend to meet these objectives. Organic foods are becoming more popular, and for food to be labelled as organic, irradiation is not permitted. Spices that are not sterilized can be potent sources for microbial contamination and growth

Table: 4 A comparisons of microbiological parameters adopted by different countries for import of black pepper

Particulars	Agmark (India)	ASTA	ESA	Malaysia	IPC
Salmonella	Not allowed	Not allowed	Not allowed	Not allowed	Not allowed
Yeast and mould			106 No./g	102 No. count/ g max	
Escherichia coli			103 No./ g	101 No./ g max	
Aflatoxin B1		2 ppb (max)	5 ppb		
Aflatoxin B1+B2+G1+G2	30 ppb (max)	4 ppb (max)	10 ppb (max)		

Note: ppb=parts per billion; 106 g=106 numbers per gram

Source: Aarathi *et al*. (2012)

2. Cardamom: In dried cardamom requires cleaning to remove all stalks and dried remains of floral parts. This should be done by rubbing dried cardamom over a coarse surface of wire-mesh or bamboo trays. This is very well carried out while the cardamom is still hot in the curing kill (Anonymous 1991). Government of India and the Indian Standard Institution (ISI) have prescribed fairly well defined grades, popularly known as 'AGMARK' grades and Indian specifications or standards on the basis of important quality factors like colour, weight per unit volume, size and percentage of 'empties' malformed, shriveled and immature capsules. AGMARK grade designations of 'true' small cardamom and specifications for cardamom seeds (ISI, New Delhi) are presented in Table 5 and 6 respectively.

Table: 5 Agmark grade designations of 'true' small cardamom

Quantity	Grade	Trade name
Alleppey Green cardamom	AGEB	Cardamom Extra Bold
	AGB	Cardamom Bold
	AGS	Cardamom superior
	AGS 1	Shipment Green 1
	AGS 2	Shipment Green 2
	AGL	Light
Coorg Green Cardamom	CGEB	Extra Bold
	CGB	Bold
	CG 1	Superior
	CG 2	Coorg Green Motta Green
	CG 3	Shipment
	CG 4	Light
Bleached and/ or half bleached cardamom	BL 1 -	
	BL 2 -	
	BL 3 -	
Bleached white cardamom	BW 1	Mysore/ Mangalore Bleachable Cardamom - clipped
	BW 2	Unclipped
	BW 3	Bulk
	BW 4	Bulk cardamom - unclipped
Mixed cardamom	MEB	Mixed Extra Bold
	MB	Mixed Bold
	MS	Mixed superior
	MS 1	Mixed shipment 1
	MS 2	Mixed shipment 2
	ML	Mixed light
Cardamom seeds	CS 1	Prime
	CS 2	Shipment
	CS 3	Bokens

Table: 6 Specifications for cardamom seeds, India (Indian Standards Institution, New Delhi)

S.No	Grade	Trade name	Extraneous matter	Light seeds	Weight (G/Imin)	General characteristics
1.	CS-1	Prime	0.5	3.0	675	Decorticated dry seeds of any variety of *Elettaria cardamum*
2.	CS-2	Shipment	1.0	5.0	660	
3.	CS-3	Brokens	2.0			

3. Ginger: Dried ginger is marketed on the basis of geographical origin and the form of preparation. The chemical and physical characteristics of the spice differ from one producing region to another. Indian dried ginger is classified as Malabar ginger, Assamese ginger and Himachal ginger. But the two types of the spice which are in great demand in the world market are Cochin and Calicut ginger, which come under the Malabar ginger type. The bulk of our exports are of rough-scraped, whole rhizomes. Sometimes, coated ginger is also exported. Bleached or limed Calicut ginger is mainly exported to the Middle Eastern countries. Cochin dried ginger is about 20 mm long and has a light brown to yellowish-gray colour, whereas, Calicut dried ginger is orange to reddish-brown in colour and is generally considered to be inferior in quality to the Cochin spice. Both types are graded prior to export into the following categories, according to the number of fingers on the rhizomes—B (three fingers), C (two fingers) and pieces (individual finger). The grades of whole ginger and the specification are given in the table below.

Grade	Specification	Size of Rhizome
Calicut (NGK)	Garbled (distorted), non-bleached	Not less than 20mm in size
Calicut (NUGK)	Ungarbled, non-bleached	Small, cut pieces, <20mm in length
Cochin (NGC) NUGC	Garbled, non-bleached Ungarbled, non-bleached	Not less than 20 mm in length Small, cut pieces, not less than 20 mm in length
BGC Cochin (BUGC)	Garbled, non-bleached Ungarbled, bleached	Not less than 20 mm in length Small, cut pieces of less than 20 mm in length

Cleanliness has always been a major concern for the importing countries. Trade in spices is governed by numerous national as well as regional regulations. For example, dried cardamom and ginger exported to the United States must conform to the specifications laid

down by the American Spice Trade Association (ASTA). The specifications of ASTA for cleanliness of turmeric imported to US are given in Table 7**.**

Table: 7 ASTA cleanliness specifications for ginger

Whole Ginger : Chemical and Physical Specification	
Specification	**Suggested limit**
Whole cleaned insect by count	4
Mammalian excreta by mg/lb	3
Other excreta, by mg/lb	3.0
Mold % by weight	3.0
Insect defiled/ Infested % by weight	3.0
Extraneous % by weight	1.0
FDA/DAL	**None**
Moldy and /or insect infested pieces	Avg. 3 % by weight
Mammalian excreta	Avg. 3mg/lb
Volatile oil	2.0% min
Moisture	12.0 max
Ash	5.0% max
Acid insoluble ash	1.0% max
Average bulk index(mg/100 gm)	N/A
Grounded Ginger : Chemical and Physical Specification	
FDA/DAL	None
Volatile oil	12.0 max
Moisture	5.0% max
Total ash	1.0% max
Ash	12.0 max
Military Specification (EE-S-631J, 1981)	
Volatile oil (mg/100g)	1.5 min
Moisture	12.0%
Total Ash	7.0%
Acid insoluble ash	1.0%
Crude fiber	8.0%
Starch	42.0% max
Granulation	95% min through a U.S.S. 40
Bulk index (mg/100g)	210

The specifications of various grades of Indian ginger and ginger powder under Agmark are given in Tables 8-11. Agmark certification is currently not mandatory for export trade. However, it is still valued as a mark of quality. Indian Standard Specifications (ISS) for ginger are almost in line with the Agmark specifications. The minimum rhizome size of rhizomes as per ISS is 20 mm (IS 1998:2008).

Table: 8 AGMARK grade designations of GARBLED NON BLEACHED ginger (whole)

Grade Designation	Size of rhizomes (length in mm) Min.	Organic extraneous matter, % (m/m), Max	Inorganic extraneous matter, % (m/m), Max	Moisture % (m/m), Max Total ash % (m/m), Max	Total ash % (m/m), Max	Calcium (as calcium oxide) % (m/m), Max	Volatile oil % (ml/100g) Min.
Special	20.0	1.5	0.5	12.0	8.0	1.1	1.5
Standard	15.0	1.5	0.5	13.0	8.0	1.1	1.0

Source: Spices Board (2006); Pieces of rhizomes smaller than 15 mm can be graded with the marking 'Garbled Non –bleached Ginger (Pieces)'. It may be marked as 'Garbled Non Bleached Calicut' (NGK) or 'Garbled Non bleached Cochin' (NGC) depending upon the its place of origin

Table: 9 AGMARK grade designations of UNGARBLED NON BLEACHED ginger (whole)

Grade Designation	Size of rhizomes (length in mm) Min.	Organic extraneous matter, % (m/m), Max	Inorganic extraneous matter, % (m/m), Max	Very light pieces % (m/m) Max.	Moisture % (m/m), Max Total ash % (m/m), Max	Total ash % (m/) Max	Calcium (as calcium oxide) % (m/m), Max	Volatile oil % (ml / 100g) Min.
Special	20.0	1.5	0.5	4.0	12.0	8.0	1.1	1.5
Standard	15.0	1.5	0.5	6.0	13.0	8.0	1.1	1.0

Source: Spices Board (2006); Pieces of rhizomes smaller than 15 mm can be graded with the marking 'Unarbled Non –bleached Ginger (Pieces)'. It may be marked as 'Garbled Non Bleached Calicut' (NGK) or 'Garbled Non bleached Cochin' (NGC) depending upon the its place of origin

Table: 10 AGMARK grade designations of GARBLED BLEACHED ginger (whole)

Grade Designation	Size of rhizomes (length in mm) Min.	Organic extraneous matter, % (m/m), Max	Inorganic extraneous matter, % (m/m), Max	Moisture % (m/m), Max Total ash % (m/m), Max	Total ash % (m/m), Max	Calcium (as calcium oxide) % (m/m), Max	Volatile oil % (ml/100g) Min.
Special	20.0	1.5	0.5	12.0	12.0	2.5	1.5
Standard	15.0	1.5	0.5	13.0	12.0	4.0	1.0

Source: Spices Board (2006); Pieces of rhizomes smaller than 15 mm can be graded with the marking 'Garbled bleached Ginger (Pieces)'. It may be marked as 'Garbled Non Bleached Calicut' (NGK) or 'Garbled Non bleached Cochin' (NGC) depending upon the its place of origin Ginger.

Table: 11 AGMARK grade designations of UNGARBLED BLEACHED ginger (whole)

Grade Designation	Size of rhizomes (length in mm) Min.	extraneous matter, % (m/m), Max	Very light pieces % (m/m) Max.	Moisture % (m/m), Max Total ash % (m/m), Max	Total ash % (m/m), Max	Calcium (as calcium oxide) % (m/m), Max	Volatile oil % (ml / 100g) Min.
Special	20.0	2.0	4.0	12.0	12.0	2.5	1.5
Standard	15.0	2.0	5.0	13.0	12.0	4.0	1.0

Source: Spices Board (2006); Pieces of rhizomes smaller than 15 mm can be graded with the marking 'Garbled Non –bleached Ginger (Pieces)'. It may be marked as 'Garbled Non Bleached Calicut' (NGK) or 'Garbled Non bleached Cochin' (NGC) depending upon the its place of origin

4. Turmeric: Turmeric is included in the list of spices which must have an Agmark grading before they can be exported from India. Three grades of finger turmeric, two of bulb turmeric and one grade of powdered turmeric are specified, as follows:

1. Finger turmeric, other than the Alleppey variety is sub-graded into 'Special' Good' and 'Fair.

2. Alleppey finger turmeric is sub-graded into 'Good' and 'Fair'.
3. Rajapore finger turmeric is sub-graded into 'Special'. 'Good' and 'Fair'.

The maximum limit for extraneous matter in the prime sub-grades of the above grades of whole turmeric is 1.0%. In the case of Alleppey finger turmeric, which is exported to the United States (Anandaraj *et al* 2011), the content of extraneous matter according to the specifications of the American Spice Trade Association is usually less than 0.5%. In the case of the turmeric powder, the characteristics are more exacting. The maximum percentage limits are specified for moisture, total ash, acid insoluble ash and starch. The ASTA **(1)** and FDA (2) chemical and physical specification of turmeric are as follows: (1) Whole dead insects by count 3; mammalian excreta (mg/lb) 5; other excreta (mg/lb) 5; mould (% by weight) 3; insect defiled (% by weight) 2.5 (2) volatile oiV curcumin (% min) **5;** moisture (% max) 10; ash (% max) 8; acid insoluble ash (% max) 1.0, average bulk index (mg/100 g) N/A.

Table: 12 ASTA cleanliness specifications for Turmeric

Whole Turmeric : Chemical and Physical Specification	
Specification	**Suggested limit**
Whole cleaned insect by count	3
Mammalian excreta by mg/lb	5
Other excreta, by mg/lb	5.0
Mold % by weight	3.0
Insect defiled/ Infested % by weight	2.50
Extraneous % by weight	0.50
FDA/DAL	**None**
Curcumin content	5.0% min
Moisture	10.0% max
Ash	8.0% max
Acid insoluble ash	1.0% max
Average bulk index(mg/100 gm)	N/A
Grounded Turmeric : Chemical and Physical Specification	
FDA/DAL	None
Curcumin	5.0%
Moisture	10.0 %
Ash	8.0 %

Military Specification (EE-S-631J, 1981)	
Volatile oil (mg/100g)	3.5 min
Moisture	10.0%
Total Ash	8.0%
Acid insoluble ash	0.6%
Crude fiber	9.5%
Colour powder (express as curcumin)	5.0-6.6%
Granulation	95% min through a U.S.S. 40
Bulk index (mg/100g)	185

5. Nutmeg: The dried nutmegs are graded by hand according to their weight, shape and colour. After grading, the nutmegs are fumigated with methyl bromide to protect them from storage pests.

The following classifications have been made in nutmeg trade.

1. **Whole and sound nutmeg** :This is used in spice trade as: (a) large (b) medium and (c) small
2. **Sound shrivels**: These are employed for grading, but are usually too expensive for oil distillation.
3. **Rejections:** Considerably low-priced, this grade can be used for the distillation of oil.

4. Broken and warmy

This grade is also suitable for oil distillation. The grades of mace are as follows;

a) Banda *Mace* is considered to be the finest It has a bright orange colour and a fine aroma

b) Jaye Estate Mace is golden yellow, interspersed with brilliant crimson streaks.

c) Siauw Mace is of a lighter colour than Banda *mace* and contains less volatile oil

d) West Indian Mace, often regarded as the fourth grade of East Indian mace, is derived from M. *argentea.* It contains less volatile oil with an undesirable turpentine-like aroma. It is unsuitable for distillation purposes. `Banda' and Penan maces are considered to be superior in quality by the trad the world over. Mace is available in the market as 'whole', 'broken' or 'ground'

6. Vanilla: There are four important grades. The first (best) grade beans consist of those above 16 cm in length, soft to touch without any blemishes and containing 2.5% vanillin. The second-grade beans consist of those of 12-15 cm length, without blemishes and with more than 1.8% vanillin. The third-grade beans are shorter, with a length of 8-12 cm and with some blemishes. The rest of the beans are taken as fourth (last) grade and are of poor quality.

The grades or types of vanilla (beans) entering the trade are: Mexican vanilla, Bourbon vanilla (from Madagascar) Indonesian vanilla,Tahiti vanilla (from Tahiti), Vanillons (from West Indies)

7. Clove: Whole cloves are graded as special (Hand-picked), Grade-2, Grade-3, Ground (powdered) cloves, while the defective cloves are named as *Khoker cloves,* Headless cloves, Mother cloves, Extraneous matter, etc.

Table: 13 ASTA cleanliness specifications for Clove

Whole Clove : Chemical and Physical Specification	
Specification	**Suggested limit**
Whole cleaned insect by count	4
Mammalian excreta by mg/lb	5
Other excreta, by mg/lb	8.0
Mold % by weight	1.0
Insect defiled/ Infested % by weight	1.0
Extraneous % by weight	1.0 (5% allowances for unuttered clove stem over and above tolerance for the other extraneous matter permitted
FDA/DAL	**None**
Adulteration with stem by weight	Avg. 5 % by weight
Volatile oil	16.0% min
Moisture	8.0 max
Ash	5.0% max
Acid insoluble ash	0.5% max
Average bulk index(mg/100 gm)	240
Grounded Clove : Chemical and Physical Specification	
FDA/DAL	None

Volatile oil	14.0 max
Moisture	8.0% max
Total ash	5.0% max
Ash	0.5 max
Military Specification (EE-S-631J, 1981)	
Volatile oil (mg/100g)	15.0 min
Moisture	9.0%
Total Ash	6.0%
Acid insoluble ash	0.50%
Granulation	95% min through a U.S.S. 30
Bulk index (mg/100g)	180

8. Cinnamon: The graded slips are rolled to form pipes by fitting them over the outer edges of the slips. Soon after piping, they are allowed to dry. The bark-free ones of finest, smoothest quality are graded as "00000", the coarsest being grade "0" and the remaining ones are graded as 'chips', 'pieces', `quillings' (broken pieces) and 'graded featherings'. The outer bark possesses a slightly acidic flavour and its removal enhances the delicate aroma. Good quality cinnamon should not be thicker than a thick paper. It should be light brown with wavy lines and produce a fractured sound when broken. When chewed, it should become soft, melt in the mouth and sweeten the breath. The bark of a large shoot is coarse, whereas the tender ones are very thin and straw coloured. The shoots which are exposed to the sun are said to be more spicy than those grown under the shade. The best quality cinnamon is always obtained from the thin bark from the shoots in the centre of the bush and from the middle portion of the shoot. Commercial bark should not be more than 0.5 cm thick and the thinner the bark the better the grade. Broken quills are exported as quillings and the inner bark of twigs and twisted shoots as feathering. They are used mainly for grinding or for the distillation of cinnamon oil

Table: 14 Commercial Specifications of Cinnamon

Colour	Pale brown to slightly reddish colour Ground cinnamon – yellowish to reddish brown in colour
Odour	Characteristic fresh aroma
Flavour	Delicate and sweet flavor characteristic to Ceylon cinnamon. It shall be free from foreign flavor. Including mustiness.
Moisture	Not more than 15% for quills and 12% for other grades

Volatile Oil	Minimum 1% for quills and 0.7% for other grades on dry basis.
Shelf Life	Minimum of 1 year
Packing	Packaged in clean, sound, dry packages, made of of jute, cloth, paper or polyethylene bags.

