THE ADHOC PACKAGE OF PRACTICES RECOMMENDATIONS FOR ORGANIC FARMING

Editors

Dr.D.Alexander
Dr.S.Rajan
Dr.L.Rajamony
Dr.K.Ushakumari
Dr.Sajan Kurien

DIRECTORATE OF RESEARCH
KERALA AGRICULTURAL UNIVERSITY
THRISSUR-680656, KERALA, INDIA

English

THE ADHOC PACKAGE OF PRACTICES RECOMMENDATIONS FOR ORGANIC FARMING

June, 2009

Copies:

Compilation and Editing:

General guidelines

Dr.K.Ushakumari
Dr.V.L.Geethakumari

Rice

Dr.P.V.Balachandran
Dr.S.Leena Kumari

Fruits, Vegetables, Ornamental Plants and Tuber Crops

Dr.C.S.Jayachandran Nair
Dr.L.Rajamony
Dr.Abdul Wahab

Plantation Crops, Spices, Medicinal and Aromatic Plants

Dr.E.V.Nybe
Dr.S.Rajan
Dr.N.Mini Raj

Plant Protection

Dr.T. Nalinakumari
Dr. P. Sivaprasad

Final compilation:

Dr.K.E.Savithri

Published by:

Director of Extension
Kerala Agricultural University
Mannuthy 680 651
Thrissur, Kerala

Printed at:

Kerala Agricultural University Press, Mannuthy – 680 651 Thrissur - Kerala

Correct Citation:

Kerala Agricultural University 2009

THE ADHOC PACKAGE OF PRACTICES RECOMMENDATIONS FOR ORGANIC FARMING

Directorate of Research
Vellanikkara, KAU Post – 680 656 Thrissur, Kerala, India.

KERALA AGRICULTURAL UNIVERSITY
K.A.U. P.O.
Vellanikkara 680 656

K.R. Viswambaran, IAS
Vice Chancellor

FOREWORD

Agricultural practices, world over, have been undergoing changes over a period of time. The intensive agricultural practices followed during the past four decades in our country resulted in food security and self-sufficiency. This was achieved through development of input responsive varieties coupled with use of chemical fertilizers and plant protection chemicals. The Green Revolution in India, undoubtedly, boosted the overall agricultural production. However, productivity decline is experiencing in many intensively cultivated areas where organic manures were partially or totally excluded. The intensification of land use with increased dependence on agro-chemicals resulted in stagnation of crop yield in many situations, which necessitated a change to a sustainable farming system approach having inbuilt features of equilibrium between farming and nature. This type of farming system, later on, came to be known as organic farming.

Various technologies like Biological agriculture, Biodynamic farming, Health food, Green Food have been in vogue in the area of organic farming. But it is well recognized that organic agriculture is a holistic food production management system, which promotes and sustains agro-ecosystem, health, biodiversity, biological cycles and soil biological activity. In general, organic farming hinges on extensive use of naturally available resources, preferably on-farm inputs to enhance soil fertility, in contrast to chemical fertilizers.

The concept of organic farming is not new to Indian farming community. Several forms of organic farming are being successfully practiced in diverse agro-climatic situations, particu

larly in rainfed, tribal and hill areas of the country. Much of the forest produce of economic importance like medicinal plants by default come under this category. In rainfed and semi-arid condition, it has been demonstrated that the productivity with organic farming is comparable to conventional agriculture. Today in India over 2.5 million hectares are brought under organic cultivation in contrast to 31 million hectares in the world.

In this context, it is worth mentioning the result of the swot analysis on organic farming in India conducted at Modipuram in 2006, which states that a major portion of the cultivable area in India is organic by default. The study also revealed the global interest in natural health foods, availability of vast pool of traditional knowledge, lack of incentives for production of organic inputs, poor local infrastructure facilities for processing and value addition, lack of satisfactory income, absence of regulation on supply system, non-remunerative and fluctuating prices of organic produce. These tips give enough cue for future line of action. While strongly advocating organic farming in the State, we should be sensitive on the increasing requirement of food due to the ever-increasing population growth. Kerala being a consumer State for almost every food item, a small percent of increase in gap between production and supply is bound to have serious repercussions. Hence a strategic approach is needed while switching over to organic farming, which should be in selected crops, in selected locations and in a phased manner. Above all, there is a need for an ideal organic farming policy to be formulated in the State.

The *Adhoc* Package of Practices Recommendations for Organic Farming aims at providing necessary guidelines to the practitioners and potential followers of organic farming. The feed back on this will be of immense use for subsequent refinement.

I congratulate all the scientists who have contributed in this venture. I also appreciate the steps and initiatives taken by the Directorate of Research in bringing out this timely publication

K.R. Viswambharan

PREFACE

Green revolution is a milestone in the development of independent India. The boosted food grain production by green revolution was achieved mainly through the use of high yielding varieties of crops. These high yielding varieties are highly fertilizer responsive and to some extent amenable to pests and diseases. This in turn demanded increased use of fertilizers and plant protection chemicals. The unscientific and indiscriminate use of agro-chemicals has affected the soil health adversely and brought down the fertility of soil and productivity of crops. In addition, it has resulted in the over exploitation of soil leading to nutrient imbalance. Moreover, a negative impact of chemical agriculture on environment and human health has been reported and documented. Increased environmental awareness and health conciousness promoted the scientists and planners to think about organic agriculture as an alternate way for sustainable agriculture with protection to environment and human health.

In Kerala, considering the unique situation both climatologically and topographically, organic farming can be promoted as an alternative farming system in selected areas and in selected crops.

The Adhoc Package of Practices Recommendations for Organic Farming is the outcome of research findings of KAU and a series of interactions carried out by scientists of Kerala Agricultural University among themselves and also with scientists of CPCRI, CTCRI, IISR, the extension personnel of the Department of Agriculture and progressive farmers. We sincerly hope that this will be very much useful to the farming community of Kerala especially to those involved /interested in organic farming. We also welcome all suggestions for further refinement of this publication.

We whole-heartedly acknowledge the inputs given by the contributors to various sections.

Editors

LIST OF CONTRIBUTORS

General Guidelines

Dr.K.Ushakumari
Dr.V.L.Geethakumari

Rice

Dr.P.V.Balachandran
Dr.S.Leena Kumari
Dr.P.Raji
Dr. P. K. Ashokan
Dr. V. George Thomas
Dr. C. T. Abraham
Dr. P. S. John
Dr. K. Ushakumari
Dr. V. L. Geethakumari
Dr. K.Anilakumar
Dr. N. K. Sasidharan
Dr. P. K. Sushama
Dr.M. Indira
Dr.T. Nalinakumari
Dr. K.S.Meenakumari

Fruits, Vegetables, Ornamental Plants and Tuber Crops

Fruits

Dr. C.S.Jayachandran Nair
Dr.L.Rajamony
Dr.P.K.Rajeevan
Dr.P.K.Valsalakumari
Dr.T.Radha
Dr.K.P.Kuriakose
Dr.K.C.Aipe
Dr.N.K.Sasidharan
Dr.Jose Mathew
Dr Maicykutty P Mathew
Dr.T.Sabeena George
Dr.N.K.Parameswaran
Dr.C.K.Geetha
Dr.P.K.Sudha Devi
Dr.J.P. Naik
Dr.P.Rajendran
Dr.A.Suma
Dr.A.Sobhana
Dr.Lekha Rani
Dr.Mini.C.

Vegetables

Dr.M.Abdul Wahab
Dr.T.E.George
Dr.Sallykutty Joseph
Dr.V.A.Celine
Dr.V.L.Geethakumari
Dr.Meera Bai
Dr. Sally K Mathew
Dr.P.G.Sadan Kumar
Dr.P.Sukumari
Dr.Devadas.V.S.
Dr.K.V.Suresh Babu
Dr Baby Lissy Markose
Dr. K.P.Prasanna
Dr. K. Krishnakumari
Dr.P.B. Usha
Dr. I. Sreelatha Kumari
Dr. C. Narayanankutty

Tuber Crops

Dr.R.Pushpa Kumari
Dr.N.K.Sasidharan
Dr.Swadija
Dr. K.A. Inasi

Dr. Annamma George
Dr.M.L.Jyothi
Dr. Sudharmayi Devi

Special Group

Dr.T.NalinaKumari
Dr.Jim Thomas
Dr.A.V. Mathew
Dr. Sally K Mathew
Dr. Ambika Devi
Dr. P. Sivaprasad
Dr. C. Nanda Kumar
Dr.C.Gokulapalan
Dr. M.S. Sheela
Dr.T.Jiji
Dr.N.Anitha
Dr.Sainamole Kurien
Dr.V.B.Padmanabhan

Plantation, Spice, Medicinal and Aromatic Crops

Dr.P.C.Balakrishnan (Coconut)

Dr.Jose Mathew (Cashew)

Dr.V.K.Mallika (Cocoa)

Dr.V.K. Raju (Nutmeg)

Dr. N. Mini Raj (Ginger, Turmeric)

Dr.Baby P. Skaria and Dr.Anil Kumar (Medicinal &Aromatic Plants)

Dr.K.R. Lyla (Biological Control)

Dr.P.Sivaprasad (Biological Control)

Dr.Joseph Rajkumar (Cardamom)

Dr. E.V. Nybe (Black Pepper, Vanilla)

Dr.Jim Thomas (Pest Control)

***

CONTENTS

Medicinal Aromatic Plants

Chethikoduveli
Neela Amari
Chengazhinirkizhangu
Kasthurimanjal
Chittaratha
Black Musli
Holostemma
Long Pepper
Kacholam
Asoka
Strychnine Tree
Eucalyptus
Lemon Grass
Palmarosa
Vetiver

Ornamental Plants

Anthurium
Orchids
Jasmine
Tuberose
Marigold

Farming on House Terrace

Resources for Organic Farming

Green manure crops
Green leaf manure crops
Azolla
Soil solarization
Composting
Biocontrol agents
Biofertilisers
Botanical pesticides
Botanical preparation for pest control
Preparation of permitted fungicides
Preparation of Panchagavya and Dasagavya
Organic Certification
APPENDIX-I Average nutrient content of common manures
APPENDIX-II Products for use in fertilising and soil conditioning
APPENDIX-III Products for pest and disease control

GENERAL GUIDELINES FOR ORGANIC FARMING

Organic farming is a crop production method respecting the rules of the nature, targeted to produce nutritive, healthy and pollution free food. It maximizes the use of on - farm resources and minimizes the use of off – farm inputs. It is a farming system that seeks to avoid the use of chemical fertilizers and pesticides. Commitment to protect and preserve nature is a pre-requisite for practicing organic farming. In organic farming, the entire ecosystem (i.e. plant, animal, soil, water and microorganisms) is to be protected. Organic cultivation improves structure and fertility of the soil through balanced choice of crops and implementation of diversified cropping system. Now, the consumers prefer natural / ethnic foods, particularly organic foods across the world and are ready to pay premium price for such foods. The demand for organic agriculture products is on the increase day by day.