Stringent health and food laws exist in all developed countries. These countries often revise such laws in the light of new scientific findings. For example, it might so happen that monitoring to find out the presence of certain disease causing organisms in food stuffs is made mandatory all on a sudden. Similarly, changes are often made in the tolerance levels of pesticide residues. These countries are also steadily bringing down the permissible levels of other impurities. Thus scientific and technological advancement brings forth new challenges in the export trade. The health and food laws which are increasingly becoming stringent reflect the grave concern of the respective government for the safety and welfare of their people.

A new consciousness is growing all over the world about disease-causing organisms, poisonous substances and impurities. Parallel to this, the degree of excellence which consumers expect from foods is also growing. Exporting countries are thus constrained to maintain quality standards set by the importing countries. According to projections made by the Food and Agriculture Organisation, food exports will register significant growth in the next decade. Increasing our share in this expanding market offers opportunity as well as a challenge.

Conclusion: We export spices mostly to developed countries like USA, UK, Germany, other European Countries, Japan, Canada etc. These countries have stringent food laws and regulations to ensure that foods which include spices, are safe, whole - some and produced under sanitary and hygienic conditions. Hence, spices exported into these countries should be free from bacterial contamination, mould, mycotoxins, harmful chemicals including pesticide residues and other pollutants, insect infestation and filth contributed by animals, insects or insanitary conditions in the farm, warehouse, package or carrier. The concern of the importing countries about food safety and quality is understandable as several cases of foodborne diseases and food poisoning occur in these countries as a result of consuming contaminated food

In order to compete and retain our position in the world spices market, our ability to meet the quality expectations in the areas of pesticide residues, mycotoxins and microbial

load should be strengthened. Quality is the key to good marketing of spices. Our motto should be 'clean spices' rather than 'cleaned spices' Broad-basing the spices export basket by product diversification to meet global quality standards. Price competition in the global market is another major challenge for the Indian spice industry. It is the responsibility of the traders and spices producer to maintain the quality and update the regulations and quality requirements of the importers to compete with other countries. Most Indian spices are much valued in the world market because of their intrinsic qualities; hence, maintaining the quality as per the standards is the way to sustain the competiveness in the market with others.

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19. SCOPE OF ENTREPRENEURSHIP IN SPICE CROPS

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India: A Global Spice Hub

India is known as the 'The home of spices'. India is the leading producer, consumer and exporter of spices in the world and meets nearly half of the global demand for spices. Spices are produced almost in all states of India. A whopping 75 spices out of 109 listed by ISO are produced in India.

Harnessing the technological developments over a period of time, Indian spices have unleashed their application capabilities to cover a wider spectrum of industry verticals such as spice and food processing industries, pharmaceutical and medical segments. As a result, Indian spice industry has witnessed increasing number of varieties of value-added spices and spice products in ground, crushed, cracked, blended, dehydrated forms in bulk, in brine and in consumer packs Examples: curry mixes, natural food colours, spice extracts, spice oil, oleoresins, organic spice varieties, etc.

Landmark Events in the Development of Spices Industry in India

- First research station for pepper established in India at Panniyur, Kerala in 1952-53.
- Establishment of National Research Centre for Spices (NRCS) in 1986.
- Establishment of Spices Board of India (clubbing the activities of Spices Export Promotion Council and the Cardamom Board) in 1986, which is a statutory body responsible for the development and growth of all the major Indian spices, having commercial significance.
- NRCS upgraded as Indian Institute of Spice Research. (IISR) 1996.
- Establishment of International pepper exchange at Mattancherry, Kerala in 1997.

Trading in Spices on Commodity Exchanges in India

In India, trading in spices futures dates back almost a century ago to pre-Independence period. Even in the post-Independence period when futures trading in most of the commodities were banned in mid-1960s, Pepper and Turmeric futures continued to be traded on commodity exchanges in India.

Table:1. List of spices notified under Section 15 of The F.C.(R.) Act

Aniseed	Coriander seed
Betelnuts	Ginger
Cardamom	Methi
Chillies	Nutmegs
Cinnamon	Pepper
Cloves	Turmeric

A committee on Forward Markets under the Chairmanship of Prof. K.N. Kabra, at the time of introduction of economic reforms, recommended up gradation of futures trading in pepper to the level of international futures markets. At present, 12 out of 103 commodities in which futures trading is permitted belong to spices category. However, six spices, viz., Chilli, Coriander, Jeera, Pepper, Turmeric and Cardamom constitute spice complex for actual derivatives trading in India. The performance of these contracts illustrates the success of efficient price discovery in the Indian domestic market through derivatives trading. Albeit the fact is that no other futures contracts of spices are actively traded on any of leading international exchanges. The list of spices notified and important market centre is given in the table 1&2.

Table: 2. Average prices of major spices in important market centers (Price in Rs. /Kg.)

Spices	Market	2013-14	2014-15
Pepper-MG1	Cochin	448.29	686.64
Chilli	Guntur	67.06	68.66
Ginger-Best	Cochin	181.68	274.55
Turmeric	Chennai	99.79	101.79
Garlic	Chennai	38.49	45.95
Coriander	Chennai	79.29	113.88
Cumin	Chennai	139.01	127.95
Fennel	Chennai	87.91	110.59

Spices	Market	2013-14	2014-15
Fenugreek	Chennai	37.13	65.08
Ajwan seed	Chennai	101.40	133.35
Mustard seed	Chennai	53.53	50.21
Tamarind	Chennai	69.45	86.99
Clove	Cochin	914.77	1015.74
Nutmeg without shell	Cochin	551.34	494.52
Mace	Cochin	637.80	771.91
Saffron	Delhi	154848	172804

Source: Spice Board of India, Annual Report 2014-15

Agriculture in Andaman and Nicobar Island

Agriculture land available in Andaman and Nicobar Islands is very limited and restricted within 6 percent of the total area of this place. Due to the need to increase the fertility of

this land, intense measures have been taken to bring scientific revolution to increase the production capability.

Agriculture crops in Andaman and Nicobar Islands include vegetables, which are cultivated during summer season when the climate is quite favorable for food productivity. The vegetable cultivation of the Andaman and Nicobar Islands includes vegetables like radish, lobia, brinjal, ladies finger, poi, cucurbits, marsa, etc. Agriculture of Andaman and Nicobar Island also produces vegetables like knolkhol, tomato, capsicum, cauliflower etc, which are mainly winter season vegetables.

Andaman and Nicobar Islands agriculture has very recently included the hilly areas to promote plantation of different spices crops and fruits. The hilly areas are best used for horticulture, with cultivation of crops like coconut and fruits like pineapple, guava, jackfruit, mango, citrus fruits and other special fruits specially found in this island. Agriculture activity also includes red oil palm, rubber and cashew nut cultivation. A minimum amount of oilseeds and pulses cultivation could be seen in Andaman and Nicobar Islands.

Spice production in Islands

In island, Spices like pepper, clove, nutmeg, and cinnamon are grown under multi-tier cropping system. The ANI is default 'organic spice' producing region. A large portion of their production is sold to tourist and transported to mainland as well. Productivity of spices like black pepper , cinnamon , clove, nutmeg, chilles (dried), turmeric and ginger respectively for the 2006 and 2012 is given in the table.3.

Table:3. Status of spices crops in island from 2006 to 2012

Years	2006			2012		
Crops	Area (ha)	Production (t)	Productivity (t/ha)	Area (ha)	Production (t)	Productivity (t/ha)
Arecanut	046.4	3058	0.76	4220	5950	1.40
Coconut	20927	78	3749 nuts/ha	21800	105	4816 nuts/ha
Black pepper	697.0	36	0.05	600	31.71	0.05
Cloves	200.0	7.84	0.04	156	5.1	0.03
Cinnamom	153.0	18	0.12	150	28	0.18
Nutmeg	82.60	870	10.53	70	351000	5041nos/ha
Chilles (Dried)	-	-	-	115	174	1.51
Ginger	-	-	-	210	1855	8.83
Turmeric	-	-	-	80	485	6.06

Source: CIPMC, Prot Blair(2006) & NHM, New Delhi (2013)

According to the State Tourism Department of A & N islands, around 2,00,000 tourists visit Andaman Islands annually, but they do not get spices as the local vendors purchase them from farmers and export to mainland India.

Farmers of the Andaman and Nicobar Islands are organic growers of spices, including black pepper, by default as they do not provide fertilizer or compost to spice trees in their home gardens. Total of 29000 ha (25000 ha coconut + 4000 ha arecanut) of arable lands (50, 000 ha) in the islands are under plantation crops which provide suitable environment for the spice production. In addition 3000 ha sloppy lands are under vegetable cultivation. If one-fourth of the coconut and arecanut plantation and sloppy lands are utilized for organic cultivation of black pepper, it is estimated to produce 2020 MT annually. Technologies are developed for black pepper cultivation which make the cultivation efficient.

The departmental farms situated at various Island of UT are functional and produce vegetable seedlings in season and planting materials of Spices such as Cinnamon, Clove, Nutmeg, Bay leaf, Black pepper etc. are raised in the departmental nurseries to fulfill the demand of farmers for holistic development.

SWOC ANALYSIS OF ISLAND AGRICULTURE

Strength

- ❖ Congenial agro climatic conditions for the cultivation.
- ❖ Wide scope of rainwater harvesting.
- ❖ Consumption of chemical fertilizer and pesticides is very low.
- ❖ Treasure house of medicinal & aromatic plants.
- ❖ Proximity of South East Asian countries, for International market.
- ❖ Scope for integrated Silviculture/Agro Forestry systems.
- ❖ Govt. plantations with the department for production of planting materials.
- ❖ Presence of CARI / KVKs in the Union Territory.

Weakness

- ❖ Remoteness and scattered nature of the islands & poor connectivity.
- ❖ Non-availability of organized marketing and processing facilities.
- ❖ Lack of perennial water resource.
- ❖ Natural calamities, erratic rainfall.
- ❖ Prevalence of pest & diseases due to conducive weather condition.

- Fluctuating price trends of farm produce.
- High labour cost.
- Undulating land topography.

Opportunity

- Potential for organic farming and export of value added organic products.
- Potential for commercializing High Value Crops, indigenous medicinal & aromatic plants & extraction of essential oils.
- Potential for multiple cropping mixed farming in the existing coconut /Arecanut garden as multitier cropping systems.
- Potential for promotion of mushroom cultivation and apiculture.
- Strengthening of post harvest infrastructure facilities & establishment of processing, marketing infrastructures and storages.
- To attract and retain educated youth in agriculture related activities.
- To increase competitiveness of commodities.
- Employment generation through non-farm activities.

Challenges

- Uncertain weather conditions leading to disruption of ferry services and communication.
- Lack of storage and market facilities.
- Reluctance of the youth to take up farm activities.
- Occurrence of pest & diseases.
- Fluctuating price trends of farm produce.

Cultivation of Spices for Higher Income

What to Do ?

- Grow Horticultural Crops for higher income from lesser area.
- For healthy crop use high quality planting material.
- To keep fruits and vegetables fresh for longer period, use cold storage facility/cool houses.
- Earn maximum profit by adopting correct method of harvesting, cleaning, grading, processing and packaging.

- ❖ Produce off-season vegetables and flowers in poly-houses, low tunnels.
- ❖ Always use recommended variety of seeds as per local climate and adopt recommended seed rate and other package of practices.
- ❖ Replace seeds of paddy, pulses (except arhar), oilseeds (except mustard and sunflower) once in three years, seeds of maize, arhar, mustard and sunflower once in two years.
- ❖ Always procure certified seeds from authorized agencies and store the seeds in a cool, dry and clean place.
- ❖ Always use treated seeds for sowing and test for quality parameters like purity, germination, free from weed seed etc., before sowing.

Spices and its by products inclusive of benefits from coconut & arecanut

India is the biggest producer and consumer of spices in the world. The international trade in spices is estimated at about 906, 700 tonnes valued at $ 2125 million. India commands a formidable position in world spice trade with a share of 37 % in volume and 23 % in value. There is ample scope for new markets of novel value added and processed products from spices.

Types of Spices

Fruit	:	Cardamom, Chilli, Cumin, Fennel, Pepper
Seed	:	Mustard, Coriander, Nutmeg
Leaf	:	Bay leaf, Tejpat, Coriander
Root	:	Ginger, Turmeric
Bark	:	Cinnamon
Flower bud	:	Cloves

Uses of Spices

The primary application of all the three – spices, herbs and condiments – remains the same, i.e. they are used for adding flavour, aroma, colour and taste to food and drinks, and sometimes also as preservatives or anti-bacterial agents, or as refreshing or invigorating agents. Although spices are very commonly used in the form of a powder, some are used as tinctures obtained by extracting essential oils and many are used as a whole.

The use of spice in food has started from time immemorial but they have found new applications in the course of history as ingredients of medicines, perfumes, incense, soaps

and many pharmaceutical products. Most of Spices are indigenous to tropical Asia, the West Indies and South America. Hence, spices have always served as a primary and prominent source to earn the much needed foreign exchange by developing countries in these regions, which historically have been exporting these basic agricultural commodities to developed countries, which have limited production of the same.

Pepper

Black pepper: Black pepper (*Piper nigrum*), called as the king of spices is one of the oldest and best-known spice in the world. In India there are only few states like Kerala, Karnataka, Tamil Nadu and Andaman and Nicobar islands that produce black pepper. Though, Kerala ranks the first in its production, the Andaman Islands are known for its quality. The black pepper has earned a high market, local, national and international as well because of its wide use in pharmaceuticals, flavouring industries and household consumption as a spice.

White pepper: White pepper is prepared from ripe berries or by decorticating black pepper. White pepper is garbled, sorted and packed in gunny bags. Approximately 25 kg white pepper is obtained from 100 kg ripe berries.

Decorticated black pepper: This is a form of white pepper produced by mechanical decortications of outer skin of black pepper.

Pepper oil: Black pepper is crushed to coarse powder and steam distilled to obtain 2.5 to 3.5% colourless to pale green essential oil which becomes viscous on ageing. It is used in perfumery and in flavouring.

Pepper oleoresin: Extraction of black pepper with organic solvents like acetone, ethanol or dichloro ethane provides 10-13% oleoresin possessing the odour, flavour and pungent principles of spice. Piperine content of oleoresin is 35 to 50%.

We have attempted to understand the returns by scientific planting of black pepper under arecanut in area of 0.10 ha . The cost involved during the gestation period along with the returns is reflected in the table.4. This is best suited for the small farmers holdings which is with the maximum farmers.

Table: 3. Technological Demonstration of Black pepper under arecanut in an area of 0 .10 ha i.e. 1000 m²

A.	Cost of Cultivation			Cost in Rs.
1st year	a)	Cost of rooted Black Pepper seedlings	150 nos (3nos each) @ Rs. 5/-	1500.00
	b)	Labour charges for pitting, farm application & planting	5 mandays @ Rs300/-	1500.00
	c)	Cost of FYM	(1/2 truck)	3000.00
	d)	Labour charger for after care & maintenance	5 mandays/ month x 12 months x Rs 300/-	18000.00
	Total			**24000.00**
2nd year	a)	Cost of FYM	(1/2 truck)	3000
	b)	Labour charge for after care & maintenance	5 mandays /month x 12 months x Rs.300	18000
	Total			**21000**
3rd year	a)	Cost of FYM	(1/2 truck)	3000
	b)	Labour charge for after care & maintenance	5 mandays /month x 12 months x Rs.300	18000
	Total			**21000**
4th year	a)	Cost of FYM	(1/2 truck)	3000
	b)	Labour charge for after care & maintenance	5 man/day /month x 12 months x Rs.300	18000
	Total			**21000**
B.	**Returns**			
5th year	1Kg/plant=150 Kg /Unit @ Rs.350/-			52,500
	Total			**52,500**

Ginger

From ginger many value added products like green ginger, dry ginger, ginger powder, ginger oil, ginger oleoresin and preserved ginger can be obtained. They pave the way for developments of many small scale industries. The most important indigenous cultivators like Jorhat, Maran, Wynad Local, Nadia and other popular exotic cultivar Rio-de-janerio, and

high yielding varieties like IISR Varada, IISR Mahima and IISR Rejatha may be popularized for increasing productivity. Mahima is also resistant to root knot nematode. Other improved varieties of ginger are Suprabha, Suruchi, Suravi (released by OUAT Pottangi, Orissa). These varieties have very high export potential as India has 50% share in oil and Oleoresins trade in world market.

Tamarind

Tamarind is an apt crop for waste, degraded and dry land areas. Value added products like pulp, juice concentrate, tamarind kernel powder, tamarind pickle, tamarind candy, tamarind pulp powder, jam, paste, syrup and pectins can be prepared from tamarind with minimum investment. The value added products from tamarind have domestic and international market. Tamarind is easily available anywhere in India. The cost of production is also very low. Tamarind based products can attract both buyers from domestic and international level.

Turmeric

IISR, Kozhikode has released high yielding and high quality (5.5-6.0% curcumin) turmeric varieties viz. IISR Prabha, IISR Pratibha, IISR Kedaram & IISR Alleppey Supreme. Kanthi, Sobha, Sona and Varna are the improved varieties of turmeric from Kerala Agriculture University, Trissur, Kerala and Suranjana a new variety released for West Bengal by the BCKV, Kalyani are also suitable for adoption in A & N Islands, the agro climatic conditions being similar.

Cardamom seed and powder

Cardamom seeds are obtained by decorticating capsules. Cardamom powder is obtained by grinding seeds.

Cardamom oil

Produced commercially by steam distillation of crushed fruits or powdered seeds of cardamom. Oil percentage is 8-11.

Cardamom oleoresin

Oleoresin is obtained by solvent extraction. Of late, super critical fluid extraction is also adopted. Oleoresin is produced in a relatively small scale only.

Fixed oil of cardamom seeds

Obtained from seeds. Major constituents of oil are oleic and palmatic acids.

Major initiatives of Spice promotion by Spice Board of India

i) Sending business samples

Registered manufacturer exporters of spices having Spices House Certificate. Spices Board Logo, certified organic spice growers and exporters and brand registered exporters are covered under the programme. During 2014-15, the Board disbursed financial assistance totalling of Rs.8.26 lakh to 16 exporters.

ii) Printing promotional literatures/brochures

Promotional literatures and brochures are the preliminary promotional material to fetch the buyers for the produce. Exporters who have SHC/ Logo/ Brand registered with the Board/ Organic Certification are eligible to avail the assistance at the rate of 50 per cent of the cost subject to a maximum of Rs. 2.00 lakhs per brochure and maximum twice during the plan period. Printing promotional literatures/brochures, video films/CDs and other electronic modes to project competencies and capabilities of exporters and the range of products and services offered to the prospective buyers abroad is supported by the Board.

iii) Packaging development and bar coding registration

The programme envisages improvement and modernisation of export packaging for increased shelf life, reduce storage space, establishing traceability and better presentation of Indian spices in markets abroad. Registered exporters can avail assistance to the tune of 50 percent of the cost of packaging development and bar coding registration subject to a ceiling of Rs. 1.00 lakh per exporter per year.

iv) Brand promotion loan scheme

The objective of the programme is to assist penetration of Indian brands in the identified overseas markets, through a series of measures leading to the positioning of quality Indian spice brands within the reach of the foreign consumers with a clear mark of traceability and food safety. Under this programme, exporters who have registered their brand will provided financial assistance towards interest free loan up to Rs.100 lakh per brand. With an objective to position specified brands in the identified outlets and selected cities abroad, 100 percent of slotting/listing fee, promotional expenditures and 50 percent of the cost of product development will be considered under the project. The Board has released a total amount of Rs.61.14 lakh to two exporters during the period.

v) Spices Park

The Regional crop specific Spices Park is a well conceived approach to have an integrated operation for cultivation, post harvesting, processing for value addition, packaging, storage

and exports of spices and spice products. The Spices Park will ensure a better pricing for the produce by eliminating intermediaries from the supply chain system currently followed locally for trading of spices. The facilities available in the Spices Park can be utilized by the farming community for selling their produce directly to the exporters by improving the quality of the products. Hence, the farmer community will get premium price for their produce.

Locations of crop specific Spices parks

Board is establishing Spices Parks in 8 locations across the major producing/assembling centres of spices during the XI plan period. The mission is to establish at least one Spice park in every states of the Country by the end of the XII plan period. The location of the Parks and Spices covered are as follows :

Location	State	Spices Covered
Chhindwara	Madhya Pradesh	Garlic & Chilly
Puttady	Kerala	Pepper & Cardamom
Guntur	Andhra Pradesh	Chilli
Sivaganga	Tamil Nadu	Turmeric, Chilli & Coriander
Jodhpur	Rajasthan	Cumin, Coriander
Mehsana	Gujarat	Cumin, Fennel Coriander
Kota	Rajasthan	Coriander, Cumin
Guna	Madhya Pradesh	Coriander, Fenugreek & Garlic

Facilities at Spices Parks

Spice Parks will function as a common facility centre for development of spice industries. The basic objective of the concept is to provide common infrastructure facilities for both post harvest and processing operations of spices, which also aims to backward integration by providing rural employment. All the Spices Park will have processing facilities at par with international standards in which the produces could undergo cleaning, grading, sorting, grinding, packing, warehousing etc. Apart from this, Board will develop the common infrastructure facilities like Roads, uninterrupted water and power supply system, Fire fighting & Control systems, Weighing bridges, effluent Treatment Plants, facilities for Bank & Post office counters, Restaurant, Business centers, Guest house etc. Spices Park will also render educative services to the farming/trading community. Spice Park provides training programmes to the farmers on GAP, Post harvest operations, advanced processing practices and global food safety and quality standards.

Public Private Participation

Under the concept of the Spice Park, Board will lease out the lands available in the Spice Park to private entrepreneurs for developing their own processing plants for value addition. The Private entrepreneurs will develop their processing plants in the Spices Park. The grower community can make use of these facilities for selling their produce directly to the exporters so that they can avail the premium price for their products. On other side, exporters can develop a link with reliable farming community for an uninterrupted supply of raw material for their business. Moreover the establishment of the processing plants by the exporters will create local employment opportunities.

vi) Signature Stall

The signature shops named 'Spices India' is a new initiative by the Board with the objective to promote a unique brand image to Indian Spices and serve as an experiential centre for customers to touch, smell and feel spices and to educate them on various culinary, neutraceutical and medicinal uses of spices. As a Pilot project, the first of its kind signature shop was opened in Cochin in September, 2013. The design objective of the store is to create an experiential story line about Indian Spices in a retail space by talking about the history of Indian Spices, its unique uses, culinary uses, health Benefits, personal care product among others.

vii) Contract Farming/ Contract Marketing

Contract farming or marketing essentially is arrangement between the farmer- producers and the agri-business firm to producers and agreed quantity and quality of the produce at a particular price and time. It can only be pure procurement transaction or can extend to the supply of inputs or even beyond. Contract farming is emerging as an important mode of procurement of raw material by agri-business firms in India due to the developments in the field of agricultural marketing, changes in habits and agricultural technology in the new economic environment. This is an important initiative for reducing transaction costs by establishing farmer processor linkages in addition to the already existing methods of linking the farmers to the consumers.

With a view to empower the farmers to get better price realization and wider markets for their produce, crop specific Spices Parks have been established in major production/market centers. The Parks will facilitate the farmers to utilize the common infrastructure facilities for cleaning, grading, packing and steam sterilization which will ensure the quality of the product and thus a higher price. The scientific packing and warehousing facilities in the park and the quality testing facility in the laboratory will improve the overall quality of spices

produced in the locality. Spices Park is a well conceived approach to have an integrated operation for cultivation, post harvesting, processing for value-addition, packaging and storage of spices and spice products.

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20. SPICES BASED AGRO-TOURISM OPPORTUNITIES IN ANDAMAN & NICOBAR ISLANDS

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Agritourism or agrotourism, is most broadlydefined as tourism activity of bringing visitors to agriculture based operation at farm. Agrotourism has different definitions in different parts of the world, and sometimes refers specifically to farm stays. Agrotourism is a form of niche tourism that is considered a growth industry in many parts of the world, including several countires. Other terms associated with agritourism are "agritainment", "value added products", "farm direct marketing" and "sustainable agriculture etc. It includes a wide variety of activities, including exploring a plantation, get to know the lifestyle of farm people, exposure to the specific agricultural activities, buying produce direct from a farm stand, navigating a set agricultural processing activities, packaging and marketing of products, picking or processing of fruits/other produce, feeding animals, or staying at a bed and breakfast (B&B) on a farm.o

Generally tourism industry offers great chance for the tourists to learn about new places, people, cultures, cuisines. It offers stress relaxing conditions by way of exposure to newer things in individuals' lives. In modern days, due to urbanization and move towards non-agricultural activities, the present generation is less exposed to traditional agricultural activities and also the importance of agricultural livelihood for sustaining the food availability. In the recent years, people have become more interested to know how their food is produced. They want to meet farmers and processors and talk with them about what goes into food production. For many tourists who visit farms, especially children, the visit marks the first time they see the source of their food, be it a dairy cow, a paddy field, or a bunch of grapes they can pick and taste right under a vineyard. Farmers use this interest to develop traffic at their farm, and interest in the quality of their products, as well as awareness of their products.

A farm stay can be defined as any type of accommodation on a functional farm having various activities of a typical agricultural farm. Some farm stays may be interactive. Some are family-focused, offering children opportunities to feed animals, collect eggs and learn how a farm functions. Others don't allow children and instead offer a peaceful retreat for adults. The term "farm stay" can also describe a work exchange agreement, where the guest works a set number of hours per week in exchange for free or affordable accommodation. Possible farm stay accommodations include cabins, cottages, converted barns/outbuildings, farmhouse

guest rooms, platform tents, tent camping etc. Farm stays are described as agritourism (a farmer opening his/her farm to tourists for any reason, including farm stands, ecotourism (Responsible travel to natural areas that conserves the environment and improves the well-being of local people), and geotourism (tourism that sustains or enhances the geographical character of a place—its environment, culture, aesthetics, heritage, and the well-being of its residents).

Agritourism is widespread in the United States with a wide range of activities that include picking fruits and vegetables, riding horses, tasting honey, learning about wine and cheesemaking, or shopping in farm gift shops and farm stands for local and regional produce or hand-crafted gifts. IN Europe and Canada the popular activities include, wine tourism, dairy, maize fields, wheat fields, cherry picking, chocolate making, wool production etc.

Agro-tourism and Spice tourism in India

Agro-tourism is the latest concept in the Indian tourism industry, which normally occurs on farms.Popular examples of agro tourism in India includes Tea tour. Coffee tour, chocolate tour, agri-village tour, apple orchard tour, spices tour etc. In this series, spice tourism activities are promoted in major spice growing regions of the country mostly in Kerala, Karnataka, Tamil Nadu and North eastern region. The world renowned spices such as Black Pepper, Cinnamon, Nutmeg, Clove, Turmeric, Ginger are grown in Andaman and Nicobar Islands. These along with other minor spices and plantation crops such as coconut and aricanut could offer good scope promoting spice tourism in these islands which will increase the income of the spice farmers and increase the marketing of island produced spices for higher prices. Spice tourism promotion would also hasten the process of adoption of improved technologies to keep the spice plantations more productive and healthy thereby increasing the productivity. Spice tourism would also promote the introduction of newer technologies for production of niche products in the Islands.

Generally, the agrotourism provides a vent to escape from the daily hectic life in the peaceful rural environment. Provides opportunity to experience the real India and have the experience of the lifetime on the farm stay, to relax and revitalize in the in the pure natural environment, surrounded by magnificent setting.Spices based Agrotourismin A& N Islands could provide opportunity to experience the real enchanting and authentic contact with the rural life, cultures, daily routine of farm workers, use of spices in the food, new cuisines and to taste the local genuine food and get familiar with the various farming tasks during the visit.

Gender mainstreaming in Agro-tourism

Gender mainstreaming is referred to the public policyconcept of assessing the different implications for women and men of any plannedagriculturallybased operation or activity that brings visitors to afarm, in all areas and levels. It essentially offers a pluralistic approach that values the diversity among both men and women.

Agriculture is one of the most widespread and oldest activities in the world. It plays crucial role in sustained food production, environmental protection, landscape preservation, rural employment and food security throughout the world. However, agriculture is not uniform throughout the world and it varies with weather, preference, suitability, level of participation of Society, differing awareness etc. There are different elements such asthe scale of farming, crop and livestock combinations, intensity of farming/ cropping, ways and means of disposal of farm produce, the level of farm mechanization (small-scale farmers/ informal small-scale agriculture, commercial farming/plantation agriculture, self-sufficient farming, organic farming etc.) that are influencing the structure of agriculture and thereby agrotourism.

From a gender point of view, there are significant gaps between women and men. Studies at various places have indicated that women farm holders have significantly smaller farms than men farm holders. The share of female farm holders is particularly high on farms with no clear specialization in livestock rearing or crop production. The specialized activities such as harvesting, farm processing, pollination, unique value addition methods, waste utilization practices, new planting, rural recipesetc are mostly undertaken by women.

Women in Agro-tourism -Gender issues and opportunities

Involvement of women in Agriculture changes with age and low-skilled workers in modern agricultural practices. Use of newer machineries, changed interests, cropping pattern and need for additional training in modern facilities change the structure of women involvement. The prevailing lower level of employment opportunities and level of education in rural areas, competitionand ease of reach of help are other crucial issues that need to be addressed to ensure the participation of women in Agrotourism. Development of entrepreneurship and self-employment in agriculture is crucial for the improvement of women's employment situation.

The contribution of women in the rural economy need to be promoted through self-employment and small businesses. Women can be at the forefront of innovation and diversification in rural areas by developing new activities, production lines and services.

Women can develop agro-tourism activities such as artisan food and drink production, craft enterprises, and herbal tourism. Women have the added advantage of an awareness and knowledge of local needs, and specific interpersonal and communication skills.

It has been accepted widely that generally, the women are the driving force for the maintenance, conservation and development of rural areas, both in cultural and economic terms. It is very well established that they contribute to the preservation of a rich and diversified cultural heritage and the transmission of traditions in every walks of life. The women folk represent a considerable proportion of the workforce in agriculture and contribute to the rural development. Studies have also reported that many who are involved in agricultural work do not receive a separate income from their male members of the household.By assisting their farmer husbands and other self-employed men, they are not entitled to social security in their own right and often do not hold property rights to land or farms.

In the light of the above, it is believed that Agrotourism would provide an alternate opportunity for social security to Women in Agriculture. The development of rural areas requires the creation and development of new economic activities in the form of new farms and diversification into non-agricultural activities. This may include the provision of services to agriculture and forestry, and the development of activities related to healthcare, social integration and tourism.