The general guidelines on organic production of crops are prepared based on National Programme for Organic Production (NPOP) launched by Government of India. These guidelines enable the growers to attain more or less the same level of the productivity of conventional farming within a few years and at the same time maintain the fertility of the soil and protect the ecological balance.

It is essential that all the crops in the organic field follow an organic method of production. Though the farmers are free to convert a portion of the farm, it is advisable that the entire farm is converted to organic. However, in the case of large farms, the conversion can be phased out for which a conversion plan is drawn out and followed systematically. The time from the start of organic management to the certification of crops and / or animal husbandry is known as the conversion period. The whole farm including the livestock should be converted according to the standard over a period of three years. A simultaneous production of conventional, in conversion and / or organic crops or animal products, which cannot be clearly distinguished from each other is not allowed. To ensure a clear separation between organic and conventional production, a buffer zone or a natural barrier should be maintained. An isolation distance of at least

A buffer zone of 25 m width is to be left from all around the organic. The produce from this isolation belt shall not be treated as organic. Mixed farming systems integrating crop husbandry and livestock are the most ideal where the livestock is also maintained following organic standards. This would enable the use of by-products in the farm itself without depending on external sources

National Standards for Organic Crop production

Choice of crops and varieties

All species and varieties that are cultivated should be adapted to the soil and climatic conditions and be naturally resistant to pest and disease of the region. All seeds and planting materials should be from crops of organic cultivation. When organic planting materials are not available, chemically untreated conventional planting materials shall be used initially. The use of genetically engineered seeds, pollen, transgenic plants and plant materials is not allowed.

Conversion period

The establishment of an organic management system and building of soil fertility requires an interim period, the conversion period. The duration of the conversion period will depend upon

- The past use of the land
- The ecological situation

The plant products produced annually can be certified organic when the national standards requirements have been met during a conversion period of atleast two years before sowing or in the case of perennial crops other than grassland, atleast 3 years before the first harvest of the products. Conversion period can be extended by the certification program depending on the past use of the land and environmental conditions. The accredited certification program may allow plant products to be sold as "produce of organic agriculture in process of conversion" when these national standards stipulation have been met for at least 12 months

Diversity in crop production

Diversity in crop production is achieved by a combination of:

- A versatile crop rotation with legumes
- An appropriate coverage of the soil during the year of production with diverse plant species.
- Follow crop rotation for annual crops and intercropping for perennial crops.
- Avoid crops belonging to the same family in the rotation.
- Biofencing with green manure shrubs or neem and other plant protection agents.

Manurial Policy

Sufficient quantities of biodegradable materials of microbial, plant or animal origin should be returned to the soil to increase or atleast maintain its fertility and the biological activity within it. Organic material must be the product of organic farms and the farms must become self sufficient in producing such organic material

Soil fertility should be maintained or enhanced by

1. Raising green manure crops, leguminous crops
2. Incorporate crops residues
3. Use biodegradable materials of microbial, plant or animal origin
4. Encourage the use of on - farm organic inputs
5. Use of synthetic or chemical fertilizers and growth regulators are not permitted
6. Mineral based materials like rock phosphate, gypsum, lime etc in limited quantities and in their natural compositions.
7. Prevent the accumulation of heavy metals and other pollutants

8. Minimize the nutrient loss by management practices
9. Apply manures as per soil test results
10. Maintain adequate p^H levels
11. Manures containing human excreta shall not be used (Products for use in fertilizing and soil conditioning are listed in Appendix II)

Pests, diseases and weed management

Organic farming systems should be carried out in a way, which ensures that losses from pests, diseases and weeds are minimized. Conditions for minimizing the loss due to pests, diseases and weeds are

1. Balanced manurial programme
2. Use of crops and varieties well adapted to the environment
3. Fertile soil of high biological activities
4. Adopt rotations
5. Companion planting
6. Green manuring
7. Natural enemies of pests and diseases should be protected and encouraged.
8. Cultivate trap crops

Pest and disease control

1. Prohibit the use of synthetic chemicals
2. Use preventive cultural techniques
3. Encourage and protect natural enemies
4. Use products from local plants and of biological origin prepared at the farm.
5. Prohibit the use of genetically engineered organisms and products
6. Brand name products must always be evaluated (Products for pests and disease control is given in Appendix III)

Weed control

1. Slash weeding
2. Use mechanical weed control
3. Use weeded materials as mulch
4. Use clean equipments for organically managed areas
5. Use of synthetic herbicides, synthetic growth regulators and synthetic dyes are prohibited

Contamination control

All relevant measures should be taken to minimize contamination from outside and within the farm. Accumulation of heavy metals and other pollutants should be limited. That cultivation has to guard against the possibility of pesticide and weedicide contamination and the carriage of inorganic chemicals used as fertilizers by irrigation and drainage. For protected structure coverings, plastic mulches, fleeces, insect netting and silage rapping, only products based on polyethylene and polypropylene or other polycarbonates are allowed. These shall be removed from the soil after use and shall not be burned on the farm land. The use of polychloride-based product is prohibited.

Soil and water conservation

Soil and water resources should be handled in a sustainable manner. Relevant measures should be taken to prevent erosion, salination of soil, excessive and improper use of water and the pollution of ground and surface water. In sloppy lands adequate precautions should be taken to avoid the entry of run off water and drift from the neighboring farms. Clearing land through the means of burning organic matter shall be restricted to the minimum. The clearing of primary forest is prohibited.

Food Processing and Handling

Storage, transportation, processing and labelling

Organic produce must be stored, transported and conveyed to the final consumer in its pristine stage. Co-mingling with inorganic products shall be prevented. Pests at the storage and processing stage must be controlled by means of physical barriers, sound and light, with temperature and atmospheric control. Mixture of organic and non-organic products must be prevented during processing. Additives and substances that diminish or alter the nature of organic produce are to be avoided. Irradiation is not allowed. Processing methods should be based on mechanical, physical and biological process. Packaging must take care to prevent material contact to diminish the organic purity of the produce. Eco-friendly, biodegradable materials should be the preferred media of packing. Waste generating packaging and pollution causing packing materials are discouraged. Labelling shall convey clear and accurate information on the organic status of the product. The label for organic products should be clearly distinguishable from the label for conventional products. The labelling of organic produce must declare openly the fact of totally organic or under conversion period. Direct sales by producers are to be encouraged. Equal wages for equal tasks is a practiced principle in organic farming. The women and children's rights are left inviolate. The practice of organic farming is found to be compatible with the preservation and improvement of the environment. The Government of India having concern for the health and well being of its citizenry finds it necessary to institute a system to assure them a supply of food and food materials free from unnatural treatment of additives.

RICE (*Oryza sativa*)

Rice can be cultivated under a variety of climatic and soil conditions. Rice cultivation is conditioned by temperature parameters at the different phases of growth. The critical mean temperature for flowering and fertilization ranges from 16 to 20^0C, whereas, during ripening, the range is from 18 to 32^0C. Temperature beyond 35^0C affects grain filling. Rice comes up well in different soil types. For normal growth, a pH range of 5.0-8.0 is suitable.

It is recommended to follow organic farming practices in toto for *Pokkali, Kaipad* and *Koottumundakan* rice as well as medicinal and scented rices. In other rice growing situations, organic farming may be followed depending on the availability of organic resources and an assured market for organic produce.

In general, rice can be grown as transplanted or direct sown crop during three seasons as shown below depending on the agroclimatic situations.

Table 1. Different rice growing seasons of Kerala

Agroclimatic situations	*Seasons*	*Period*	
		From	*To*
General	Virippu (I crop / autumn)	April-May	Sept-Oct
	Mundakan (II crop / winter)	Sept-Oct	Dec-Jan
	Puncha (III crop / summer)	Dec-Jan	March-April
Onattukara	Virippu (I crop / autumn)	April	August
	Mundakan (II crop / winter)	Aug-Sept	Dec-Jan
Kuttanad	Additional crop	May-June	Aug-Sept
	Puncha	Oct-Nov	Feb-March
Kole (single cropped area)	Mundakan (*Kadumkrishi*)	Aug-Sept	Dec-Jan
Pokkali	Virippu (I crop / autumn)	May-June	Sept-Oct
	Mundakan	Aug-Sept	Dec-Jan
Kaippad	Mundakan (II crop / winter)	Sept-Oct	Dec-Jan
	Puncha (III crop / summer)	Dec-Jan	March-April
High ranges	Nancha	May-June	Oct-Nov
	Puncha	Dec-Jan	April-May

Variety

The variety chosen should not only be suitable for the agro-climatic region but also resistant / tolerant to the pests and diseases predominant in that location. The seeds should be organically produced.

Table 2.Varieties suited for different situations

System / Region	*Season*	*Varieties*
Pokkali	Virippu	Vytilla 1, Vytilla 2, Vytilla 3, Vytilla 4, Vytilla 5, Vytilla 6, Vytilla 7 and local/ traditional varieties such as Kuruka, Anakkodan and Pokkali.
	Mundakan	Orpandy, Oarumundakan
Kaipad	Mundakan	Traditional varieties like Kuthiru, Mundon, Orpandy, Mundon etc.
	Puncha	Orkazhama
Koottumundakan	Virippu+ Mundakan	**Traditional combinations** Chettivirippu+Mundakan (Alappuzha) Chenkayama+ Chettadi (Palakkad) **High yielding combinations** Swarnaprabha+ Makaram, Swarnaprabha+ Kumbham, Karthika+Makaram, Karthika+Kumbham
Medicinal rice	Virippu/ Mundakan/ Puncha	Njavara
Scented rice	Nancha / Puncha	Jeerakasala, Gandhakasala
	Virippu	Rajakayama, Kothampalarikkayama, Kunjikayama, Pookkilathari etc.
	Mundakan	Neycheera
Upland (*Modan* land) Purely rainfed	First crop	PTB 28, PTB 29, PTB 30, Suvarnamodan, Annapurna, Mattatriveni, Swarnaprabha, Rohini, Aiswarya
Palliyals (*Myals*) Single crop terraced	First crop	Early duration: Rohini, Annapurna, Mattatriveni, Jyothy, Kairali, Kanchana, Harsha, Karthika, Ahalya Medium duration: Aswathy, Sabari, Bharathy, Jaya, Mahsuri, Aiswarya, Aathira

System/Region	*Season*	*Varieties*
Double crop wet lands: a. Semi-dry cultivation	First crop	Early duration: Mattatriveni, Annapurna, Jyothy, Swarnaprabha, Ahalya, Varsha, Rohini, Karthika, Aruna, Makom, Revathy, Remanika, Krishnanjana, Kanchana, Harsha, Kairali, Kunjukunju Varna, Kunjukunju Priya Medium duration: Aswathy, Sabari, Bharathy, Jaya, Mahsuri, Arathy, Bhadra, Pavizham, Remya, Kanakom, Ranjini, Pavithra, Panchami, Uma, Karishma, Gouri, Aathira, Aiswarya
	Second crop (except Rohini)	Any of the varieties suggested for the first crop season Early duration: Annapurna, Mattatriveni, Jyothy, Swarnaprabha, Kairali, Kanchana, Karthika, Aruna, Makom, Revathy, Remanika, Krishnanjana, Varsha, Rohini, Ahalya, Kunjukunju Varna, Kunjukunju, Priya
b.Transplanted	First crop	Medium duration: Jaya, Sabari, Bharathy, Aswathy, Mahsuri, Aathira, Aiswarya, Pavizham, Remya, Kanakom, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri. Late duration: Mangalamahsuri
	Second crop	Early duration: Annapurna, Mattatriveni, Jyothy, Kairali, Kanchana, Karthika, Makom, Revathy, Remanika, Krishnanjana, Kunjukunju Varna, Kunjukunju Priya Medium duration: Aswathy, Sabari, Bharathy, Jaya, Mahsuri, Aathira, Aiswarya, Pavizham, Remya, Kanakom, Renjini, Pavithra, Panchami, Uma, Karishma
	Third crop	Late duration: Mangalamahsuri, Pranava, Swetha, Karuna, Resmi, Nila, Makaram, Khumbham, Dhanu Early duration: Annapurna, Mattatriveni, Jyothy, Swarnaprabha, Kairali, Kanchana, Karthika, Makom, Revathy, Remanika, Krishnanjana, Ahalya, Harsha, Varsha Medium duration: Sabari, Bharathy, Jaya, Aathira, Aiswarya, Pavizham, Remya, Kanakom, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri.

System/Region	*Season*	*Varieties*
Kuttanad area	Puncha	Early duration: Karthika, Makom, Jyothy, Mattatriveni, Annapurna, Revathy, Remanika, Krishnanjana Medium duration: Bhadra, Asha, Pavizham, Remya, Kanakom, Jaya, Sabari, Bharathy, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri
	Additional crop	Early duration: Karthika, Aruna, Makom, Annapurna, Jyothy, Mattatriveni, Revathy, Remanika, Krishnanjana Medium duration:Pavizham, Remya, Kanakom, Jaya, Sabari, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri.
Kole area	Mundakan	Extra short duration: Hraswa Early duration: Annapurna, Mattatriveni, Jyothy, Swarnaprabha, Karthika, Aruna, Makom, Kanchana, Kairali, Revathy, Remanika, Krishnanjana, Ahalya, Varsha Medium duration: Aswathy, Sabari, Bharathy, Pavizham, Remya, Kanakom, Jaya, Aiswarya, Renjini, Pavithra, Panchami, Uma, Karishma, Bhadra
Deep ill- drained regions of southern districts	First crop	Remya, Arathy
	Second crop	Kottarakkara-1, Lakshmi, Nila, Makaram, Kumbham, Mangalamahsuri
Waterlogged and flooded areas	First crop	IR-5, Pankaj, Jagannath, H4, Mahsuri, Neeraja, Mangalamahsuri
Oorumundakan	Second crop	Late duration: Sagara
Onattukara and coastal sandy areas	First crop	PTB 23
a. Where HYVs do not come up	Second crop	PTB 20
b. Where HYVs come up well	First crop	Early duration: Annapurna, Mattatriveni, Jyothy, Bhagya, Rohini, Onam, Chingam, Aruna, Makom, Karthika, Revathy, Remanika, Krishnanjana Medium duration: Jaya, Sabari, Bharathy, Aswathy, Pavizham, Remya, Kanakom, Arathy, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri.

System/Region	*Season*	*Varieties*
	Second crop	Early Duration: Annapurna, Mattatriveni, Makom, Jyothy, Karthika, Revathy, Remanika, Krishnanjana Medium duration: Jaya, Sabari, Bharathy, Aswathi, Pavizham, Remya, Kanakom, Dhanya (season bound), Renjini, Pavithra, Panchami, Uma, Karishma, Gouri.
	Third crop	Early Duration: Annapurna, Mattatriveni, Rohini, Makom, Revathi, Remanika, Krishnanjana. Medium duration: Jaya, Sabari, Bharathy, Aswathy, Pavizham, Remya, Kanakom, Renjini, Pavithra, Panchami, Uma, Karishma, Gouri.
Poonthalpadam		Makom, Mattatriveni, Neeraja
High altitude area: a. Single crop areas		WND-1, WND-2, Aswathy, Jaya, Sabari, Mahsuri, Bhadra, IR 8, Aathira
b. Double crop areas	First crop	Aswathy, Jaya, Sabari, Bharathy, Bhadra, Deepthi, Aathira, IR 8
	Second crop	Aswathy, Jaya, Sabari, Bharathy, Bhadra, Deepthi, Aathira, IR 8
c. Eastern lateritic regions of Kollam & Alappuzha districts	Second crop	Lakshmi
Chitoor black soil	First crop	ASD 16, ASD 17, Mahsuri, Varsha, ADT 43
	Second crop	Ponni, Vellaponni, Ponmani, ASD 16, ASD 17, Pranava, Swetha, Bhadra, Renjini.

Seed rate

Transplanting- 60-85 kg / ha
Broadcasting- 80-100 kg / ha
Dibbling –80-90 kg / ha

(In Pokkali cultivation, for Vytilla varieties 100 kg/ha may be sown on the beds or mounds formed in the field.)

Seed treatment

Dry seed treatment - Dress the seeds with the talc based formulation of *Pseudomonas fluorescens* (P1 and P14) @ 10 g / kg seed at the time of sowing.

Wet seed treatment – Soak the seeds for 12 to 16 hours in a solution of *P.fluorescens* (P1 and P14) prepared @ 10 g / litres of water / kg seed

Nursery

For transplanting, healthy seedlings have to be raised in seed beds. Adopt wet or dry method for raising seedlings. The choice depends primarily on the availability of water.

Wet method

The wet method can be adopted in areas where water is available. Prepare raised beds of 5-10 cm height, 1-1.5 m width and of convenient length with drainage channels between the beds. The total seedbed area should be 1000 m^2 for each ha of the field to be transplanted. Apply vermicompost @ 500g / m^2 and rice husk ash @ 100 g / $m^2$of the nursery bed and mix well with the soil at the time of preparation of the field. Application of vermicompost reduces the incidence of thrips. If vermicompost is not available, apply compost or cattle manure @ 1 kg / m^2 and 100g of rice husk ash / m^2 of the nursery bed and mix well with the soil at the time of preparation of the field.

Dry method

This method is practiced in areas where sufficient water is not available and the time of planting is uncertain. Prepare raised beds of 1-1.5 m width 15 cm height and of convenient length. Apply vermicompost @ 500 g/ m^2 and rice husk ash @ 100 g / m^2 of the nursery bed. If vermicompost is not available, apply compost or cattle manure @ 1 kg / m^2 and 100g of rice husk ash / m^2 of the nursery bed and mix well with the soil at the time of preparation of the field. Sow the seeds treated as described under dry seed treatment method, evenly over the bed and cover with fine sand / soil.

Age of seedlings

Seedlings are ready to be pulled out when they attain the stage of 4-5 leaves, about 18 days after sowing in the case of short duration varieties and 20-25 days after sowing in the case of medium duration varieties. Seedlings more than 30 days old when transplanted in the field recover slower than younger seedlings, especially, if they suffer stem and root injury. However, during the virippu season, age of seedlings can go up to 35 days in case of medium duration varieties and 25 days for short duration varieties. Irrigate seedbeds a day before pulling out the seedlings to soften the soil and to facilitate washing of roots. Pull out one or a few seedlings at a time to reduce damage. Wash off mud and soil from the roots carefully and tie the seedlings into bundles of convenient size for transplanting. Pruning of the top portion and root is not recommended as it inflicts wounds through which disease causing organisms may subsequently enter.

Preparation of land

General

Plough the field thoroughly to incorporate the weeds and straw into the soil. Ensure a smooth, level field for transplanting the seedlings. It would be better to transplant 10-15 days after incorporating organic manure.

Kuttanad

Drain out standing water from the main field. Plough the field thoroughly to incorporate the weeds in the field. Ensure a smooth and levelled field. Maintain a thin film of water to facilitate sowing so that the germinated seeds do not get covered with clayey soil, which affects seedling establishment.

Kole

For the first crop in Kole, after the cessation of the heavy monsoon, dewatering is effected by petti and para or centrifugal pump and rarely by chakkram. Land is ploughed thoroughly and transplanting is done.