For gender mainstreaming in spices based agrotourism, the main objectives to beensuring that women who live and work do not suffer discrimination, get more awareness, curbing the exodus of women from rural areas to urban areas, thereby helping to combat rural depopulation and ageing, ensuring that women contribute to the economic development of rural areas with their entry into the spice tourism, document and popularize the unique farming practices involving women, conduct of awareness prgrammes and provide safe working environment

SWOT ANALYSIS of Spice tourism in A&N Islands

Strengths

- ❖ Well established existing tourism industry
- ❖ Availability of spice gardens and scope for expansion of area
- ❖ A strong supplementary source of Income for farmers would attract the stakeholders
- ❖ Organic production of spices and awareness about the goodness of organic products
- ❖ Possibility of newer employment generation for women and overall rural development

Weakness

- Growth of the Industry may be slow.
- Less educated farmers and farm women need varied training on newer opprtunities
- Lack of government / Institutional support in form of subsidies and marketing
- Lack of spice-tourism training centers and propaganda
- Lack of awareness, motivation and financial resources

Opportunity

- As a new branch of Tourism has immense scope of growth with the involvement of different stakeholders
- More farmers can be beneficiaries including women and the spice tourism industry can be unique combining with other island tourism activities
- More opportunities for women empowerment attracting good social support
- Government support can increase the outreach of this tourism through public-private partnership mode
- State owned land under different areas of the Islands can be cultivated & converted of facilitate agri/spice tourism in selected localities

Threats

- Climatic condition and the difficulties in transporation
- Rampant migration of population from farming to other activities
- Being a new area of tourism, faces less competition resulting in slower growth rate

Suggested models for Spices based agro tourism

- Coconut and Arecanut based spices farming tour comprising the activities of the plantations, products, components of cropping systems, farm exploration and stay
- Spice farming practices- planting, harvesting, farm processing etc
- Organic spice products- farm processing, storage, packing, marketing
- Niche products from spices along with fruits and vegetables- beverages, candies, health products, nutraceuticals, cosmetics etc
- Spices and plantation based handicrafts- dry flowers, aromatic mats, coconut shell packaging of spices
- Traditional recipes unique to the island communities with unique combination of island produced organic spices
- Awareness and spice health sessions in natural environments

Spices have been integral to Indian history. In Andaman and Nicobar Islands, out of about 500t00 ha of land under agriculture, about 25000 ha are occupied with plantations of coconut and aricanut. Most of these areas are potentially suitable for integrating several spices such as Black Pepper, Cinnamon, Nutmeg, Clove, Vanilla, Ginger, Turmeric, turmeric, Garcinia and many more minor and herbal spices. Considering the strengths and opportunities listed above, promotion of spices based agrotourism in the Islands would be highly remunerative and empowering the farming community in income generation and self-sustenance. Spice tourism is of benefit to both the tourism industry as well as the tourists. The tourists get to visit spice farms and gardens and are provided knowledge on the different spices grown in the state, spice processing practices, grading methods, effective packaging, quality control methods etc. The support from government and other stakeholder organizatons in the form of training, creating awareness, creation of infrastructure and promotion of Island spices based delicacies are the needs for strengthening the spice tourism in the Islands. The uniqueness of Andaman tourism sector should be integrated with agrotourism more particularly organic spices tourism.

21. MARKET-LED APPROACH AND INSTITUTIONAL INNOVATIONS IN AGRI-EXTENSION FOR PROMOTION OF SPICES AS ENTERPRISE

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With globalization of market, farmers have to transform themselves from mere producers cum sellers in the domestic market to a wider market to best realize the returns for their investments, risks and efforts. This to be achieved, farmers need to know answers to questions like what to produce, when to produce, how much to produce, when and where to sell, at what price and form to sell their produce. Farmers received most of the production technologies from extension system. Extension system now needs to be oriented with knowledge and skills related to market.

An efficient marketing system is essential for the development of the agricultural sector. In as much as it provides outlets and incentives for increased production, the marketing system contributes greatly to the commercialization of subsistence farmers. Failure to develop the agricultural marketing system is likely to negate most, if not all efforts to increase agricultural production (FAO, 2000). It is expected that future agricultural growth would largely accrue from improvements in productivity of diversified farming systems with regional specialization and sustainable management of natural resources, especially land and water, effective linkages of production systems with marketing, agro-processing and other. The Government provides much of the infrastructure required for efficient marketing. One of the most important is the information and extension services to farmers besides transport & communication facilities, public utility supply. like water, electricity, fiscal and trade administration and public storage, market and abattoir facilities (FAO, 2000).

In the changing scenario of Indian agriculture, with newly added face of marketing, the extension system is likely to undergo a series of crises.

Knowledge-skill input crisis

Besides the production technologies, the extensionists now, have to get equipped with market information which requires further training to the extensionists and additional funding.

Efficacy crisis

Already, the extension system is under criticism. With the increased and enriched role, they have to perform multiple activities to prove their efficacy.

Credibility crisis

Even with all the market knowledge and efficacy in performing their role, the extension system may face the credibility crisis due to rapid and unexpected changes in the market.

Reorganization structure crisis

With assumption of new roles, the reorganization structure may be prone to changes and the system has to adjust itself to this shock.

Challenges

- The gigantic size/ mechanism of the public extension system in the country is heavily burdened with performance of multi-farious activities in the field. Extension system acted as liaison between the researcher and farmer. They are endowed with the responsibility of conveying research findings from the scientists to the farmers and feeding back the impressions of the farmers to the scientists. The new dimension of marketing may overburden and become agenda beyond their comprehension and capability. The public extension system is already under severe criticism for delivering the services. In the light of this scenario, the challenges remain to motivate the extension personnel to learn the new knowledge and skills of marketing before assigning them marketing extension jobs to establish their credibility and facilitate significant profits for the farming community.
- Sporadic success stories of using information technology by farmers are publicized. There is an urgent need to strategically frame an information policy to make the farmers info-rich. Internet technology has percolated down upto the Taluk level and in some states up to village level. Search engines and the present websites furnish general information presently. Agricultural market related information is not available readily on the internet. Hence, a whole network of skilled personnel need to be engaged in collection of current information and creation of relevant websites pertaining to / serving specific needs of farmers. Creation of websites should be mandatory in different languages to equip the farmers with information. These websites should contain information like market networks, likely price trends, current prices, demands status etc.

- In short, Kipling's, seven servants may be employed to get answers to questions like what and how much to produce, in what form to sell, at what price to sell, when to sell and where to sell. Information technology should be able to provide this kind of information to the farmers with press a button' on the computer on a continuous updated basis. Then and only then, the much talked about IT revolution would be beneficial to farmers.
- Generation of data on the market intelligence would be huge task by itself. Department of market already possess much of the data. Hence, establishment of linkages between agriculture line department and Departments of Market will strengthen the market-led extension.
- Extension cadre development poses a new challenge to the newly designed role. The present extension system suffers from several limitations of stationery, mobility, travel allowances, personnel development, etc. There is a dire need to upgrade these basic facilities and free the extension cadres from the shackles of the hygiene factors and enthuse them to look forward for the motivating factors like achievement, job satisfaction, recognition etc.
- Reorganization of the extension system like the position of Additional Director extension may be redesignated as additional Director Extension and marketing and be made to look after the extension and marketing.

Enhanced roles of Agricultural extension personnel in light of market-led extension

- SWOC analysis of the market: Strengths (demand, high market ability, good price etc.), Weaknesses (the reverse of the above), Opportunities (export to other places, appropriate time of selling etc.) and Challenges (imports and perish ability of the products etc.) need to be analyzed about the markets. Accordingly, the farmers need to be made aware of this analysis for planning of their production and marketing.
- Organization of Farmers' Interest Group (FIGs) on commodity basis and building their capabilities with regard to management of their farm enterprise.
- Supporting and enhancing the capacities of locally established groups under various schemes/ programmers like watershed committees' users groups, SHGs, water users' associations, thrift and credit groups. These groups need to be educated on the importance, utility and benefit of self- help group.
- Enhancing the interactive and communication skills of the farmers to exchange their views with customers and other market forces (middlemen) for getting feedback and gain the bargaining during direct marketing ex. Rythu Bazars, Agri-mandi and Uzavar Santhaigal etc.

- Establishing marketing and agro-processing linkages between farmers, groups, markets and private processors.
- Advice on products planning: Selection of crops to be grown and varieties suiting the land hlding and marketability of produce will be the starting pint of agri-enterprise Extension system plays an important role in providing information in this regard.
- Educating the farming community: to treat agriculture as an entrepreneurial activity and accordingly plan various phases of crop production and marketing
- Direct marketing: farmers need to be informed about the benefits of direct marketing. In some of the states, Rytu Bazars in AP, Apni Mandis in Punjab and Haryana and Uzavar Santhigal in Tamilnadu have shown success.
- Capacity building of FIGs in terms improved production, post harvest operations, storage and transport and marketing
- Acquiring complete market intelligence regularly on various aspects of markets
- Regular usage of internet facility through computers to get updated on market intelligence
- Publication of agricultural market information in news papers, radio and television besides internet.
- Organization of study tours of FIGs: to the successful farmers/ FIGs for various operatin with similar socio-economic and farming systems as the farmers learn more from each other.
- Production of video films of success stories of commodity specific farmers
- Creation of websites of successful FIGs in the field of agribusiness management with all the information to help other Figs achieve success.

Required information to extension system and farmers

- Present agricultural scenario and land use pattern
- Suitability of land holding to various crops/ enterprises
- Crops in demand in near future
- Market prices of crops in demand
- Availability of inputs
- Credit facilities
- Desired qualities of the products by consumers

- Market network of the local area and the price differences in various markets
- Network of storage and warehouse facilities available
- Transport facilities
- Regular updating of market intelligence
- Production technologies like improved varieties, organic farming, usage of bio-fertilizers and bio-pesticides, IPM, INM, and right methods of harvesting etc.
- Post- harvest management like processing, grading, standardization of produce, value addition, packaging, storage, certification, etc. with reference to food grains, fruits and vegetables, eggs, poultry, fish, etc.

Flow chart of agriculture as an enterprise

Rupee (credit/investment)

↓

What to produce

↓

Analysis of land holding for suitability of enterprises/ crops

↓

Decision on how much to produce/how much land holding to each enterprise/crop

↓

How to produce

↓

Post harvest technology

↓

Value addition

↓

Storage/transport

↓

When to sell

↓

Where to sell

↓

At what price to sell

↓

Selling

↓

Rupee

↓

Investment

Paradigm shift from Production-led Extension to Market-led Extension

Aspects	Production-led extension	Market-led extension
Purpose/objectives	Transfer of production technologies	Enabling farmers to get optimum returns out of the enterprise
Expected end results	Delivery of messages Adoption of package of practices by most of the farmers	High returns
Focus	Production/yields "seed to seed"	Whole process as an enterprise/ High returns "Money to Money"
Technology	Fixed package recommended for an agro-climatic zone covering very huge area irrespective of different farming situations	Diverse baskets of package of practices suitable to local situation/ farming systems
Extensionists' interaction	Messages, Training, Motivating, Recommendations	Joint analysis of the issues varied choices for adoption Consultation
Linkages/liaison	Research-Extension-Farmer	Research-Extension-Farmer extended by market linkages
Extensionists role	Limited to delivery mode and feedback to research system	Enriched with market intelligence besides the TOT function: Establishment of marketing and agro-processing linkages between farmer groups, markets and processors
Contact with farmers	Individual	Farmers' Interest Groups Focused groups/SHGs

Maintenance of Records	Not much importance as the focus was on production	Very important as agriculture viewed as an enterprise to understand the cost benefit ratio and the profits generated
Information Technology support	Emphasis on production technologies	Market intelligence including likely price trends, demand position, current prices, market practices, communication net work etc besides production technologies

(Ahmed & S.Dam Roy *et.al.*)

Emerging and evolving institutional innovations in agri-extension

Providing broad-based services to the farming community and playing a central in agricultural innovation systems in order to integrate the various components effectively are the major responsibilities expected by the contemporary agricultural extension service providers. There are many such institutional innovations are emerging with a way to provide either broad-based services to the majority small and marginal farmers of the country or playing the integration role among the major components of the agricultural innovation systems or both.

Producer cooperatives, one of the popular institutional arrangements, strive to cater to the location-specific demands of the stakeholders especially the farmers, in terms of arranging agricultural inputs including credit, market facilities, etc and thus provide scale of economies in addition to multiply the voice of the small and marginal producers. Amul model of Gujarat in milk has shown the entire world not only how an organized cooperative system can bring vibrancy to the livelihood pattern of the milk producers but also how the producers can diversify their activities through established business models. However, there are by and large inadequacies in the cooperative system with respect to efficiency, strategies in profit-making ways and eliminating the political intervention. Hence, there was an attempt in 2002 through an amendment in Companies Act, 1956, by which primary producers are allowed to establish a 'producers company' by their own with a minimum start-up capital. Here, the provision is such that only primary producers can be the members and the non-producers cannot become a member in the company and in such a way that there was an attempt to eliminate the political intervention. The producer company provisions can encourage the company to act with the goodness of the cooperatives and the vibrancy of the private limited companies. After the amendment in 2002, it has been reported that there are

about 150 producer companies are established all over the country in agriculture and allied activities and activities pertaining to rural development.

The private sector started realizing the scope and opportunities in taking the services to the rural and agricultural stakeholders. In the agricultural arena there are many models pertaining to contract, corporate and cooperative farming such as the like of APNLBP for public-private partnership (Andhra Pradesh Netherlands Biotechnology Programme) (presently Agri-Biotech Foundation), PEPSI Co. for contract farming in tomato, chillies, potato, Marico in Safflower and Reliance Industries, TATA, AVT Private Limited for corporate farming in tea/ cashew etc. The private sector also understood the potential of Information and Communication Technologies (ICTs) in providing the knowledge access and market intelligence to the farming community and thus established their business around such services to their rural customers. The best model for such institutional arrangement has been the ITC e-Choupal model that has been under operation in many states of the country. Apart from this, Hariyali Kisan Bazars, Tata Kisan Sagar, Mahindra Krishi Vihars, i-kisan of Nagarjuna fertilizers are the successful models in this category. The change in the consumption pattern of the economically improved citizens of the country, especially the increasing urban population provides opportunities again for the private sector to target them with fresh, packaged, value-added and ready to eat/ serve commodities. Such private players (More, Reliance Fresh, Spencer's, Wal-Mart etc.) when procure the primary produce from the farmers, either intentionally or indirectly tend to facilitate many services to them and thereby support the livelihood.

Agri-clinics and Agribusiness Centres Scheme (ACABC) has been under operation by Directorate of Extension, Ministry of Agriculture to provide employment as well as entrepreneurship opportunities to unemployed agricultural graduates by training them in agri-business avenues, so that such entrepreneurs can extend broad-based services to the farming community. So far, there are about 10000 agripreneurs successfully established agribusiness ventures and serve the farming community in more than 30 agribusiness arenas. Similarly, there is an another programme by Directorate of Extension, Ministry of Agriculture through MANAGE, Hyderabad is to train the input dealers in agri-extension services and thus this programme on 'Diploma in Agricultural Extension Services for Input Dealers (DAESI)' provide opportunity for the farmers and rural customers to avail the services from input dealers.

Besides, many NGOs like DHAN, PRADHAN, MYRADA, BAIF, SKDRDP etc place themselves in a central position and arrange to integrate many public as well as the private and voluntary service provides for the betterment of their target farmers. Some of the

mainstream media organizations like E-TV, Deccan Development Society, *Adike Patrike,* The Hindu etc attempt to provide knowledge access to the farmers and also try to integrate the extension service providers. Krishi Vigyan Kendras (KVKs) being the main outreach arm of Indian Council of Agricultural Research (ICAR), have a critical role in spearheading the agricultural extension programmes and service delivery at district level and below form. As science-based extension system, KVKs are expected to provide capacity building, on-farm technology validation, demonstration and dissemination of agro technologies and other diagnostic services for sustainable agricultural and rural development. Growth of KVKs has been phenomenal from one KVK in 1974 to about 630 in 2012. The mandate of KVKs evolved from vocational training to on-farm testing, technology assessment and refinement and now KVKs are considered as knowledge and resource centres and thus poised to extend broad-based services.

Convergence of all the emerging institutional innovations at various levels with appropriate platform is needed to facilitate efficient services and avoid duplication efforts as well scaling-up of successful models. Agricultural Technology Management Agency (ATMA), an institutional innovation in the agri-extension of the frontline system itself, has been conceived formulated and implemented in all districts of the country. It aims at convergence of not only all the agricultural and rural development schemes but also the various services providers in a single platform at village, block, district and state level with adequate and appropriate participation of the target beneficiaries either directly or through their representatives.