For the second crop, land is prepared thoroughly and direct sowing of sprouted seeds or transplanting is done.

Onattukara

With the onset of pre-monsoon showers, land is ploughed thoroughly. Dibbling of unsprouted seeds behind the country plough is the common practice.

Pokkali

By April, the bunds are being strengthened and sluices repaired for regulating water level. Fields are then drained during low tide and the sluices are closed. When the soil in the field becomes dry, mounds of 1 m base and 0.5 m height are formed. This facilitates the washing down of the dissolved salts from the surface of the mounds, which are ultimately removed from the field by tidal action. The mounds act as elevated *in situ* nursery and protect the seedlings from flash floods.

A special method is adopted for sprouting the seeds. The seeds are tightly packed in baskets made of plaited coconut leaves, the inside of which is lined by banana or teak leaves. These baskets are then immersed in fresh water ponds for 12 to 15 hours. They are then taken out and stored in shade. The radicle just sprouts and remains quiescent under this condition for more than 30 days. When the soil and weather conditions become favourable for sowing, the baskets containing the seeds are re-soaked for 3 to 6 hours before sowing. The mounds in the field are then raked and top levelled. The sprouted seeds are sown on the top of mounds, which act as an *in situ* nursery. When the seedlings reach a height of 40-45 cm (in 30-35 days), the mounds are cut into pieces with a few seedlings, which are uniformly spread in the field.

Koottumundakan

In this system of rice cultivation, a mixture of seeds of a non-photosensitive (virippu) variety and a photosensitive (mundakan) variety of rice in the proportion 70:30 (w/w) is sown during virippu season. This system is practised in areas where sowing / planting of mundakan crop is not possible due to excess water in the field. Hence, mixture of the two varieties is sown in the first crop season (April-May). The first crop variety will be ready for harvest in August-September and the second crop variety can be harvested in December-

January. No cultivation is practised after the harvest of first crop season variety. But organic manures are applied and incorporated. Though the yield will be less than that of the two independent crops, this type of cultivation is taken up in view of the special circumstances prevailing in such areas.

Transplanting

Transplant seedlings of appropriate age for the variety @ 2-3 seedling per hill in rows, at spacing as shown in Table 3. Leave wider row of 30 cm after every 3 m to facilitate spraying and other cultural operations. Transplant seedlings at a depth of 3-4 cm

Table 3.Spacing for rice transplantation

Season	Duration	Spacing	No. of hills/m^2
First crop	Medium Short	20 cm x 15 cm 15 cm x 10 cm	33 67
Second crop	Medium Short	20 cm x 10 cm 15 cm x 10 cm	67 50
Third crop	Medium Short	20 cm x 10 cm 15 cm x 10 cm	50 67

Liming

In general, addition of lime is absolutely necessary when the pH is lower than 5.5 and it is advisable when pH varies between 5.5 and 6.5. For direct seeded crops during the first season, apply lime @ 600 kg/ha in two split doses, the first dose of 350 kg/ha as basal dressing at the time of first ploughing and the second dose of 250 kg/ha as top dressing about one month after sowing. For transplanted crop, apply lime @ 600 kg/ha in two split doses, 350 kg/ha as basal dressing and 250 kg/ha as top dressing about one month after transplanting. For *Pokkali* areas, apply lime @ 1000 kg/ha, 50% at the time of preparation of mounds and the rest at the time of dismantling the mounds. For top dressing, lime may be applied one week prior to the application of manures.

Manuring

Option 1

Local varieties - Apply 5 tonnes of FYM/ compost/ green leaf manure or 2.5 tonnes of vermicompost as basal + 300-500 kg oil cakes (ground nut cake, neem cake etc.) / ha half as basal and half as top dressing at active tillering stage.

Short duration varieties - Apply 5 tonnes of FYM/ compost/ green leaf manure or 2.5 tonnes of vermicompost as basal + 500-750 kg oil cakes (ground nut cake, neem cake etc.) / ha half as basal and half as top dressing at active tillering stage.

Medium duration varieties - Apply 5 tonnes of FYM/ compost/ green leaf manure or 2.5 tonnes of vermicompost as basal + 600-800 kg oil cakes (ground nut cake, neem cake etc.) / ha half as basal and half as top dressing at active tillering stage.

Methods of Green manuring

Leguminous green manures used in rice based cropping system include *Sesbania aculeata, Sesbania rostrata, Sesbania speciosa* and *Crotalaria juncea*. These are grown during the pre rice season between April and June and the biomass is incorporated into the soil before rice is transplanted. Wherever limited irrigation facilities are available, grain legumes such as green gram, black gram and cowpea can be grown in summer season.

In situ green manuring

Farmers can choose the green manure crop according to their local availability and agroclimatic conditions. Daincha (*Sesbania aculeata*) is the commonly used and ideal green manure crop for rice fields. Usually after the harvest of *rabi* crop, daincha is sown with the receipt of summer showers and it is ploughed and incorporated 8-10 weeks after sowing. Among the green manure crops, *Sesbania aculeata* is the one, which can supply highest amount of biomass and nitrogen. It is fairly drought tolerant and resistant to waterlogging. It is suitable for loamy and clayey soils. One crop of daincha can add 10-20 tonnes of biomass per ha. For sowing one ha area, 20-25 kg of seed is required. It can fix about 75-80 kg N per ha depending on the environmental conditions.

Intercropping with cowpea

During *kharif* season, when dry sowing is practised in low lands, cowpea seeds may be mixed with paddy seeds @ 12.5 kg / ha. It is necessary that a non-trailing type of cowpea should be used. Cowpea will be grown as an intercrop and with the onset of monsoon, when the rice field gets submerged, cowpea gets decayed and incorporated in the soil adding substantial quantity of green manure.

Option 2

One tonne of farm yard manure and one tonne of green leaf manure, dual culture of Azolla and application of biofertilizers like *Azospirillum*, phosphobacteria, potassium mobilising bacteria and PGPR mix 1.

Option 3

Substitution of one-third of recommended dose of fertilizer by FYM, one third by vermicompost , one third by neem cake + Azospirillum 2kg/ha and P solubilising bacteria 2 kg/ha.

Methods of application of biofertilsers

Azospirillum

Seed treatment**:**

Mix the carrier based inoculum 200 g in 200 ml of rice gruel to make a slurry which is sufficient to treat 10 kg of seed. The seeds are mixed in the slurry so as to have a uniform coating of the inoculum over the seeds and then shade dried for 30 minutes. The shade-dried seeds should be sown within 24 hours.

Main field application:

2 kg *Azospirillum* is mixed with 50 kg of dried powdered farm yard manure and then broadcast in one ha of main field just before transplanting.

Phosphorus Solubilising Bacteria (PSB)

Carrier based phosphobacteria can be applied as seed treatment and field application as in the case of *Azospirillum.*

Potassium mobilizing bacteria

Mix 500 ml of liquid formulation of potassium mobilizing bacteria (*Fraturia aurentia*) with 50 kg of FYM for field application in one ha.

PGPR mix 1

It is a biofertilizer that provides N, P and K. Apply as:

1. Seed treatment
2. Dip the root in PGPR mix1 10% solution for 10 minutes before transplanting and
3. Field application @ 2.5 kg/ one litre in 100kg organic manure for one hectare.

Azolla

Azolla can be applied as green manure for rice before transplanting. For this, Azolla is grown 15-20 days before transplanting of rice by applying 1-2 t fresh inoculum per ha in a well prepared field. Rock phosphate is applied @ 62.5 kg/ha in three equal splits at an interval of seven days. After the formation of thick mat, water is drained out and the field is ploughed for incorporating Azolla.

***Dual culture*:**

Growing of Azolla along with rice is more easy and feasible. Azolla technology is very efficient in terms of nitrogen fixation and biomass accumulation during *rabi* season due to better environmental conditions for its vegetative multiplication. It can also be used for late *kharif* season. Fresh biomass of Azolla is applied in the main field 7-10 days after transplanting rice. Inoculation of fresh biomass of Azolla @ 200 kg / ha could multiply faster and cover the rice field as a green mat in 2-3 weeks period with 15-20 tonnes biomass accumulation. Azolla is incorporated at the time of first weeding. It can be done with a weeder or leave it for self decomposition. Azolla decompose in the flooded rice field in 2-3 weeks period. During the incorporation of Azolla, the left over fronds float on water surface which multiply and cover the rice field. Again 2-3 incorporation is possible. The cultivation of Azolla not only supplies biomass and N, but also contributes K, P, Ca, S, Zn, and Fe. The suppression of weed growth is another added advantage of Azolla cultivation along with rice.

to about 5 cm until maximum tillering stage. Drain water 13 days before harvest.

Water management

Maintain water level at about 1.5 cm during transplanting. Thereafter increase it gradually to about 5 cm until maximum tillering stage. Drain water 13 days before harvest.

[Note: In areas where water for irrigation is assured and where acidity is high, draining and reflooding every 15 days are recommended. In flood prone areas, aged seedlings of Mahsuri or other varieties recommended for waterlogged conditions may be planted. The planting may be preponed or postponed to avoid synchronization of the critical stages of maximum tillering or heading with the usual flood period in the tract.]

During the *mundakan* crop season, water level of 5 cm need not be maintained continuously after the cessation of northeast monsoon. Five centimetre irrigation once in 6 days will be quite adequate for project areas where water is assured.

For summer rice (in situation where the ground water level is shallow, i.e., within 1 m from the surface), 5 cm irrigation two days after disappearance of ponded water is sufficient instead of 5 cm continuous submergence throughout the crop period.

Irrigation schedule for rice under limited water resources

For summer rice under limited resources of water, phasic stress irrigation can be practised to the advantage of saving substantial quantity of irrigation water without any significant reduction in yield. About 20-30% more area can be irrigated with the same water resources by adopting any of the following phasic stress irrigation schedules (Table 7). Depending up on the schedule, water saving ranges from 24-36% of the requirement for 5 cm continuous submergence throughout the crop growth. Grain yield reduction in the above practice is only 0.1% to 1.6%.