At this juncture, studying, deliberating and analysing the various models of institutional innovations in terms of providing the needed services and integrating the related stakeholders for the benefit of the farmers-the target beneficiaries of all such innovations is very much important for arriving at strategies for expansion and sustenance of efforts, scaling-up innovation models and refinement of such models if any. As discussed earlier, no model will be a blanket recommendation for entire country. But to arrive at 'best-fit' and 'location-specific' models, it is necessary to discuss and deliberate such innovations in order to recommend implacable strategies.

Innovations in agri-extension-guiding principles for formulating a framework

The framework (Sulaiman *et al* 2011) for strengthening and reforming extension to be a strong component in the national agricultural innovation system should have the elements such as,

- ❖ A broad scope for service provision beyond technology transfer
- ❖ Extensive use of partnerships to fulfill an expanded mandate
- ❖ To have a learning-based approach
- ❖ Preparations for having negotiations with a wide range of stakeholders for developing workable and effective service arrangements
- ❖ Ready to represent and address the client's interests at the management level, so that the programme remains accountable to its clients

Needed Shift in extension roles (Sulaiman and Hall, 2004)

Aspects of Extension	Shift from	Shift to
Content of extension	Technology dissemination, improving farm productivity, forming farmers groups, providing services, market information	Supporting rural livelihoods, improving farm and non-farm income, building independent and farmer-operated organizations, enabling farmers to access services from other agencies, market development
Monitoring and evaluation	Input and output targets	Continuous learning
Planning and implementation strategy	Doing it alone	Through partnerships
Sources of innovation	Centrally generated information for wide implementation	Locally evolved with diverse approaches and multiple partners
Role of technical research	Technology development	Source of technical expertise and supporting adaptive research
Approaches	Uniform and fixed	Evolving and diverse
Capacity development of staff	Training	Learning by doing, facilitated experimentation
Capacity development of extension system	Personnel and infrastructure	Development of linkages and networks
Policy approach	Prescriptive/ blue prints	Facilitating evolution of locally relevant approaches
Introducing new working practices	Staff training	Changing organizational culture through action learning
Paradigm	Transfer of technology	Innovation system

Indicators for monitoring institutional innovations(Sulaiman, 2011)

Output indicators	Outcome indicators
Farmer groups/ producer associations, sustenance and maintenance of records	Increase in income, production, productivity, additional employment created
Formation of new markets, marketing and price realization	Sustenance of the arrangement, continuance, expansion and impact
Training organized	Enhanced capacity for collaboration and continuance of good practices, new partnerships formed, other institutional changes generated
New inputs and technologies distributed, purchased, used	New funding generated
Access to credit and repayment	Ability to respond to new demands
Development of value-added products	Governance mechanisms; how different stakeholder views are expressed and quality of response
Infrastructure developed and capacity utilized	
Partnerships, new working arrangements, new areas of collaboration, quality of interactions	
Reforms promoted, changes in guidelines related to funding and collaboration	

Suggested framework for institutional innovations in agri-extension (Sulaiman, 2011)

Phase/ activity of institutional innovation/ approach	Framework activities
Planning-phase	Conduct individual consultations, workshops, sample surveys
	Identify key partners
	Develop a shared vision for the programme
Institutional human development	Recruit experts with skills that are demanded
	Negotiate to get right kind of staff on any mode including deputation
	Identify and contract consultants
	Conduct training, exposure visits and case analyses
	Conduct an organizational and management review
Technical support	Identify best technologies, refine or adapt them to local conditions, do adaptive research
	Make available best and efficient inputs in time either directly or brokering arrangements with other suppliers
	Recruit qualified technical staff and train them so that they remain up to date
Credit and financial support	Understand the financial/ credit landscape
	Negotiate with financing agencies
	Guarantee transactions and set up revolving funds
	Organize producers for group lending
	Influence policies for mainstream credit operations
Organizational development	Form producer organizations
	Enhance skills through appropriate capacity building
Market development	Analyze the market chain
	Negotiate with different actors in the value-chain
	Create new markets, if needed
	Develop new products

Market–led extension system establishes its position by helping the farmers realize high returns for the produce and minimize the production costs and improve the product value and marketability. Information technology, electronic and print media need to be harnessed to disseminate the production and market information. Indian farmers have moved from subsistence to self-sufficiency due to advent of production technologies.

Extension can and should expand its role, given its significance for the larger agricultural innovation system. The guiding principles of institutional innovations provide an opportunity for expanding the role of extension by raising questions on the nature of extension's tasks, recognizing the need for new expertise, facilitating a review of extension's current interactions and highlighting the importance of institutional innovations. These tasks are important for developing and sustaining a capacity for innovation, which should be main focus of investing in this approach. Before designing the programme and operational strategy for investment, it would be better to undertake an institutional diagnosis to understand the range of organizations within the agricultural innovation systems, their expertise and activities and their pattern of interaction. The scope of specific extension investment and the priorities will vary in relation to the national, district and local situations.

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22. ORGANIC CULTIVATION OF GINGER IN PLANTATION BASED CROPPING SYSTEM IN SOUTH ANDAMAN - A SUCCESS STORY

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Coconut is one of the most widely grown plantation crops in the humid tropics of Andaman and Nicobar Islands. It is either grown as a monocrop or a major component in an integrated farming system model in the Island with animals. In a normal spacing of 7.5 x7.5 m in coconut plantation, the available interspaces may be utilized for growing intercrops. Intercropping in perennial cropping system increases the profit and the resources are effectively utilized for harnessing maximum production per unit area. The choice of intercrops is important as the economic returns per unit area depend on various factors like agroclimatic and edaphic conditions. However, in the plantation based cropping system of the Island, there is no proper selection of species nor proper combination and management by the farmers of South Andaman As a result, the income derived is much below the potential and the holdings are exposed to the degrading effects of natural forces causing erosion and deterioration of soil health. Spices are found to be the most successful intercrops in coconut plantation. Among the spices, the demonstration trial for ginger was taken up by a team of scientist from ICAR-CIARI in different farmers' field under the DASD funded CSS (MIDH) NHM project. Five farmers from South Andaman namely Smti. Chellamal, Rangachang village, Shri. Patchamuthu, Calicut village, Shri. Arockya samy, New Bimbliton village, Shri. P.K. Mohammed Basheer, Kanyapuram village and Smti. Pushpam, Ferrargunj village shown successful cultivation of ginger under coconut plantation. The farmers were provided with seed material of ginger (50 Kg each) and were trained with scientific production technology of ginger. The 'Jorhat' variety of ginger showed better performance in the Islands and hence this particular variety was distributed to the farmers for demonstration trial. The farmers were invited for the training programmes which were conducted at ICAR-CIARI, in which hands on training were given to them on various aspects of organic ginger production techniques.

Techniques of cultivation and crop management

The use of fertilizers is very limited in the Island and hence the farmers were encouraged to grow ginger organically with use of FYM and vermicompost. Observations indicated the adoption of the following practices by the farmers which helped them to reap extra income.

- Ginger was planted in areas where there is no water stagnation inside the coconut plantation.
- The site for planting ginger was changed during every season

- Basal application of organic manure *viz* farm yard manure or vermicompost
- Seed treatment with biocontrol agent and drying before planting
- The weight of the seed rhizome used was approx. 25–30 gm and 4–5 cm length in size.
- Glyricidia green leaf mulching after sowing and after 45 days to conserve soil moisture
- Weeding after 45 days and earthing up
- Application of neem cake to control diseases.

At the end the farmers realized a total yield of 145 to 150 kg of ginger from 0.02 ha area plot. The farmers have taken care to maintain the farm records to ascertain the cost of cultivation. Considering the prevailing market rate of Rs100- 150 per kg of ginger they were able to earn about Rs 15000 as additional income. Thus the farmers had successfully cultivated the crops and they realized that there is a good demand for spices especially ginger. Encouraged by this learning experience, they have expanded the area under ginger cultivation and at present they have become one of the major suppliers of seed rhizomes of ginger for the needy farmers of their respective villages. Some of the farmers have developed their own marketing of ginger in smart package of 1 Kg.

Ginger cultivation by successful woman farmers in South Andaman

Successful ginger cultivation in Kanyapuram and Ferrargunj, South Andaman

23. SCOPE OF ORGANIC TURMERIC CULTIVATION IN NORTH & MIDDLE ANDAMAN DISTRICT

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Turmeric is the dried rhizome of *Curcuma longa* L considered as the sacred spice of India. It is used in diversified forms as a condiment, flavouring and colouring agent and as a principal ingredient in Indian culinary as curry powder. It has been widely reported to possess anti cancer and anti viral activities and hence finds use in the drug industry and cosmetic industry. It finds a place in offerings on religious and ceremonial occasions. The increasing demand for natural products as food additives makes turmeric as ideal produce as a food colourant.

Scenario

North & Middle Andaman having a total cultivable area 7583.7 ha. Out of which 3000 ha is under plantation crops. Presently turmeric is cultivated in a very limited area in N & M Andaman about 25 ha area with a production of 60 MT. There is huge potential of cultivation turmeric as a intercrop. At present farmers are cultivating turmeric for their domestic use only. Few farmers are cultivating for commercial purpose. Farmers are cultivating turmeric organically using locally available organic input. The farmers from Diglipur Block comprising villages Like Ramnagar, Radhanagar, Sitanagar, Ramkrishnapur, Nabagram, Madhayam Gram, Kalipur, Keralapuram, Gandhinagar, Ganeshnagar are cultivating turmeric as intercrop in coconut and arecanut plantations. Some farmers are cultivating turmeric solely on hilly land during rainy season. In Mayabunder block, villages comprises of Chainpur, Bajota, Pudu Madurai, Tugapur, Karmatang, Hanspuri, Gujinallah Ranchi and Bengali community farmers cultivating turmeric as sole crop in hilly land during rainy season. Whereas, in Billyground area, farmers are cultivating turmeric as intercrop under coconut and arecanut plantations. The farmers of Baratang Islands cultivating turmeric as sole crop whereas the farmers from Uttara, Kadamtala and Urmillapur farmers cultivate turmeric as intercrop in arecanut plantations. The farmers of Betapur, Dharmapur, T.V. Kulam area undertaking intensive turmeric cultivation practices.

Climate and soil

Turmeric requires a warm and humid climate. It can be grown in diverse tropical conditions from sea level and up to 1500 m above MSL within a temperature range of 20-30°C with a rainfall of 1500 mm or more per annum. The climate of Andaman & Nicobar Island with high humidity with more rainfall is typically suitable for growth and cultivation of turmeric. It also increase the curcumin percentage of turmeric. Though turmeric thrives in different types of soil ranging from light black loam, red soils to clayey loams, rich loamy soils having natural drainage are found to be better. The soil of N & M Andaman ranges from clay to clay loam with acidic condtion pH 5.5-6.7). Turmeric cannot stand water stagnation. Turmeric gown here as rainfed condition. Turmeric can be cultivated organically as an intercrop along with other crops provided that all the companion crops are also organically grown. In some areas, turmeric is grown as an intercrop with mango, coconut and arecanut. Turmeric is planted during April-July with the receipt of pre monsoon showers.

Land preparation

While preparing the land, minimum tillage operations is adopted. Beds of 15 cm height, 1 m width and of convenient length are prepared giving at least 50 cm spacing between beds. In the some case ridges and furrows are prepared and the rhizomes are planted in shallow pits on the top of the ridges across the slop on hilly land. Spacing generally adopted is 45-60 cm between the ridges and 15-20 cm between the plants.

Planting material & Variety

Carefully preserved seed rhizomes collected from organically grown fields, free from pests and diseases are used for planting. However, to begin with, seed material from high yielding local varieties can be used in the absence of organically produced seeds. For sowing, both the mother - rhizomes and fingers are used. The fingers are cut into 4 - 5 cm long pieces, and the mother rhizomes are planted as such or split into two; each having at least one sound bud. The seed is sometimes sprouted under moist straw before sowing. A number of locally available varieties are grown, however improved varieties like Prabha, Ranga, Prathibha, GL Durum III CLS 22 are found suitable in this island.

Manuring

Turmeric needs heavy manuring. Application of well rotten cow dung or compost from own farm @ 2-3 tonne /acre may be given as basal dose while planting rhizomes in the pits. In addition, application of neem cake @ 0.8 tonnes/ acre is also desirable.

Harvesting and curing

The crop is to be harvested at the right maturity and is ready for harvesting in about 7 to 9 months after sowing depending upon the variety. Usually the land is ploughed and the rhizomes are gathered by hand picking or the clumps are carefully lifted with a spade. Harvested rhizomes are cleaned of mud and other extraneous matter adhering to them. The average yield per acre is 8 -10 tonnes of green turmeric. Fingers are separated from mother rhizomes. Mother rhizomes are usually kept as seed material. The green turmeric is cured for obtaining dry turmeric.

Preservation of seed

Rhizomes for seed are generally heaped under the shade of trees or in well-ventilated sheds and covered with turmeric leaves. Sometimes, the heap is plastered over with earth mixed with cow dung. The seed rhizomes can also be stored in pits with sawdust. The pits can be covered with wooden planks with one or two holes for aeration.

Yield

The yield of pure crop varies from 8000 to 10000 kg per acre. Under exceptionally favourable conditions, viz. abundant manuring and copious irrigation it may be as high as 12000 kg per acre.

Marketing

Farmers sale their produce in local market as powder, raw turmeric and as seed rhizome for planting materials

Possibility

Turmeric can be cultivated in large and commercial scale organically in North and Middle Andaman. The climatic condition is suitable for turmeric cultivation. Farmers can grow turmeric as intercrop in their existing coconut and arecanut plantation. It can be grown in hilly land by making terrace. The organically grown turmeric may fetch high market value and it can be marketed internationally with a reputed brand from Andaman. To achieve this, good infrastructure on processing and storage are necessarily established in North and Middle Andaman

Turmeric as intercrop

Turmeric on hilly land as sole crop

Organically grown turmeric from farmers field (Harvesting & Curing)

24. INSECT PESTS OF SELECTED SPICE CROPS

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The important pests of major spices, nature of damage, life cycle and their management practices are given in this chapter. Under the management practices, general recommendations followed in other places are given. However, the use of chemicals are to be avoided in organic production areas.

1. BLACK PEPPER (*Piper nigrum L.*)

Black pepper is infested by 56 insect species in India, attacking different parts of pepper roots, stems, shoots, leaves, spikes and berries. However, based on the nature and extent of damage, pollu beetle (*Longitarsus nigripennis* Mots.), top shoot borer (*Cydia hemidoxa* Meyr.), leaf gall thrips (*Liothrips karnyi* Bagn.) and scale insects (*Lepidosaphes piperis* Green and *Aspidiotus destructor* Sign.) are considered as major pests of black pepper in India.

i) Pollu Beetle (*Lanka ramakrishnae*)

The pollu beetle is the most destructive pest of pepper in India and its incidence was reported 6–40 per cent on berries. The pest infestation was higher in plains and in areas below 300 m MSL and there was meagre infestation reported in areas above 900 m MSL.

Nature of Damage Adult beetle feeds on tender shoots leaves and spikes by scraping the tissues resulting in black sunken patches. It feeds on leaves by making small irregular circular holes. Severely infested leaves, shoots and spikes rot and drop due to secondary infection. The grubs causes damage by boring into tender berries and feed on the internal tissues. The infested berries turn yellow initially and later black and crumble when pressed. A single grub could damage 2-4 berries as a group. Sometimes the entire distal portion of the spike dries up when the grub, while tunnelling through from one berry to another, damages the main stem of the spike. The pest infestation is generally more severe in shaded areas in the plantation.

Lifecycle

Female lays egg singly or 2-3 on the rind of tender berries or shoots or spikes in a shallow elliptical hole covered with faecal matter. The eggs are oval, 0.75 mm long and incubation period 3–8 days. Three instars of grub lasting for 20–40 days. Fully grown grubs 5.5 mm long and are creamy yellow. Pupation occur in earthen cocoons and lasts for 6–8 days. Adults 2.5mm long, the head, thorax yellowish brown and the elytra black. Hind femur

enlarged and jumps away quickly when disturbed. Females can be identified by the presence of a sclerotized spine attached to the mid-ventral wall of the genital chamber. There are many overlapping generations in a year. The pest population was positively and significantly correlated with rainfall.

Management Spraying of quinalphos 0.05 per cent during July and October was more effective in controlling the pest infestation. Laboratory bioassays conducted with entomopathogenic fungi such as *Beauvaria bassiana* Bals. (Vuill.) and *B. brongniartii* (Sacc.) Petch. effective against grubs. Some of the commercial neem products were also effective in reducing the pest damage in the field.

ii) Top Shoot Borer (*Cydia hemidoxa*)

Top shoot borer is a serious pest of pepper in 2–3 years old plantations and is widely distributed throughout Kerala in the plains and also at higher altitudes. In South Kerala, up to 48 per cent of shoots were observed in one year old plantation.

Nature of Damage

Larvae of top shoot borer infest tender, terminal orthotropic shoots. The earlier instar larvae scrape and feed on the epidermis of tender terminal shoots and sometimes on tender leaves also. The later instars bore into tender stems and feed on the internal contents resulting in decay and drying up of infested shoots. Generally a single inter nodal region is sufficient for a larva to complete its development. Consequent to the death of the terminal shoot, new shoots arise from the axillary buds which may also get attacked subsequently. Repeated infestation of tender terminal shoots affects the growth of vine and its establishment especially during early stages. Up to 57 per cent reduction in growth was observed on 1 year old vines when there were three repeated infestations on the same vine during a year.

Life cycle

The adults are small moths with a wing span of 10–15 mm, the forewings being crimson red and yellow and the hind wings grey. There are five larval instars. Fully grown larvae are greyish green and measure 12–14 mm in length. The larval period lasts for a maximum of 14 days. Pupation generally occurs either within the infested shoot or just outside it. The pupae are elongated and measure about 2 mm in length; pupal period lasts for 8–10 days. The pest infestation is observed in the field throughout the year but is higher during the monsoon period (August–December) when young vines actively grow and numerous succulent shoots are available on them.

Management

Spraying of quinalphos 0.05 per cent twice a year during June and September has also been suggested for controlling the pest. The insecticide spray given for pollu beetle management is adequate to control top shoot borer also. *Hexamermis* sp. (Mermithidae) and *Apanteles cypris* Nixon (Braconidae) were more common parasitizing up to 76.7 and 20.0 per cent of larvae during August and September, respectively.

ii) Leaf Gall Thrips (*Liothrips karnyi*)

It is a persistent pest of pepper and serious on younger vines. The pest infestation was more serious in Wyanad, Idukki, Thiruvananthapuram (Kerala), Shimoga, Kodagu (Karnataka) and Nilgiris (Tamil Nadu) and their incidence is positive and significantly correlated with altitude.

Nature of Damage

Leaf gall thrips initially infest tender leaves causing the leaf margins to curl downwards and inwards resulting in the formation of marginal, tubular, hypophyllous galls. As the infested leaves grow they become crinkled, malformed and reduced in size; the leaf margins also turn chlorotic later. The process of maturation involves epidermal hypertrophy and proliferation and formation of sclereid bands and vascular proliferation. In case of severe infestation on younger vines, may cause adverse effect on growth.

Life cycle

The adults 2.5-3.0 mm, black, the larvae and pupae are creamy white. Adult in length. Female lays creamy white eggs in cluster with in leaf gall and hatch in 6–8 days. There are two instars, pre-pupa and two pupal stages last for 4–7, 4–7, 2, 2–3 and 2–3 days, respectively. Leaf gall thrips initially infest tender leaves and remain in them till the leaves are partly mature. The pest population was higher some pepper growing area during the monsoon period.

Management

Dimethoate 0.05 per cent was more effective when sprayed during emergence of new flushes during June/July. *Montandoniola moraguesi* (Puton) (Anthocoridae) and *Andothrips flavipes* Schmutz (Phlaeothripidae) play a significant role in natural control of the pest. *Geogarypus* sp. (Geogarypidae), *Lestodiplosis* sp. (Cecidomyiidae) and *Rhodesiella* sp. (Chloropidae) are predaceous on juvenile stages.

iii) Scale Insects-Mussel Scale (*Lepidosaphes piperis*) and Coconut Scale (*Aspidiotus destructor*)

Scales insect attacks pepper in high altitudes above 600m MSL. The percent damage is ranged between 20 - 47.5 per cent infestation reported in Shevroy hills and Idukki (Kerala).

Nature of damage

L. piperis attacks main stems, lateral branches of younger vines, mature leaves and berries. The severe de-sapping of leaves causes chlorotic spots leads to drying of leaves. One or two years old younger wines are vulnerable if the attack is on main stem. An infested lateral branch of older vine wilt and dries up. It also infests nursery in the plains. *A. destructor* is highly polyphagous and feeds on more than 20 crops in India. It attacks mostly on leaves and rarely on lateral branches and berries. It causes yellow spots or patches on leaves.

Life cycle

Adult females of *L. piperis* are 3–4 mm long, dark brown scale. The eggs are white and covered by females. First and second larval stages last for 9–12 days each. Prepupal and pupal stages of male each lasts for 2–3 days. Adult females of *A. destructor* are 1.5–2.0 mm long, circular and light yellow. The eggs are creamy yellow and the two larval stages last for 6-7 and 4-5 days. Prepupal and pupal stages of males each lasts for 6–7 and 4–5 days. Both the species reproduces parthenogenically.

Management

Malathion and dimethoate (0.1 % each) were effective against *L. piperis* when sprayed twice at 30 day intervals during January/February. Spraying of dimethoate 0.05 per cent was effective against *A. destructor*. Neemgold, a commercial formulation of neem causes 58 per cent reduction in scale population. Application of insecticides has to be avoided during harvesting period judiciously to avoid residues in the product. *Aphytis* sp. (Aphelinidae), *Pseudoscymnus* sp. and *Chilocorus circumdatus* (Gyllenhall) (Coccinellidae) are common natural enemies. Rainfall has a deleterious effect on the population of both the species of scale insects.

iv) Minor pests

Infestation of *Bemisia tabaci* (Genn.), Pepper whitefly, *Aleurocanthus piperis* Mask., the mealy whitefly (*Aleurodicus dispersus* Russell) has also been observed on black pepper in Kerala.Grasshopper *Xenocatantops humilis* (Serville) feed on the leaf lamina causing irregular shaped large feeding holes. The cotton leaf hopper *Amrasca devastans* (Dist.) is listed as a pest of black pepper. Black citrus aphid (*Toxoptera aurantii*) infests black

pepper in both nursery and field. Mealy bugs *Icerya aegyptiaca* (Dgl.), *Planococcus minor* (Mask.), *P. citri* (Risso), *Ferrisia virgata* (Ckll.), *P. longispinus* (Targioni) and *P. orchidicola* Takahashi are reported infesting pepper. Scale insects, *Coccus piperis* Green, *Pinnaspis aspidistrae* Sign., *Marsipococcus marsupialis* Green, *Protopulvinaria longivalvata* Green, *Parlatoria pergandii* Com., *P. strachani* (Cooley), *P. marchali* Ckll., *Chionaspis raricosa* Green, *Pseudaulacaspis* sp., *P. cockerelli* (Cooley), *Unaspis* sp. and *Anomalococcus indicus* Ayyar were recorded on pepper. Two other thrips species *L. pallipes* Karny and *L. chavicae* (Z.) collected from leaf roll galls from Wynad. Maggots of the gall midge, *Cecidomyia malabarensis* Felt, common in nursery which develops inside berries, leaf stalks, leaf veins and shoots of pepper vines.

2. GINGER (*Zingiber officinale* Rosc. Family Zingiberaceae)

Ginger is perennial herbaceous and their rhizomes are used as spices. India tops the world with the production of 10.8 lakh tonnes and 164850 hectare area under cultivation.

i) Shoot borer (*Conogethes punctiferalis*)

The shoot borer is a major pest of ginger. It attacks more than 120 species of plants all over the world. The adults lay eggs on tender leaves and the larvae initially feed on the chlorophyll contents of the leaves and later bore in to the pseudo stems. Fresh infestation of borer can be identified by the presence of wet excreta with chewed tissues at the bore holes. The central leaf of damaged shoot become yellow and the shoot dries out. Yield loss up to 38g per clump is reported when 50% of the shoots are damaged by the insect. The adults are medium-sized moths and the wings contain minute black spots. The insect attack is noticed during the active growth period of the crop. The insect has several natural enemies to its fate. Natural populations of the enemies need to be monitored before initiating insecticide based control measures.

Application of malathion (0.1%) at monthly intervals during July to October is found to be effective in reducing the pest population. Pruning and destroying freshly infested shoots during June to August and spraying of insecticide such as malathion (0.1%) during September to October can be followed to reduce the number of insecticide sprays and to effectively manage the pest. Mulching with leaves of plants such as mahaneem (*Melia dubia* Cav.) and spraying quinalphos (0.05%) + Ozoneem (1500 ppm) is also found effective for the management of the pest.

ii) Rhizome scale (*Aspidiella hartii*)

The rhizome scale is posing threat to ginger in storage and is reported from all the ginger growing tracts. The insect also infests turmeric (*Curcuma longa*), elephant foot yam

(*Amorphophallus paeoniifolius)*, yams (*Dioscorea alata*, *D. esculenta* and *D. rotundata)*, taro (*Colocasia esculenta)* and tannia (*Xanthosoma sagittifolium)*. The adult female insects are circular, light brown to grey colored and measures about 1.5 mm in diameter. Generally, the scale infestation starts in the field towards the later stages of plant growth and when infested rhizomes are stored, the insect multiplies and feeding by the insects leads to shriveling of buds and the rhizomes become unfit for planting. Timely harvest and discarding of severely infested rhizomes during storage reduces further spread of the pest in storage. An integrated strategy including, timely harvest, discarding severely infested rhizomes, dipping the seed rhizomes in quinalphos (0.075%) and storage in dried leaves of *Strychnos nux-vomica* L. and saw dust (1:1 proportion) is effective for the management of the rhizome scale.

iii) Minor pests

a) Leaf roller (*Udaspes folus*)

The leaf roller popularly known as grass demons is widely distributed in most of the ginger growing tracts. The pest is also reported from countries in South East Asia and Australia feeding on plants belonging to Zingiberaceae family. The larvae cut and roll leaf margins and feed within the rolls. In Kerala, the pest occurs during August to October. The adults are medium sized butterflies with a wing span of 20 x 45 mm and with brownish-black wings with large white spots. The egg, larval and pupal periods last for 4-5, 13-25 and 6-7 days, respectively on ginger. There are five larval instars. The fully grown larvae are olive green in color and the pupae are light green with a beak-like anterior end and a tapering posterior end. The control measures adopted for shoot borer are generally sufficient to manage the insect in the fields.

b) Root grubs (*Holotrichia* spp.)

White grubs cause serious damage to ginger by feeding on roots and newly formed rhizomes. The insect attack results in yellowing of leaves and severe infestations lead to loss of pseudo stems. If the infestation is severe, the entire crop may be lost. The adult beetle can survive feeding on leaves of *Ficus* sp. Mechanical collection and destruction of adults during their peak periods of emergence and application of the entomophagous fungus *Metarrhizium anisopliae* Sorokin mixed with fine cow dung is effective for the management of white grubs. In severely affected areas, chemical treatment such as drenching with chlorpyriphos (0.075%) along with mechanical collection and destruction of beetles is found effective.

3.TURMERIC (*Curcuma longa*, Family Zingiberaceae)

i) Shoot borer (*Conogethes punctiferalis*,)

The nature of damage by shoot borer to turmeric is similar to ginger. Up to 75% shoot damage and 26% yield loss is reported due to the bore in turmeric. Spraying Malathion (0.1%) or lamda-cyhalothrin (0.0125%) at 21 days intervals during July to October is found effective in control of the pest. Adopt spray schedule coinciding with the first symptoms of attack in the field.

ii) Rhizome scale (*Aspidiella hartii*)

The rhizome scale severely infests stored turmeric rhizomes. As in the case of ginger, the insect suck sap from stored seed rhizomes of turmeric, making them unfit for planting. The control measures recommended for ginger scales can be adopted for management of the pest on turmeric.

iii)Leaf roller (*Udaspes folus*)

The leaf roller is polyphagous and in addition to cultivated turmeric and ginger, it has also been recorded on *Z. zerumbet, Cucuma angustifolia*, *C. amada, Elettaria cardamomum, Aframomum melegueta*, *Hedychium* sp., wild lilies and few species of grasses. Spraying of chemicals found effective for the control of shoot bore such as malathion (0.1%) or lamda-cyhalothrin (0.0125%) is generally sufficient to manage the pest.

iv) Minor pests

a) Leaf beetle (*Lima* sp)

The adults and grubs of *Lema* spp. are found to damage turmeric by scraping the chlorophyll content of the leaves, especially during monsoon season. The feeding marks are manifested as long parallel white patches. The chemical control measures adopted for control of shoot borer such as spraying of malathion (0.1%) is effective in suppressing the pest populations.

b)Lacewing bug (*Stephanitis typicus*)

The tingid bug suck sap from the leaves. The severely infested leaves turn pale and gradually dry up. Spraying of dimethoate (0.06%) is found to be effective against the pests.

c)Turmeric thrips (*Panchaetothrips indicus*)

The tingid bug sucks sap from the leaves. The severely infested leaves turn pale and gradually dry up. Spraying of dimethoate (0.06%) is found to be effective against the pests.

4.CLOVE (*Syzygium aromaticum*, Myrtaceae)

The clove of commerce is the dry, fully mature but unopened flower buds of the clove tree (*Syzygium aromaticum* (L.) Merr. et Perry) (Myrtaceae). Clove is grown in about 4780 hectares in India with an annual production of about 1420 tonnes. Clove is mostly grown in the slopes of Western Ghats in Tamil Nadu especially in Kanyakuamri and Tirunelveli districts and also in Kerala.

i) Stem borer (*Sahayadrassus malabaricus*)

The larva of stem borer attacks the main stem of young clove trees at the basal region girdling the stem and boring 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. Fully grown larvae are yellowish white with a black head capsule and measure 6–10 cm in length. The adults are large moths with a wing span of about 11 cm and are greyish brown with mottled wings.

Management: The stem borer can be controlled during initial stages of attack by injecting / spraying quinalphos 0.1% into and around the bore hole after removing the frass. Swabbing the main stem with carbaryl and keeping the basins free of weeds are prophylactic measures for reducing the pest infestation.

ii) Scale insects

Many species of scale insects infest clove plants in the nursery and sometimes young plants in the field. The scale insects generally seen on clove include wax scale (C*eroplastes floridensis* Com.), shield scale (*Pulvinaria psidii*) and soft scale (*Kilifia accuminata* Sign.). The scales are generally seen on tender stems and lower surfaces of leaves. Scale insects feed on plant sap and cause the shoots to wilt and the plants present a sickly appearance. Sometimes the affected leaves are covered with sooty mould.

Management: Scale insects can be controlled by spraying dimethoate (0.05%).

5. NUT MUG (*Myristica fragrans*, Myristicaceae)

Nutmeg (*Myristica fragrans* Houtt.) (Myristicaceae) used as spice in two ways viz., as a dried kernel of the seed and the mace which is a dried aril surrounding the seed. Nutmeg is grown in about 4800 hectares in India with an annual production of about 1420 tonnes. Nutmeg is mainly grown in Thrissur, Ernakulam and Kottayam districts of Kerala and the hilly regions of Kanyakumari and Tirunelveli districts of Tamil Nadu.

i) Black scale (*Saissetia nigra)*

Black scales infest tender stems and leaves especially in the nursery and sometimes on 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 the plants present a sickly appearance.

ii) Shield scale (*Protopulvinaria mangiferae*)

The shield scale is creamy brown and oval and occurs on tender leaves and stems especially in nursery plants. The pest infestation results in wilting of leaves and shoots and the plants present a sickly appearance.

iii) White scale *Pseudaulacaspis cockerelli)*

White scales are flat and shaped like a fish scale and occur clustered together on the lower surface of leaves especially in nursery plants. The pest infestation results in yellow streaks and spots on affected leaves and in severe infestations the leaves wilt and the plants present a sickly appearance.

Management: The scale insects mentioned above and other species that may also occur sporadically on nutmeg can be controlled by spraying dimethoate (0.05%).