Table 4. Categories of irrigation schedule for rice

Schedule	*Stages*		
	Rooting to max.tillering	*Max. tillering toheading*	*Heading to maturity*
Category I	Continuous submergence	Saturation point*	Saturation
Category II	Saturation point*	Continuous submergence	Continuous submergence
Category III	Continuous submergence	Continuous submergence	Hair cracking of surface*
Category IV	Hair cracking of surface*	Continuous submergence	Hair cracking of surface*

*Irrigation at 5 cm to be given at the stages marked.

Weed management

Keep the rice field free from weeds upto 45 days by hand weeding.

1. Generally, weed problems are higher in semi dry rice followed by wet seeded rice and the least in transplanted rice. Problem weeds like Pollakala (*Sacciolepis interrupta*) and jungle rice (*Echinocloa colona*) associated with semi dry rice can be managed by changing the method of sowing. Wherever possible, follow transplanting or wet seeding.
2. Rotation with upland crops can reduce the problems of weeds commonly associated with wet seeded rice.
3. Maintaining 5 cm standing water in the field will reduce the weed problems considerably.
4. Intercropping of cowpea in the semi dry rice during *kharif* season is effective in reducing weed problems. With the onset of southwest monsoon, the field will get standing water and then cowpea plants will get decomposed. In case the monsoon is delayed, cowpea seedlings should be manually uprooted to prevent them from smothering rice plants.
5. Closer planting or higher seed rate will increase the population per unit area. Transplanting rice seedlings at two seedlings per hill with 10 cm x 10 cm spacing or sowing at seed rate of 100 kg / ha are effective to reduce the weed problems.
6. In wet seeded rice, green manure crops like Daincha can be sown in alternate rows with rice, using a seed drum. At one month stage, the green manure crop should be incorporated using a conoweeder.
7. Conoweeder can be used for uprooting and incorporating weeds in rice planted or sown with seed drum. The conoweeder should be operated in both directions for better weed control.
8. Follow stale seed bed technique as detailed below:

Stale seed bed technique for dry seeded rice

Start the land preparation before the start of premonsoon showers. Plough the field thoroughly so as to get a fine seed bed. Weeds are allowed to emerge following pre monsoon showers. After one week period, germinated weeds are destroyed by shallow cultivation (hoeing). Rice is then seeded into the weed free field without any further soil disturbance. This method is effective in reducing the weed population during the early stages of the crop.

Stale seed bed technique for wet seeded rice

Ploughing and levelling of field is done after dewatering the field and kept as such for a minimum period of one week. The weed seeds, especially those of *Echnochloa* spp. will germinate by this period. The germinated seedlings are destroyed by flooding the field for 5-7 days. Sprouted seeds are then sown after dewatering the field. In wet seeded fields, stale seed bed technique can be done even without initial ploughing and levelling. First dewater the field and keep drained for one week period. Germinated weed seedlings can be destroyed by reflooding the field for 1-2 weeks. This practice in combination with stale seedbed can keep the field weed free up to 30DAS. This method has been found effective to control *Echinochloa* spp and wild rice.

Plant protection

Pests

Stem borer (*Scirpophaga incertulas*)

The female moth has yellowish forewings with a single dark spot on the centre of forewings while the male has numerous small brown spots. The female moth lays eggs on the leaves in grooves and covers with tuft of hairs . The larva is pale yellow in colour and damage results from larval feeding within the stem.

Symptoms: At vegetative stage the central shoot dies off turning yellow in colour, which is called "dead heart". When the plants are attacked at the panicle formation stage, the grains become chaffy forming 'white ear'. Both dead heart and white ear will come out easily when pulled up and the feeding injuries can be seen at the base

Dead heart

White ear

Brown plant hopper (*Nilaparvata lugens*)

The first instar nymphs are white in colour. Later turn ochraceous brown in colour. Adults are also ochraceous brown coloured.

Symptoms: Nymphs and adults suck sap from the basal portion of the plants. In severe cases plants dry up in circular patches causing "hopper burn" symptoms.

Brown plant hopper

Leaf folder (*Cnaphalocrocis medinalis*)

The moth is orange yellow with many brown wavy lines and bands on the wing. The newly hatched larva is greenish white in colour; the full grown larva is light greenish in colour.

Symptoms: The larvae fold the leaves or roll them longitudinally or web 2-3 leaves together and remain inside and scrape the green matter resulting in white patches on the leaves.

Case worm (*Nymphula depunctalis*)

The ault is small white coloured delicate moth which has pale brown spots and patches. Caterpillars are pale green with orange head.

Symptoms: The larvae cut the leaf tips and form tubes.The larvae scrape the leaves remaining inside the tubular leaf cases causing white patches. Such leaf cases can be seen hanging on the under side of the leaves or

Case worm

floating in water. Since the larva is semi aquatic it requires water for respiration through abdominal gills. The larvae fill the leaf cases with water from the field and move up to the plants for feeding, when the oxygen exhausts they again fall to the field and fill the cases with fresh water. This at times become a severe menace in early transplanted stage and under conditions of water logging. Severely affected field have a whitish appearance.

Gall midge (*Orseolia oryzae*)

Adult fly is a small mosquito like insect with long legs. The female lay eggs in between the leaf sheath. The emerging maggots move downwards and feed on growing points leading to gall formation.

Symptom: In the place of normal central leaves a tubular gall commonly called "Silver shoot" will be formed.

Ear head bug (*Leptocorisa acuta*)

The bugs are slender with long antennae and legs. Nymphs are green to brown and adults are yellowish brown in colour. The bugs breed all the year round on grasses and other plants.

Symptoms: Rice fields severely attacked by this pest emit a characteristic foul odour. Hence the bug is known by the name "gundhi bug". The nymphs and adults suck the sap from developing grains in the milky stage resulting in partially filled grains or chaffy grains. Brown or black spots appear around the point of injury of the bugs.

Blue beetle (*Leptispa pigmaea*)

Blue beetle

Small elongated bluish coloured beetle. The damage due to this pest is severe in northern parts of Kerala.

Symptoms: White parallel streaks or patches along the axes of the leaves. Both the adults and grubs feed on leaves.

Thrips (*Stenchaetothrips biformis*)

Thrips are minute insects usually 1-2 mm long, black coloured.

Symptoms: The insects slash the leaf tissue and feed on sap. The tips of leaves get rolled and leaves become needle like. Later the leaves turn yellow and dry up starting from the tip.

Hispa *(Dicladispa armigera)*

Beetles are blue black in colour with spines.

Symptoms: Both the adults and grubs cause damage. The adults feed on the green portion of the leaf leaving only epidermal membranes. The grubs mine into the leaf producing long irregular white blotches. Early stages of the crop are more susceptible to the attack of this pest.

Whorl maggot (*Hydrellia philippina*)

The adult fly is very small (2mm long) and lay eggs on young leaf surface.

Symptoms: The larvae move to the center of the plant and feed on inner margins of the developing leaves. As the leaves expand, yellow damaged area become visible. Damage occurs from seedling to maximum tillering stage. Yellowish white marginal blotching with few holes on emerging leaves. Shrivelling of leaves, stunting of plants and delayed maturity are other symptoms.

Green leaf hoppers (*Nephotettix* spp.)

The adults are 3-5 mm long, bright green with variable black markings. Symptoms : Both the nymphs and adults suck sap from the leaves resulting in yellowing of the leaves. They acts as vector of Rice Tungro Virus.

Management of pests

Varietal resistance/ tolerance

Cultivation of tolerant varieties is one of the easy, eco-friendly and economical methods of pest management. Many rice varieties are having multiple resistance/ tolerance to pests. While selecting the varieties for organic farming, emphasis should be given to multiple resistance / tolerance to major pests of that locality. Use of a variety with some degree of genetic resistance, combined with other non chemical methods can manage the pests effectively.

Rice varieties with multiple tolerance to major pests

Aruna, Aathira, Aiswarya, Nila, Revathy, Remanika, Karishma, Krishnanjana.	-	BPH and gall fly
Nila (PTB 48)	-	Thrips, PH , gall midge, stem borer
Kanakom, Karthika	-	BPH , stem borer and gallfly
Makom, Reshmi	-	BPH, stem borer, gall fly and leaf
Aruna	-	BPH, stem borer, gall midge
Jayathi	-	BPH, GLH and leaf roller
Bhagya	-	BPH, WBPH
Kanchana	-	Stem borer, gall midge
Sagara, Deepthi	-	Stem borer, leaf roller
Varna (VK1)	-	leaf folder, whorl maggot and stem borer
Lakshmi	-	BPH, Stem borer and leaf roller
Dhanya	-	Stem borer, gall midge
Kairali	-	Leaf roller and gall fly

Cultural control

Cultural methods that suppress insect pest population have several advantages. Neither do they require costly inputs nor do they pose threat to non-target organisms and also have profound influence on insect pest survival, persistence in a particular environment and crop damage. Pest incidence can be minimized by adjusting and modifying the cultivation practices. Some of the cultural practices that can be adopted by the farmers are:

i) Field sanitation by incorporation of stubbles immediately after harvest will help to destroy over wintering population of insect pests like stem borer and gall midge. Deep ploughing after harvest is recommended.

ii) Optimum seed rate and spacing: High seed rate and closer planting cause thick population which favours the pests like leaf folder, BPH etc.

iii) Timely sowing or planting is important to avoid pest incidence. Altering the dates of sowing / transplanting preferably not coinciding the favourable climate for pest outbreak. For example late planting in the first crop season favours the incidence of gall midge. Hence late planting should be avoided.

iv) Weed control: Many of the weeds will serve as alternate and collateral hosts of several pests. Destruction of weeds in the field and bunds will help in reducing the population build up of the pests.

v) Water management: Draining the field for two days will help to reduce case worm incidence. Since it is semi aquatic pest, draining is the most effective method for its management. The incidence of thrips can be reduced by flooding the field for 24 hours.

Mechanical control

For controlling case worm, pull kerosinised rope across plants to dislodge cases hanging on the plants into water and then drain off the water.

Removal of egg masses of stem borer from the plant will help to reduce the pest population.

Light traps:

Installation of light traps in the field would attract and kill the moths of leaf folder, stem borer, BPH, gall fly and rice bug.