6. CINNAMON (*Cinnamomum verum*), Lauraceae

Cinnamon (*Cinnamommum verum* J. Presl.) (Lauraceae) is one of the oldest spice known to mankind and the dried inner bark of the tree is the spice of commerce. Cinnamon is grown in about 2360 hectares in India with an annual production of about 2460 tonnes. Cinnamon is grown in the hilly regions of Western Ghats in Kannur, Kozhikode, Wayanad and Kottayam districts of Kerala and Nilgiris District of Tamil Nadu.

i) Cinnamon butterfly (*Chilasa clytie*)

The cinnamon butterfly is the most serious pest of cinnamon in nurseries and plantations 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 form 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 larval and pupal periods last for 11–17 days and 11–13 days, respectively.

Management: Spraying quinalphos (0.05%) effectively controls the pest infestation.

ii) Leaf miner (*Conopomorpha civica)*

Infestation by leaf miner is more common during the monsoon period and generally nursery plants are seriously affected. The adult is a minute silvery grey moth. The larvae are pale grey initially and become pinkish red when fully grown measuring about 10 mm in length. They feed on the tissues between the upper and lower epidermis of tender leaves resulting in the formation of characteristic blistered patches which dry up later.

Management: Spraying quinalphos (0.05%) during emergence of new flushes is an effective prophylactic measure for controlling the pest infestation.

Many other species of leaf feeding caterpillars and beetles occur sporadically on cinnamon especially during the flushing season and defoliate the plants. Application of quinalphos (0.05%) would keep them under check.

25. DISEASE MANAGEMENT OF SELECTED SPICE CROPS

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1. Diseases of Black Pepper

i) Foot rot disease - Causal organism: *Phytophthora capsici*

Symptoms: The fungus infect all parts of the plant

Leaf: Black spots with characteristic fimbriations at the advancing margins which enlarge rapidly. The tender leaves and succulent shoot tips of freshly emerging runner shoots trailing on the soil turn black when infected. The disease spreads to the entire vine during the intermittent showers due to rain splash.

Stem & Spike: When the main stem at the ground level or at the collar region is infected, the entire vine wilts followed by shedding of leaves and spikes with or without black spots. The branches breakup at nodes and the entire vine collapses within a month.

Root: When the damage is confined to the feeder roots, the expression of the symptom is delayed till the cessation of rain and the vine starts showing declining symptoms such as yellowing, wilting, defoliation and drying up. This may occur during October-November onwards.

Management: **Phytosanitation**: Removal and destruction of dead vines along with root system. Planting materials must be collected from disease free gardens and nurseries rose preferably in solarized soil.

Cultural practices: Provide adequate drainage. Avoid injury to the root system due to cultural practices such as digging or weeding. Do not allow freshly emerging runner shoots to trail on the ground. Runner shoots must be pruned at the onset of monsoon.

Chemical control: With the onset of south-west monsoon, a prophylactic drenching with copper oxychloride 0.2% must be given to all the vines at a radius of 45-50cm @ 5-10lit/ vine followed by a foliar spray with 1% Bordeaux mixture. A second drenching and spraying with potassium phosphonate 0.3% is to be given during August-September. A third round of drenching may be given during October with copper oxychloride 0.2% @ 5-10 lit/vine.

or

After the receipt of a few monsoon showers all the vines are to be drenched with 0.125% Metalaxyl- mancozeb @ 5-10 lits/vine followed by a foliar spray with the same

or

At the onset of monsoon (May-June), apply *Trichoderma harzianum* around the base of the vine @50g/vine followed by a foliar spray with potassium phosphonate 0.3% or 1% Bordeaux mixture.

A second application of *Trichoderma* and foliar spray with Bordeaux mixture 1% or potassium phosphonate 0.3% are to be given during August-September.

ii) Pollu disease/ anthracnose disease- Causal organism: C*olletotrichum gloeosporioides*

Symptoms: The disease appears towards the end of the monsoon. Spikes /berries and leaves are affected by the disease. The affected berries show brown sunken patches during early stages and their further development is affected. In later stages the discoloration gradually increases and the berries show the characteristic cross splitting. Finally the berries turn black and dry. The fungus also causes angular to irregular brown lesions with a chlorotic halo on the leaves.

Management: Spraying 1% Bordeaux mixture soon after the appearance of the symptoms.

iii) Stunted disease: Causal Organism: Virus. Both CMV and Badna virus are involved in causing the disease

Symptoms: The vines exhibit shortening of internodes. The leaves become small and narrow with varying degrees of deformation. The leaves appear leathery, puckered and crinkled. Chlorotic spots and streaks also appear on the leaves. The yield of the affected vines decline gradually.

Management: As the disease is of viral origin there are no control measures as such. The infected plants are to be destroyed to prevent the further spread of the disease. Planting material should not be collected from infected vines or even from disease affected areas.

iv) Phyllody disease: - Causal Organism: *Phytoplasma*

Symptoms: Some of the floral buds are transformed into narrow leaf like structures. Such malformed spikes show leafy structures instead of floral buds, exhibiting phyllody symptoms. In advanced stages, the leaves become small and chlorotic and the internodes are also shortened. The affected fruiting laterals give a witches broom appearance.

***Management*:** Remove and destroy the infected vines.

2. Diseases of Ginger

1. Soft rot - Causal organism: *Pythium myriotylum. P. aphanidermatum* and *P. vexans.*

Symptoms: Water soaked lesions appear at the collar region of the pseudostems and progresses upwards and downwards, spreads to the rhizome resulting in soft rot. At a later stage root infection can be noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of leaves.

Management :Select seed rhizomes from disease free gardens, since the disease is also seed borne.

Treat the seed rhizomes with mancozeb 0.3% for 30 minutes before storage and once again before planting.

Select well drained soils for planting, since stagnation of water predisposes the plant to infection.

Provide proper drainage channels.

Application of *Trichoderma harzianum* along with neem cake @ 1kg/bed helps in preventing the disease.

Once the disease is located in the field, remove the affected clumps and drench the affected and surrounding beds with mancozeb 0.3% or Copperoxychloride 0.2%

2. Bacterial wilt- Causal organism: *Ralstonia solanacearum***.**

It is a soil as well as seed borne disease that occurs during south west monsoon when the crop is young.

Symptoms : Water soaked spots appear at the collar region of the pseudostem and progresses upwards and downwards. The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spread upwards (Symptoms can be detected in early morning as drooping and wilting of plants)

Yellowing starts from the lowermost leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting

Management: Selection of healthy rhizomes from disease free area

Selection of field with no history of bacterial wilt.

Pre-plant rhizome treatment by heat or rhizome solarization

Strict phytosanitation in the field including restrictions on movement of farm workers and irrigation water across the field

The seed rhizomes may be treated with Streptocycline 200 ppm for 30 minutes and shade dried before planting.

Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture 1% or copper oxychloride 0.2%.

iii) *Phyllosticta* Leaf spot- Causal organism: *Phyllosticta zingiberi***.**

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

Management: Spraying Bordeaux mixture 1% or mancozeb 0.2%.

iv) Fusarium yellows or dry rot-- Causal organism: Fusarium oxysporum for spp. zingiberis, predisposed by nematode infestation by Pratylenchus coffeae.

Symptoms: Yellowing of the margins of the lower leaves, this gradually spread over the entire leaf. Older leaves dry up first, followed by the younger ones. Plants may also show premature drooping, wilting, and drying in patches in the field or in the whole bed.

Management: As the disease spreads through contaminated rhizomes, selection of healthy rhizomes has been found to be effective in preventing the disease.

Rhizome treatment with hot water at 51^{o}C for 10 min is recommended in places where the disease occurs in endemic proportion.

Drench the plant base with Mancozeb (0.3%- 3g/lit) or carbendazim (0.05% i.e. 0.5g/lit)

Seed treatment and soil application of biocontrol agents like *T. harzianum, T. hamatum,* and *G. virens*

5. Mosaic Disease (Viral Disease)

The symptoms appear as a yellow and dark green mosaic pattern on leaves. The affected plants show stunting.

Management: Avoid using rhizome from diseased plants for seed purpose

3. Diseases of Turmeric

i) Rhizome rot-Causal organism: *Pythium aphanidermatum*

Symptoms : The collar region of the pseudostems becomes soft and water soaked, and the plant collapses and the rhizomes decay**.**

Management: Treat the seed rhizomes with mancozeb 0.3% for 30 min prior to storage and at the time of sowing prevents the disease.

When the disease is noticed in the field, the beds should be drenched with mancozeb 0.3%.

ii) Leaf blotch-Causal organism: *Taphrina maculans.*

Symptoms: It appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown. The leaves also turn yellow.

In severe cases the plants present a scorched appearance and the rhizome yield is reduced

Management: The disease can be controlled by spraying the plants with mancozeb 0.2%.

iii) Leaf spot - Causal organism: *Colletotrichum capsici*

Symptoms: Brown spots of various sizes on the upper surface of the young leaves. The spots are irregular in shape, whitish or grayish in the centre. Two or more spots may coalesce and form an irregular patch covering almost the whole leaf. The affected leaves eventually dry up. The rhizomes do not develop well.

Management: Spray the plants with zineb 0.3% or Bordeaux mixture 1%.

4. Diseases of Chilies

1. Bacterial wilt of solanaceous vegetables

Casual agent: *Ralstonia solabnacearum*

Symptoms

The disease starts with sudden drooping of younger leaves. Within one or two days the whole plant gets killed irrespective of the age of the plant. This pathogen after infecting one plant, spreads to nearby plants. In due course of time, entire field may get affected. The

uprooted infected plants emit foul smell and if we cut open the plant, bacterial oozing and vascular browning can be seen.

Control measures

Before cropping

- Exposing the infected soil by ploughing in hot sunny days.
- Growing of resistant cultivars
- Crop rotation with non host crops like cowpea, pulses, rice, maize.
- Destruction and removal of weeds and other plants.
- Soil application of biocontrol agents like *Trichoderma viridae* or *Pseudomonas fluroscens* @2.5 kg/ha. Application should be done by mixing with 12.5 tonnes of farmyard manure.
- Seed treatment with *Trichoderma viridae* (4g/kg of seeds) or *Pseudomonas fluroscens* (10g/kg seeds)
- Seedling treatment should be done before transplanting with *Pseudomonas fluroscens* solution (10g/litre of water).
- If severe infections are observed in earlier cropping seasons, soil application of copper oxy chloride@ 2.5 ml/litre of water for one hectare area before raising new crops.

After cropping

- Immediate removal and destruction of infected plants.
- Care should be taken during field operations to avoid wounding of plants, through which the pathogen enters the plant.
- Soil drenching with bleaching powder @2g/litre of water at 10 to 15 days intervals.
- In severe case soil drenching by streptomycin sulphate @1.5g/10 litre of water or copper oxy chloride@ 2.5 ml/litre of water in one hectare.

2. Chilli fruit rot/ anthracnose/leaf spot

Causal Organism: *Colletotrichum capsici*

Symptoms

- Symptoms are seen on leaf, stem and fruit.
- Small, circular spots on the skin of the fruit and expanded in the direction of long axis of the fruit.

- The fruits with many spots drop off prematurely resulting in heavy loss of yield.
- Fungus may also attack the fruit stalk and spread along the stem causing dieback symptoms.

Control measures

- Remove infected plant and plant debris.
- Choose resistance cultivars.
- Use certified seeds and do not use seeds from *C. capsici* infected fields.
- Use fungicides during flowering. As small fruit begin to produce, use the standard fungicide to control anthracnose on pepper, Maneb (2).
- Consult your local extension specialist for legal and efficacious fungicide products available in your state. Remember, the label is the law and the product applicator is responsible for reading and following all chemical labeling.

3. Leaf curl virus

Causal organism: Gemini virus, Begomo virus; Transmission through white fly and grafting.

Chilli leaf curl disease is important and causes heavy losses in the yield and quality of fruits. In the initial stages of growth resulting in no fruit formation. In case any fruit is formed that remain deformed and undersized.

Symptoms

- Curling of the leaves, and thickening and swelling of veins.
- Abaxial and adaxial curling of leaves accompanied by puckering and blistering of interveinal areas and thickening and swelling of veins.
- Stunted plant growth due to shortened internodes and leaves greatly reduced in size.
- Flower buds abcise before attaining full size and anthers do not contain pollen grains.

Control measures

- Treatment of seed with Imidacloprid 70 WS @ 10g/kg seed
- Covering nursery beds with nylon net of 40 mesh, dipping seedling in Imidacloprid 17.5 SL @ 7 ml /l for 20 minute,
- Growing 3 rows of maize as barrier crops, installation of yellow sticky trap @ 50/ ha, spray of Neem oil @ 2 ml/l 2-3 times at 10 days interval+ need based spray of insecticides (as a last weapon) viz., Confidor 0.3ml/l, Actara @ 0.3g/l and Regent @ 2g/lit for controlling of sucking pests and vector.

26. LIVELIHOOD DEVELOPMENT OF WOMEN THROUGH SPICES: VALUE ADDITION FOR ECONOMIC EMPOWERMENT IN ANDAMAN AND NICOBAR ISLANDS- A CASE STUDY

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India, which is the largest producer, consumer, and exporter of spices, has 48% share in the global market (volume-wise). Raw spices and value-added products are exported now. Under the value-added segment, entrepreneurs can use the technology available, produce and export innovative products such as spice-flavoured chocolates, and bathing bars, oils, and creams with spice fragrance, For the year 2016-2017, domestic market for spices was 6.13 million tonnes and exports, which include extracts, oils, blends, and powders, were 0.95 million tonnes, with exports to about 150 destinations. Other than spices no other commodity has played more pivotal role in development of modem civilization as spices.

The study area of south Andaman which falls under the union territory of Andaman and Nicobar Islands, which is located in the Indian Ocean, in the southern reaches of the Bay of Bengal, nearer to Indonesia and Thailand. (www.and.gov.in). The data of clove and nutmeg cultivation land its yield for the past five years almost stable with slight changes (Table 1 and 2).

Table 1. Status of clove cultivation

Year	Area (In Hectares)	Production (In Tons)
2012-13	156	5.25
2013-14	156	5.25
2014-15	160	10
2015-16	160	10
2016-17	156	5

Source: Spices Board of India

For the year 2012 to 2014 the area under cultivation and production was stable and it has slightly increased into in addition of 4 hectares and yield was doubled from the previous reporting years. Later the same has dropped down as in the year of 2012.

Table 2. Status of nutmeg cultivation

Year	Area (In Hectares)	Production (In Tons)
2012-13	70	47.5
2013-14	62	42
2014-15	70	50
2015-16	70	50
2016-17	70	50

Source: Spices Board of India

The Nutmeg cultivation is concerned throughout the year from 2012 to 2017 the area under cultivation was stable except in 2013 and also yield was also stable.

Methodology

The economic component of empowerment requires that women be able to engage in productive activities that will allow them some degree of financial autonomy. The study was conducted in Ferrargunj Tehnsil of South Andaman District by employing primary and secondary data in a well designed schedule to obtain the primary information.

Empowerment has come to denote women's increased control over their own lives, bodies, and environments. In discussions of women's empowerment, emphasis is often placed on women's decision-making roles, their economic self-reliance, and their legal rights to equal treatment, inheritance and protection against all forms of discrimination, in addition to the elimination of barriers to access such resources as education and information. Kishore, 2008). Only women farmers were selected as respondents of the study and the total 50 were selected by employing Stratified random sampling. The respondents were having the land holding capacity on an average from 2-5 acres of land which is being used for conventional agriculture and in addition to that they are also into the spices cultivation at micro level.

Findings of case study

About 54 % of the respondents were belonging to the Hindu, 12 % were from Muslim and 34 % from Christian and about 72 % of the respondents were belonging to Other Backward Communities and 28 % were from General Category.

Table 3. Economic background of the respondents

Variables	Beneficiaries (N=50)	
	No.	%
Economic Status		
Below Poverty Line (BPL)	6	12.0
Above Poverty Line (APL)	44	88.0
Total	50	100.0
Socio Economic Class		
Upper class	0	0
Upper middle class	36	72.0
Lower middle class	14	28.0
Upper lower class	0	0
Lower class	0	0
Total	50	100

About 88 % of the respondents were belonging to the APL (Above Poverty Line) and 12 % of respondents from BPL (Below Poverty Line) categories. Further Kuppusamy scale was employed to assess their socio economic class. Based on which 72 % were upper middle class and 28 % were lower middle class and none of them falls under neither upper class nor lower class. (Table 3)

Table 4. Type of Spices grown

Type of Spices	Beneficiaries (N=50)*	%
Ginger	44	88.0
Chilli	46	92.0
Pepper	16	32.0
Nutmeg	32	64.0
Cloves	36	72.0

*Multiple Responses

Based on the multiple responses received, the highest volume of spice dominated for cultivation was Chilli (92 %) followed by Ginger (88 %), Cloves (72 %), Nutmeg (64 %) and Pepper (16 %) (Table 4)

Table 5. Income from Spices

Income	Beneficiaries (N=50)	
	No.	%
Only source	6	12.0
Additional Source	44	88.0
Total	50	100.0

The income which was accrued from the spices (Table 5) revealed that around 88 % of the respondents got additional income for their family and 12 % got as only source of income. And they were belonging to the low socio economic status and having less than one acres of land. The category of only source are planting / cultivating the chilli and ginger as their prime spice due to the non availability of much land to do other crops.

Table 6. Type of Value Addition

Type	Beneficiaries (N=50)	
	No.	%
Using Post Harvest Technology	38	76.0
Traditional Method	12	24.0
Total	50	100.0

Table 6 describes the value addition of spices after harvesting. Around 76 % of the respondents informed that they are into using of Post Harvest Technology and 24 % of them were still following the Traditional method of drying and packing of the spices to send it to the market for sales. Here training played an important role and this was the primary reasons for which the percentage of the post harvest technology users are more than the traditional users.

Though the spice cultivation is less than the national average in Andaman and Nicobar Islands, the women farmers are more interested into spice cultivation like Ginger and Chilli, Nutmeg and Cloves than Pepper. Based on the inputs received from the respondents the maintenance work for pepper is more than other two viz Ginger and Chilli. Moreover these two can be sold easily in the local market. As far as the value addition is concerned the training imparted by the agricultural department and ICAR –CIARI from time to time has helped them to rope in technologies and scientific method. Overall the training coupled with cultivation has impacted on the livelihood of the marginal women farmers with special reference to the Ferrargunj Tehsil of South Andaman.

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27. INTEGRATED PEST MANAGEMENT IN CHILLI AND CURRY LEAF

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The description of pests, nature of damage and the integrated pest management practices for chilli and curry leaf are enumerated in this chapter. Wherever, organic production is practiced, use of chemicals need to be avoided.

1. CHILLI (*Capsicum annuum*)

i) Tobacco caterpillar, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae)

Young larvae scrap the leaves on ventral side. Grown-up caterpillar completely defoliates. Larvae also feed on young fruits. Larva is pale greenish brown with dark markings. Yellow and purplish spots are seen on the submarginal areas. Adult is stout moth with wavy white markings on the brown forewings and white hindwings are having a brown patch along its margin.

Management

- ❖ Plough the soil during summer to expose and kill pupae by sun light or bird predation.
- ❖ Castor can be grown as trap crop
- ❖ Collect and destroy the egg masses, gregarious larvae and grown up caterpillars
- ❖ Spray any one of the following insecticides: Emamectin benzoate 5 % SG@ 4 g/10 lit or Flubendiamide 20 WDG @ 6.0 g /10 lit or Indoxacarb 14.5 % SC @ 6.5 ml/10 lit or Novaluron 10 % EC @ 7.5 ml/10 lit or Spinosad 45 % SC @ 3.2 ml/10 lit or Thiodicarb 75 % WP @ 2.0 g/lit

ii) Fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera : Noctuidae)

Young larvae feed on tender foliage and from fourth instar onwards attacks fruits. They bore circular holes and thrust only a part of their body inside fruit and eat inner contents. Freshly hatched larva is yellowish white but gradually become green. Full-grown larva is apple green in colour with white and dark grey-brown longitudinal lines and sparse short hairs. Adult is light brown and medium sized moth with dull black border.

Management

- ❖ Collect and destroy the infected fruits and grown up larvae
- ❖ Setup pheromone trap with Helilure at 15 No's /ha

- ❖ Six releases of *Trichogramma chilonis* @50,000/ha per week coinciding with flowering time
- ❖ Release *Chrysoperla carnea* at weekly interval at 50,000 eggs or grubs / ha from 30 DAS.
- ❖ Spray HaNPV at $1.5x10^{12}$ POB/ha along with cotton seed oil 300 g/ha to kill larvae.
- ❖ Spray any one of the following insecticides: Spray any one of the following insecticides: Emamectin benzoate 5 % SG@ 4 g/10 lit or Flubendiamide 20 WDG @ 6.0 g /10 lit or Indoxacarb 14.5 % SC @ 6.5 ml/10 lit or Novaluron 10 % EC @ 7.5 ml/10 lit or Spinosad 45 % SC @ 3.2 ml/10 lit or Thiodicarb 75 % WP @ 2.0 g/lit

iii) Thrips, *Scirtothrips dorsalis* Hood (Thysanoptera:Thripidae)

Thrips are minute insects with fringed wings, serious during dry periods of high temperature. Nymphs are small, linear, easily fragile abdomen with straw yellow colour and adults are with fringed wings. Both adult and nymphs suck the sap from young developing leaves. Affected leaves curl upwards along the margin and get crinkled and reduced in size. They also feed on floral parts and fruits. Fruit damage result in rough brown patches affecting their quality and drastically reducing the market value.

Management

- ❖ Inter crop with agathi (*Sesbania grandiflora)* to provide shade which regulate the thrips population
- ❖ Do not follow chilli and onion mixed crop
- ❖ Treat seeds with imidacloprid 70% WS @ 12 g/kg of seed while sowing.
- ❖ Apply neem cake @ 250 kg/ha to plant beds while planting and repeat after 30 days.
- ❖ Spray with any one of the following insecticides Imidacloprid 17.8 % SL@ 3.0 ml/10 lit or Dimethoate 30 % EC @ 1.0 ml/lit or Emamectin benzoate 5 % SG @ 4 g/10 lit or Fipronil 5 % SC @ 1.5 ml/lit or Spinosad 45 % SC @ 3.2 ml/10 lit or Thiacloprid 21.7 % SC @ 6.0 ml/10 lit or Acephate 75 SP@ 1.0g/litre of water.

iv) Aphids, *Aphis gossypi* and *Myzus persicae* (Hemiptera: Aphididae)

These are small green insects and both nymphs and adults suck the sap from tender leaves and flower buds. The leaves curled and crinkled. Excretion of honeydew by aphids promotes sooty mould growth, thereby reducing photosynthesis and fruit quality. Aphids also act as vectors for transmitting mosaic virus disease.

Management:

- ❖ Treat seeds with imidacloprid 70% WS @12 g/kg of seed
- ❖ Remove all the virus affected plants and destroy.
- ❖ Spray any one of the following insecticides: Acephate 75 SP @ 1g/lit or Dimethoate 30 EC @ 2 ml/lit or Fipronil 5 % SC @ 1.0 ml/lit. or Imidacloprid 17.8 % SL @ 3.5 ml/10 lit.or in rotation when required.

v) White or Yellow Mites *Polyphagotarsonemus latus*

These are very minute mites and cannot be seen by naked eyes. Damage is more in hot and humid conditions. Adults and nymphs scrape terminal leaves and auxiliary shoots. As a result, leaves become narrow, twisted with elongated petiole. The damage is characterized by downward curling of leaves and stunted growth of plants and dropping of flowers.

Management

- ❖ Apply wettable sulphur 80 WP @ 3g/l or any acaricide (directing the spray on the ventral surface of leaves).
- ❖ Spray pongamia oil (2ml/l) mixed with acaricides.
- ❖ Spray neem seed powder extract 4% at 10 days interval when the pest incidence is low. As and when the pest incidence increases, spray with synthetic acaricides like Dicofol 18.5 EC @ 2.5ml/l and repeat the spray after 10 days, if required or Chlorfenapyr 10 % SC @ 1.5 ml/lit or Diafenthiuron 50 % WP @ 8.0 g/10 lit or Spiromesifen 22.9 % SC @5.0 ml/10 litre of water.
- ❖ Under protected conditions spary acaricides like Abamectin 1.9 EC @ 0.5ml/l or Dicofol 18.5 EC @ 2.5 ml/l or Fenazaquin 10 EC@ 1ml/l in rotation with plant products like pongamia oil or neem oil (8-10 ml/l) or neem soap (10g/l) when the leaves start curling down with all the precautions.

2. CURRY LEAF (*Murraya koenigii* L.)

The curry leaves or meetha neem, *Murraya koenigii* is a tropical to sub-tropical tree in the family Rutaceae, which is native to India and Sri Lanka. These leaves are used in almost all dishes in these areas to give a nice aroma and also used in Ayurvedic medicines. The curry leaf was found to be attacked by dozen of insect pests. The major pests of curry leaf are described hereunder.

i) Psyllid bug: *Diaphorinacitri* (Psyllidae: Hemiptera)

Common Name: Jumping plant lice

Psyllid bug is the most destructive sucking pest of curry leaf. This insect is active throughout the year and breeds from March to November. Adults are found under the leaf surface and hop out when slightly disturbed.

Nature of Damage: The tender shoot is often severely attacked by the psyllids. The damage is caused mostly by nymphs than the adults. Leaf curling, defoliation and death of shoots may result from the attack. The bugs also inject certain toxins along with saliva which cause drying and death of branches. Besides they excrete honey dews resulting in the superficial black coating on the leaves. The damage is so long lasting that the branches look sickly and the vitality of the plants deteriorates.

Life cycle: Adults are brownish bugs, measuring about 2 to 3 mm long. Eggs are laid in tender shoots and leaves.About 800 orange coloured eggs are laid in the folds of half opened leaves. They hatch into nymphs in three to five days and appear flat, circular and yellowish. Nymphal period ranges from 9 to12 days. Adults may live for about six months during winter. They are eight to nine overlapping generations in a year.

Management

- Prune and destroy bug infested twigs.
- Light and sticky traps may be fixed to capture the adults. Dusting of cow dung ash is an organic way.
- Several species of ladybird beetles predate upon the nymphs.
- Use of *Beauveria bassiana* formulation is a safe bio control method.
- Spraying of botanicals such as 5 per cent Neem seed kernel extract or 0.03 per cent azadirachtin is an ecofriendly method.
- Application of fish oil rosin soap at one part in 25 parts of water will be highly effective against this sucking pest.
- In case of severe infestation, insecticides such as malathion 0.05 per cent, carbaryl 0.1 per cent, acephate 75SP at1g/lit, triazophos 50EC at 2.5ml/lit should be sprayed.

ii) Citrus butterfly: *Papiliodemoleus* (Papilionidae: Lepidoptera)

Common Name: Lemon butterfly

The citrus butterfly is one of the major destructive pest of curry leaf plantations. It is one of the economically important pests whose larval forms cause serious damage by devouring

large quantity of foliage during later stages of their development. The larval population density will be high during October to December months and July to December is the most favourable period of its activity in general.

Nature of damage: The caterpillars feed voraciously on tender leaves right up to the mid ribs and defoliate the entire seedlings or the tree leaving behind only the midribs. They are foliage feeders, prefer blossoms and young nurseries of curry leaf. Severe pest attack resulted in entire defoliation of the tree and leads to retardation of plant growth.

Life cycle: It is a beautiful black yellow butterfly. The adult wingspan range from 80-100 mm. Its hind wings have a brick red oval patch near the anal margin and there is no tail like extension behind though common in Papilionidae. The female butterfly lays singleround, smooth eggs on tender leaves and shoots. The egg is round, light yellowish in colour, flattened at the base, smooth-surfaced and about 1.5 mm in height. Egg hatches in about 3 – 8 days. The newly hatched caterpillars were dark brown and soon developed irregular white markings on their body resembling bird's drop which gradually changes to green in later instar. This fleshy, forked, yellowish orange coloured structure called osmaterium that occurs just above the head on larvae which emitted a distinct smell. It is normally hidden when the caterpillars were disturbed; it pushed out from the top of its prothorax. The head is large and brown with a dull orange inverted V mark. The caterpillars attach themselves to branches with silk, transforming into rugose pupae, stout and 30 mm in length. They remain in the pupal form for 2–3 weeks before emerging as adults. The total developmental period from egg to adult was 28-32 days.

Management

- Hand pick the larvae and destroy
- Spraying of Azadirachtin (0.3%) twice at 8 days interval is effectively control the larval populations
- First instar - Spraying of 1.5ml monocrotophos (Nuvacron), 1ml DDVP (Nuvan)
- Field release of parasitoids *Trichogramme evanescens* and *Telenomus sp* on eggs
- *Brachymeria sp* on larvae and *Pterolus sp*. on pupae.
- Application of *Bacillus thurungiensis var. Kurstaki* at 1 ml/l + spreader

iii) Citrus black fly: *Aleurocanthus woglumi* (Aleyrodidae: Hemiptera)

Nature of damage: It damages curry leaf by sucking nutrients from foliage, which weakens the plants. Citrus blackflies excrete honeydew on which sooty molds develop. Sooty molds coat curry leaves, causing them to appear black. Sooty molds can severely impair leaf respiration and photosynthesis.

Life cycle: The adult emerges from a T-shaped split appearing in the anterior end of the pupal case. At emergence, the head is pale yellow, legs are whitish, and eyes are reddish-brown. Within 24 hours after emergence, the insect is covered with a fine wax powder, which gives it a slate blue appearance Eggs are laid in a spiral pattern on the underside of the leaf. Each female lays two to three egg-spirals during her 10 to 14 day life span. Eggs hatch within seven to 10 days. The nymphal first instar is elongate-oval and lasts seven to 16 days. The second instar is more ovate, dark brown in color with numerous spines covering the body and lasts seven to 30 days. The third instar is glossy black with spines stouter and more numerous. Pupa is ovate and glossy black with a marginal fringe of white wax.

Management

- ❖ Collect and destroy the damaged plant parts along with nymphs, pupa and adults
- ❖ Spray with 2 ml of chloropyriphos per litre of water followed by a second spray after 15 days with 1.5ml of monocrotophos
- ❖ Female lays eggs on lower surface of leaves in a form of three (15-22 eggs/whorl) whorls hence,the entire plant canopy should be drenched with the solution.
- ❖ Encourage activity of parasitoids, *Encarsia sp*., *Eretomocerusserius* and *chlysoperla sp*.

iv) Leaf roller: *Tonica zizyphi* (Oecophoridae: Lepidoptera)
Nature of Damage:The larvae roll the leaflets in large numbers and cause appreciable damage.

Life cycle: The adult moth is small brown in colour. The female moth lays eggs singly or in group along the mid ribs of leaves. A female can lays up to 404 eggs in her life span. The egg, larval and pupal period are 3-5, 9-11 and 5-10 days respectively. It pupates in leaf folds. The total life cycle of the pest is completed in 20-31 days.

Management

- ❖ Collect and destroy damaged leaf folds along with larvae and pupae.
- ❖ Encourage activity of *Brachymeria euploeae* and *Apanteles sp.*
- ❖ Spray carbaryl 10.1% or dimethoate 0.03 % or NSKE 5%.

v) Mealybugs

Life cycle: Citrus mealy bugs are soft pinkish-white insects with a waxy appearance. Mealy bugs are soft-bodied, wingless insects that grow between 1/20 and 1/5 inch long. Mealy bugs lay large clusters of several hundred eggs on the surface of a leaf, which then hatch into yellow nymphs, which feed on plant sap.

Nature of damage: In addition to causing leaves to shrivel, large infestations of citrus mealybugs can cause a tree's fruit to drop prematurely. Mealy bugs usually gather in large numbers, causing premature leaf drop and twig dieback when they feed. Like psyllids, they secrete honeydew, which attracts black sooty mold.

Management

- Clip off the infested twig to prevent further infestation initially.
- In severe conditions spray with any one of the following insecticides Imidacloprid 17.8 % SL@ 3.0 ml/10 lit or Dimethoate 30 % EC @ 1.0 ml/lit or Emamectin benzoate 5 % SG @ 4 g/10 lit or Fipronil 5 % SC @ 1.5 ml/lit or Spinosad 45 % SC @ 3.2 ml/10 lit or Thiacloprid 21.7 % SC @ 6.0 ml/10 lit or Acephate 75 SP@ 1.0g/ litre of water.


Black Pepper

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