Pheromone traps*:*

Pheromones have been found effective for the management of yellow stem borer and can be utilised for monitoring as well as for direct control through male annihilation either by mass trapping or by disrupting mating communication.

For monitoring stem borer population, three traps should be installed at an inter trap distance of 60 m in a triangular pattern in one acre field. Male moth catch is recorded at three days interval. Sudden increase in the average catch of the trap coincides with the

emergence of adults. Weekly catch of 30 males per trap can be taken as the capture threshold which precedes borer damage.

Mass trapping of stem borer by installing pheromone traps @ 20 numbers / ha can effectively reduce the stem borer damage. The pheromone trap is retained throughout the crop stage by replacing 3-4 times the 5 mg lure at 20 day intervals. Pheromone traps can be installed in the nursery also.

Biological control

Biological control is the use of bioagents for the control of pests. This strategy has gained considerable attention and appears to be a promising and viable supplement or alternative to chemical control.

Conservation of natural enemies in the rice ecosystem

Organic farming favours conservation of natural enemies in the rice field, which in turn help to keep the pest population low. The common natural enemies found in the rice ecosystems are:

1. Dragon flies and Damsel flies

Adult dragon flies fly in large numbers above the plant canopy and catch the pests on plants. Damsel flies normally fly below the rice canopy in search of flying insects as well as hoppers on plants. Their nymphs are aquatic and can climb on the plants in search of hoppers.

2. Spiders

Spiders are general predators found in the rice ecosystem. Wolf spider, Lynx spider, Jumping spider, Long jawed spider, Dwarf spider and Orb spider are some of the important spiders commonly seen. Both spider links and adults are voracious feeders of all types of pests.

3. Predatory bugs

Mirid bugs: Mirid bugs are egg predators of plant hoppers and leaf hoppers. They can also feed on first instar nymphs.

Water bugs: Water bugs feed on plant hopper nymphs which frequently move through the surface of water. The nymph also feeds on other small soft bodied insects. Both nymphs and adults of water striders feed on rice hoppers, moths and larvae that drop into water surface.

4. Predatory beetlesGround beetle:

Adults and larvae feed on larvae of leaf folder. Adults feed on plant hoppers also. Each predator can consume 3-5 larvae per day.

Rove beetle: Rove beetles are found on rice plants, water, ground surface and active during night searching for leaf hoppers, plant hoppers and larvae of leaf folder and hairy caterpillar.

Lady bird beetles: They feed on small and slow moving insects and exposed eggs. The grubs are more voracious than the adults.

5. Predatory grasshoppers

Predatory grasshoppers can be distinguished from other grasshoppers by its long antennae which are more than twice as long as its body length. They feed on the eggs of rice bug and stem borer as well as on the nymphs of plant hoppers and leaf hoppers.

6. Egg parasitoids

Egg parasitism of stem borer and leaf folders by *Trichogramma, Telenomus* and *Tetrastichus* is very high in nature. The female wasp lays eggs into the host egg and kills the latter by feeding on the host egg contents and they emerge as free living adults.*Gonatocerus* and *Anagrus* are small wasps which parasitize eggs of plant hoppers and leaf hoppers.

7. Larval parasitoids

Cotesia, Stenobracon, Macrocentrus, Xanthopimpla and *Charops* are some of the larval parasites found in the rice fields. Dark coloured wasps lay eggs on the caterpillars feeding on various parts of the plant. The emerging young ones feed on the internal content of the pest caterpillar and gradually kills it.

Inundative release of Parasitoids

The egg parasitoid *Trichogramma* is a widely used biocontrol agent in rice through out the country for the control of stem borer and leaf folder. *Trichogramma japonicum* is effective against stem borer and *Trichogramma chilonis* is effective against leaf folder. 5 cc egg card is sufficient for installation in one hectare. Six releases of these parasitoids at weekly intervals is required for a crop season. For the control of stem borer, the egg cards have to be installed in the field starting from the first week after transplanting and for leaf folder, the installation has to be started from 20 days after transplanting or when the moths of these pests are observed in large numbers in the field.

Use of biopesticides

Microbial pesticides

Bacillus thuringiensis formulations are specific to insect pests and comparatively safe to humans, natural enemies of insect pests and non target organisms. Some of these are effective against leaf folder and moderately effective against stem borer.

Botanical pesticides

Utilisation of botanical formulations especially neem formulations is an ecofriendly method of pest control in rice. Neem formulations act as feeding deterrents, growth retardants, oviposition deterrents and reproductive inhibitors. Application of 2% neem oil or 10 % neem cake extract can control rice thrips.

Pocket application of biopesticides may be adopted in heavily infested areas to control further spread of the pests and to conserve the existing natural enemy population. Careful monitoring of the field is very important to adopt proper pest management practices in a timely manner.

Diseases

The major diseases of rice are blast, sheath blight, brown spot, sheath rot and bacterial blight. "Udbatta" disease is found to occur in high altitude areas like Idukki and Wayanad districts. Other minor diseases are narrow brown leaf spot, leaf scald and false smut.

Fungal diseases

Blast *(Pyricularia oryzae)*

Symptoms: On the leaves spindle shaped (eye shaped) spots often with grey centre and brown margin are formed which coalasce together resulting in drying up of the leaves and collapse of the entire plant under favourable conditions. At the time of flowering the fungus infects neck of the panicle causing dark brown to black lesions (neck blast). If the infection occurs in early stages, all the grains will become chaffy. The neck infection also leads to breaking of the panicle at that region.

Leaf blast

Neck blast

Sheath blight *(Rhizoctonia solani)*

Symptoms: Symptoms first appear on the lower leaf sheath near the water level as greenish grey spots, which enlarge and become greyish white with brown margin. Leaves are also infected in highly susceptible varieties. On the leaves irregular spots with greenish white centre and brown margin develop. Under humid conditions white mycelial growth as well as brown sclerotia (initially white) of the fungus, which are easily detached, can be seen on the affected portion. These sclerotia are the resting structures of the fungus, which are able to survive in the soil for long period.

Sheath blight

Brown spot *(Helminthosporium oryzae)*

Symptoms: On the leaves, circular or oval dark brown spots are formed. In highly susceptible varieties, spots are larger in size and are having light brown or grey centre with dark reddish brown margin. The symptoms also appear on grains where black spots appear on glumes. The kernels of infected spikelets become shrivelled and discoloured.

Sheath rot *(Sarocladium oryzae)*

Symptoms: Oblong or irregular lesions with brown margins and grey centre or grayish brown appears throughout the leaf sheath, especially on the sheath covering the panicles. The panicles remain within the sheath or only partially emerge with whitish powdery fungal growth inside the rotten sheath. The grains become chaffy.

Sheath rot

False smut

False smut / Lakshmi disease
(*Ustilaginoidea virens)*

Symptoms: The symptoms become visible only after flowering when infected grains get transformed to yellow to orange spore balls, which later turns to dark green or black.

Bacterial blight (*Xanthomonas oryzae* - p.v. *oryzae*)

Bacterial blight

Symptoms: Bacterial blight is characterized by two phases of infection. Kresek and bacterial leaf blight. It is characterized by drying or wilting of the whole plant. The infected leaves become greyish green and begin to roll along the midrib and dry. Infected plant later bear a few small panicles at later stages. Under severe infection, plants are killed rapidly. In leaf blight, lesions appear on leaves as water soaked stripes, starting from the edges near the tip and spread downwards along the margins. The young lesion is pale green to grey green. It turns white to yellow after a day or two. Lesions may cover the entire leaf blade. The edges of the lesions are irregular or wavy.

Ooze test : Ooze test will help to distinguish the bacterial blight from other diseases. Cut the infected leaves and dip it in a glass of water and hold it against the light for few minutes without shaking. From the cut ends white milky bacterial ooze will come out as streams. This test confirms bacterial infection.

Disease management

Varietal resistance

Select varieties with built in resistance to major diseases.

Blast: Rohini, Bharati, Mattatriveni, Jayathi, Neeraja, Kairali, Kanchana, Nila, Aathira, Aiswarya, Harsha, Kanakom, Renjini, Remanika, Lakshmi, Onam, Dhanya, Sagara, Deepthi, Ahalya.

Sheath blight : Reshmi, Mattatriveni, Nila, Kairali, Karthika, Aathira, Aiswarya, Pavizham, Karthika, Aruna, Makom, Remya, Kanakom, Gouri, Lakshmi ,Bhagya, Onam, Dhanya and Sagara .

Cultural practices

- Deep summer ploughing of the fields.
- Use properly dried, disease free seeds.
- Follow optimum time for sowing / planting.
- Apply rice hull ash @ 100 g / m^2 which will help to reduce the incidence of blast in the nursery.

- Destroy /remove disease harbouring weeds from the field.
- Give optimum spacing.
- Follow proper water management. Water logging favours diseases like sheath blight. Draining the field for one or two days will help to reduce the spread of the disease.
- Avoid clipping of leaf tips at the time of transplanting in bacterial blight endemic areas.

Note: Incorporation of green manures like *Pteorocarpus marsupium* (Ungu), *Eupatorium odoratum* and *Mangifera indica* (Mango) @ 5t / ha or application of leaves of plants such as *Lawsonia inermis, Calotropis, Azadiracta indica, Datura stramonium* and *Glyricidia* @ 2.5 t / ha will also reduce incidence of sheath blight.

Bio-control agents

Application of *Pseudomonas fluorescens* P1 in different ways viz., seed treatment, seedling root dip, soil application or foliar spray will effectively control fungal diseases and bacterial diseases..

Seed treatment: Treat the seeds with talc based formulation @ 10 g per kg of seed. If wet sowing in practised, treated seeds are soaked in water for 12 hours. Drain the excess water and keep for sprouting.

Seedling root dip: Dip the roots of the seedlings before transplanting in solution of *P. fluorescens* (20 g / litre) for 30 minutes. Seedling root dip can be easily done in the field itself. Water is to be impounded in the field by taking pits or making bunds and mix the talc based formulation in water. The pulled out seedlings are to be kept in such a way so as to immerse the roots in *P.fluorescens* mixed water. After half an hour seedlings are planted in the main field. For dipping the seedlings for one ha, 2.5 kg talc based formulation is required

Soil application: Apply talc based formulation of *P. fluorescens* @ 2.5kg per ha one week after transplanting or 30-40 days after sowing for the direct sown crop. Mix 2.5kg of *P. fluorescens* with 50 kg dried cow dung or sand and broadcast in the field. Dewater the field before the application of the culture.

Foliar spray: *P. fluorescens* can be sprayed on the foliage @ 20 g / litre of water. Spraying can be repeated depending on the disease severity. The application of *P. fluorescens* for a minimum of three times like seed treatment, seedling root dip and one foliar spray or seed treatment, soil application and foliar spray will be very effective in providing protection to rice crop from disease incidence.

PGPR mix II: Root dip and foliar application of PGPR mix II give effective protection against fungal and bacterial diseases.

Foliar spray of cow dung slurry is also effective for the management of bacterial blight of rice. Fresh cow dung @ 20 g / litre is mixed in water and the supernatant is used for spraying. The bacteriophages present in the cow dung act against the pathogenic bacteria present on the plant. 500 litres of cowdung liquid is needed for one hectare.

VEGETABLES

AMARANTH *(Amaranthus spp.)*

Amaranth is the most popular leafy vegetable of Kerala. Though it can be grown throughout the year, summer is found to be the best season.

Varieties

Red	:	Kannara local, Arun, Krishna Sree
Green	:	Co-1, Co-2, Co-3 and Mohini
Mixed type	:	RenuSree
Note	:	Kannara local is a season bound variety, which comes to flowering in November-December.
Seed rate	:	1.5 to 2 kg/hectare

Method of planting:

Direct sowing and transplanting

Nursery

Solarization of the nursery bed before sowing and seed treatment with *Pseudomonas* (10 g/kg seed) can control nursery diseases. Apply FYM 10 kg enriched with Trichoderma, Neemcake 50 g, PGPR mix 1- 100 g and AMF 200 g/m^2.

Main field

Prepare the land by ploughing or digging followed by levelling. Shallow trenches of width 30-35cm are made at 30 cm apart. Transplant 20-30 days old seedlings in the shallow trenches at a distance of 20 cm in two rows. During rainy season, planting shall be done on raised beds.

Before planting, dip the roots of the seedlings in a solution containing *Pseudomonas* 20 g/litre for 20 minutes.

Manuring

Apply FYM or compost @25t/ha as basal dose. *Trichoderma*, PGPR mix 1 @2.5 kg /ha each are mixed with FYM and kept for 10-15 days at cool atmosphere. These are applied to the soil as basal dose. Top dressing can be done with any of the following manures at 7-10 days interval.

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg ha)
2. Application of biogas slurry @ 1 kg/10 litres (50 kg/ha)

3. Application of cow's urine 500 litres/ha (8 times dilution)
4. Application of vermiwash-500 litres/ha (8 times dilution)
5. Application of vermicompost - 1 t /ha
6. Application of groundnut cake-1 kg/10 litres (50 kg/ha)

Foliar spray can be given with cowdung slurry/ vermiwash/ cow's urine after each harvest.

After care

Give presowing irrigation, if the soil is not moist enough. Provide mulch in the field throughout the crop period with materials like green leaves, plant residues, decomposed coirpith, straw etc. During summer, irrigate at intervals of 2 to 3 days. Conduct weeding regularly and earth up rows during rainy season.

Plant protection

Pests

Leaf webber and leaf roller can be controlled mechanically by collecting and destroying them. Dipel or Halt (0.7 ml/litre) can be sprayed for controlling leaf webber. Apply 4% leaf extract of neem, thevetia or clerodendron with soap water.

Diseases

Leaf spot is a serious disease in rainy season and it can be controlled to a certain extent through an integrated approach.

1. Grow leafspot resistant varieties like Co-1
2. Seed treatment with *Pseudomonas* 8 g/kg of seed.
3. Soil application of *Trichoderma* as enriched cowdung- neem cake manure.
4. One kg of fresh cowdung is put in 10 litres of water and the clear solution after filtering the supernatant liquid is sprayed at regular intervals.
5. Soil application of green manures like sunnhemp/glyricidia + neemcake (100kg/ha) + *Trichoderma* (1-2 kg/ha) is found to be effective against leafspot disease.

OKRA (*Abelmoschus esculentus*)

The three main planting seasons for okra are January-February, May-June and September-October.

Varieties

Green/light green fruited: Pusa Sawani, Kiran, Salkeerthi, Susthira, Arka Anamika Red fruited: Co-1, Aruna Yellow vein mosaic resistant /tolerant varieties : Arka Anamika, Arka Abhay, Susthira, P7, Varsha Uphar (all green fruited)

Seed rate

The seed rate is 8.5kg/ha for the summer crop sown in January -February and 7 kg/ha for *kharif* crop.

Storage of seeds

Packaging of okra seeds in polythene cover (700 gauges) increases the storage life upto 7 months. Seeds treated with *Trichoderma* and *Pseudomonas* can be stored upto 5 months.

Sowing

Sow the seeds at a spacing of 60 cm between rows and 45 cm between plants for *kharif* crop and 60cm X 30cm for summer crop. 45cm x 45cm spacing is also found ideal.

Seed soaking in double the volume of water (Hydro priming) for 2 hours improved germination and vigour of the seeds. For the summer crop, soaking time can be prolonged for 16 hours before sowing. Seed treatment with *Pseudomonas* (8g/kg of seed) improve germination and vigour of seedling. Ensure sufficient moisture in the field right from the time of sowing of seeds.

Manuring

Apply lime @500 kg/ha based on the acidity of soil 15 days before sowing. Apply FYM or compost @25t/ha as basal dose. *Trichoderma*, PGPR mix 1 @ 2.5 kg /ha each are mixed with the FYM and keep for 15 days at cool atmosphere. These are applied to the soil as basal along with *Pseudomonas* @ 2 kg/ha.

Top dressing

Top dressing can be done at 10-15 days interval with any one of the following

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg/ha)
2. Application of biogas slurry @ 1 kg/10litres (50 kg/ha)
3. Application of cow's urine 500 litres/ha (8 times dilution)
4. Application of vermiwash-500 litres/ha (8 times dilution)
5. Application of vermicompost - 1 t /ha
6. Application of groundnut cake1 kg/10 litres (50 kg/ha)

Foliar spray can be given with supernatant solution of cowdung slurry/ vermiwash/ cow's urine upto flowering.

After care

Give pre-sowing irrigation, if the soil is not moist enough. Provide mulch in the field throughout the crop period with materials like green leaves, plant residues, decomposed coirpith, straw etc. During summer, irrigate the crop at intervals of 2 to 3 days. Conduct weeding regularly and earth up rows during rainy season.

Plant protection

Pests

The important pests are jassids, fruit and shoot borer and root knot nematode.

Jassids

Use neemoil-garlic mixture (2%) / nimbicidine(2ml/litre) / econeem(2ml/litre) / uneem(2ml/litre).

Lemongrass suspension (10%) can also be used for the control.

Fruit and shoot borer

1. Remove and destroy affected shoots and fruits
2. Spray with neem kernel suspension (5%)/ ginger suspension (10%)/ neem leaf extract (4%)
3. Use *Trichogramma chilonis* and *Trichogramma japonicum* @1 card each/5 cents followed by *Bacillus thuringiensis* spray (Delphin/Bioasp/Halt-0.7ml/litre)
4. Apply *Beauveria bassiana* 10% WP

Bhindi leaf roller

1. Collect and destroy the leaf rolls
2. Apply *Beauveria bassiana* 10% WP

Root knot nematode

1. Apply neem leaves or *Eupatorium* leaves @ 250 g/plant in basins one week prior to planting and water daily. The effect of this treatment persists upto 75 days after sowing in summer season.
2. Apply neem cake/castor cake @ 1 t/ha or growing of marigold (trapcrop) in between okra plants.
3. Seed treatment with *Bacillus macerans* @ 3% w/w (2.5 kg/ha) and in heavily infested area, seed treatment with *B. macerans* @ 3% w/w and drenching *with B. macerans* @ 3% solution 30 days after sowing.

Diseases

Yellow vein mosaic

Vein clearing and vein chlorosis of leaves are the characteristic symptoms. The yellow network of vein is very conspicuous and veins and veinlets are thickened. Fruit become small and yellowish green in colour. Whitefly (*Bemisia tabaci*) and leaf hopper (*Amrasca biguttula*) are the vectors of this virus. Spraying neemoil-garlic mixture (2%)or nimbicidine/ econeem/ uneem (2ml/litre). Use of disease resistant varieties (Arka Anamika, Arka Abhay and Susthira) and destruction of host weeds (*Croton sparsiflora* and *Ageratum sp*.) are also effective.

CUCURBITACIOUS VEGETABLES

Bittergourd, snakegourd, pumpkin, ashgourd, cucumber, watermelon, bottlegourd, littlegourd and ridgegourd are the important cucurbitacious vegetables cultivated in Kerala. The details of varieties, season, seed rate and spacing of these crops are given in the following table.

Table 5.Varieties, season, seed rate and spacing of different cucurbitacious egetables

Crop	*Varieties*	*Season*	*Seed rate (kg /ha)*	*Spacing*
1	2	3	4	5
Bittergourd (*Momordica charantia*)	Priya, Preethi, Priyanka	Rainfed-May-August Irrigated-January- March & September-December	5-6	2m x 2m
Snakegourd (*Trichosanthes cucumerina*)	Kaumudi, Manusree, Baby,TA – 19	Irrigated-January-March & September-December	3-4	2 m x 2 m
Cucumber (*Cucumis sativus*)	Seethal, Swarna Purna, Poinsette, Pusa Sanyog, Poona	Irrigated-January-March & September-December	0.5-0.75	2m x 1.5m
Oriental pickling melon (*Cucumis melo var.conomon*)& Culinary melon (*Cucumis melo var.acidulus*)	Khira- salad purpose. Mudicode, Arunima, Saubhagya Oriental - pickling melon.			
Water melon (*Citrullus lanatus)*	Sugar Baby, Arka Jyothi, Arka Manik	December-April	1-1.5	3m x 2m
Bottlegourd *(Lagenaria siceraria)*	Pusa Summer Prolific Long, Pusa Summer Prolific Round and Arka Bahar	Rainfed-May-August Irrigated-January- March & September-December	3-4	3m x 3m
Pumpkin *(Cucurbita moschata)*	Ambili, Suvarna, Saras	Rainfed-May-August Irrigated-January-March & September-December	1-1.5	4.5m x 2m

1	2	3	4	5
Ashgourd *(Benincasa hispida)*	KAU Local, Indu	Rainfed-May-August Irrigated-January-March& September-December	0.75-1	4.5m x 2m
Littlegourd *(Coccinia grandis)*	Sulabha, Padappai	Planting time-May-June & September-October	Stem cuttings with 3-4 nodes from female plants @ 2-3 cuttings/pit	4m x 3m
Ridgegourd (*Luffa acutangula)*	Haritham, Deepthi, Pusa Nasdhar	December-March & May-August	2.5-3	2m x 2m

Sowing/planting

Pits of 60 cm diameter and 30-45 cm depth are taken. Well rotten FYM or other organic manure (12 t/ha) is mixed with topsoil in the pit and seeds are sown at the rate of 4-5 per pit. For Littlegourd plant stem cuttings with 3-4 nodes from female plants @ 2-3 cuttings/pit. Unhealthy plants are removed after two weeks and only 3 plants are retained per pit.

Manuring

Table 6. Additional Manurial requirement (apply any one of the following manure depending upon the availability)

Nutrient source	Quantity
FYM / Cow dung/	8 t/haa
Compost/	8 t/ha
Vermicompost/	4 t/ha
Greenleaf	8 t/h

Manures are applied in 2 splits at winding and flowering stage. Apply fresh cow dung slurry @ 1 kg/litre of water at fortnightly intervals starting from flowering.

For Littlegourd, apply FYM @12.5kg/pit at the time of preparation of pits. Apply another dose of FYM@12.5kg/pit when the plants start vining.

Irrigation

During the initial stages of growth, irrigate at 2-3 days interval and on alternate days during flowering or fruiting. Irrigation at 15 mm CPE (approximately at 3 days interval for sandy loam soils) is more economical than irrigating once in two days especially during summer months for water economy.

Aftercultivation

For bittergourd, snakegourd, littlegourd and ridgegourd, erect pandals when the plants start vining. For cucumber, watermelon, bottlegourd, pumpkin and ashgourd, spread dried twigs on the ground for trailing. Conduct weeding and raking of the soil along with application of manures. Earthing up is to be done during rainy season. Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed coir pith, coconut husk, straw etc.

Plant protection

Pests

Fruit fly *(Bactrocera cucurbitae*)

1. Cover the fruits.
2. Remove and destroy infested fruits.
3. Apply neem cake 250 kg / ha (100g / pit) at planting and one month later.
4. Use any of the following fruit fly traps

i) Fish meal trap – Place 5 g dry fish in coconut shell, moisten and add 0.5 g Furadan. Put coconut shell inside a polythene cover. Make holes on the cover above shell and hang the cover from 'pandal' (trellis).

ii) Fruit fly trap can also be made by taking 20 g banana pulp in a coconut shell and beer 3 ml and palm oil 3 drops.

iii) Trap adult fruit flies using cue lure plywood blocks containing 6:4:1 mixture of ethyl alcohol : cue lure : Malathion. Re set traps at four months interval. Hang plywood blocks with pheromone @10nos./ha

iv) Trap adult fruit flies using food baits. Make a pulp of 20 g banana,10 g jaggery and 5 g furadan in 100 ml water (jaggery heated to 80 degree Celsius) at 2.5m spacing. Change traps after 3 weeks. Red banana, Robusta, Njalipoovan and Palayankodan fruits can be used.

v) Set yellow painted coconut shell traps containing carbofuran smeared banana pieces (Palayankodan) at 2 m spacing at the start of flowering till final harvest. The traps are to be replenished once in seven days.

5 Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5% WP

6. Spraying of leaf extract of *Ailanthus* 10 % and cashew 10% in combination is effective against fruit fly in bitter gourd.

Aphids, Green Jassid, White fly and Mite

1. Spray 2% neem oil + garlic emulsion spray.
2. Dissolve 60g soap in 150 ml warm water, add soap solution to neem oil and castor oil slowly and mix well. Dilute with 6 litres of water. Add 120 g garlic paste. Take the extract and spray.
3. Apply 1.5% fish oil soap.
4. For preventing mite, plant hoppers and jassids, apply 10% magnesium sulphate on leaves, which will provide strength for plants.

Leaf and flower feeder (*Diaphania* sp.)

Collect and destroy larvae.

Spray, solution containing 1 litre cow's urine + 10 g bird chilli + 9 litres water.

Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5% WP

Spraying of 10% leaf extract of *Ailanthus* and cashew is effective against fruit fly in bittergourd.

American Serpentine leaf miner

Spray neem seed kernel emulsion (4%) before 8'O clock in the morning

Epilachna beetle

1. Remove and destroy egg masses, grubs and adults occurring on leaves.
2. Use predator (*Chrysocaries johnsoni*) of larvae and pupae.
3. Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5% WP
4. Spray leaf extract of ailanthus and cashew (10%).
5. Neem oil + garlic emulsion spray (2%).

Diseases

Mosaic

Uprooting and destruction of affected plants and collateral hosts should be done.

Spraying neem based insecticide (2%) to control the vector

SOLANACEOUS VEGETABLES

Chilli, brinjal and tomato are the important solanaceous fruit vegetables grown in the state. The details of seed rate, time of planting, varieties and spacing are given below.

Table 7.Seed rate, time of planting, varieties and spacing of different solanacious vegetables

Crop	*Seed rate*	*Time of planting*	*Varieties*	*Spacing*
Chilli (*Capsicum annuum*)	1.0 kg/ha	May-June (before south-west monsoon)/ Sept.-October (for an irrigated crop). Can be grown throughout the year.	Jwalasakhi	45cm x 45 cm / 75cm x 45-60cm
			Jwalamukhi	45cm x 45 cm
			Jwala	45cm x 45 cm
			Pant C-1	45cm x 45 cm
			K-2	45cm x 45 cm
			Ujwala	45cm x 45 cm
			Anugraha	45cm x 45 cm
Brinjal (*Solanum melongena)*	370-500 g/ha	May-June (before south-west monsoon)/ Sept.-October (for an irrigated crop). Can be grown throughout the year.	Surya	60cm x 60 cm.
			Swetha	60cm x 60 cm
			Haritha	75-90cm x 60 cm
			Neelima	75-90cm x 60 cm
			Pusa Purple	60cm x 60 cm
			Cluster	
Tomato *(Lycopersicon esculentum*)	400 g/ha	October-November (for an irrigated crop)	Sakthi	60cm x 60 cm
			Mukthi	60cm x 60 cm
			Anagha	60cm x 60 cm

Nursery

Solanaceous vegetables are transplanted crops. Seeds are sown in the nursery and one month old seedlings are transplanted to the main field. An area of $2^{1}/_{2}$ cents (0.01 ha) is required for raising seedlings for one hectare. For sowing the seeds, raised seed beds of 90 to 100 cm width and convenient length are prepared in open space with fertile topsoil to which well decomposed organic matter has been incorporated. Care should be taken to prevent incidence of damping off in the nursery. For this add one kilogram of *Trichoderma* to 100kg of dried farmyard manure and 10 kg of neem cake spread under shade to which water is sprinkled for maintaining moisture. Keep the mixture for fifteen days with intermittent turning. To the nursery soil, add 1 kg of PGPR mix 1 at the time of bed preparation. After

sowing the seeds, mulch with green leaves and irrigate with a rose can daily in the morning. At the time of irrigation, add *Pseudomonas fluorescens* @ 20g/litre at frequent intervals. Remove the mulch immediately after germination of the seeds. Addition of diluted (25g/ litre) cow dung slurry or cow urine (diluted 8 times) increases the vigour of the seedlings. Restrict irrigation one week before transplanting and irrigate heavily on the previous day of transplanting.

Land preparation and transplanting

Land is prepared to a fine tilth by thorough ploughing or digging. Well rotten organic manure is incorporated in the soil and seedlings are transplanted in shallow trenches or on ridges/ levelled lands according to season. Transplanted seedlings may be given temporary shade for 3-4 days during hot days.

Manuring

Apply lime @ 500 kg/ha based on the acidity of soil 15 days before transplanting. Apply FYM or compost @ 25t/ha as basal dose to which *Trichoderma* and PGPR mix 1 each @ 2.5 kg /ha are mixed and kept for 15 days in shade. Apply *Pseudomonas* and AMF at the time of transplanting. Instead of FYM, poultry or powdered goat manure @ 1 t/ha can be applied. Dip the roots in 2% Pseudomonas or PGPR mix 1 before transplanting to the field.

Top dressing

Top dressing can be done at 7-10 days interval with any one of the following

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg/ha)
2. Soil application of biogas slurry @ 1 kg/10 litres (50 kg/ha)
3. Soil application of cow's urine 500 litres/ha (8 times dilution)
4. Soil application of vermiwash-500 litres/ha (8 times dilution)
5. Soil application of vermicompost / poultry / powdered goat manure-1 t /ha
6. Soil application of groundnut cake1 kg/10 litres (50 kg/ha)

Foliar spray can be given with cowdung slurry/ vermiwash/ cow's urine.

After cultivation

Give pre-transplanting irrigation, if the soil is not moist enough. Irrigate at two or three days interval during summer. Stake the plants if necessary. Weeding followed by organic manure application and earthing up may be done at one and two months after transplanting. Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed coir pith, coconut husk, straw, etc.

Plant Protection

Table 8.Pests and their control

Crop	*Pest*	*Control measures*
Chilli	Aphids	Spray tobacco decoction or neem oil -garlic emulsion (2%) or *Nattapoochedi* (*Hyptis suaveolens*) emulsion (10%). Spray *Verticillium lecanae* or *Fusarium pallidoroseum* (10^{10}conidia/litre). Release green lacewing bugs @ 50,000 eggs/ha.
	Jassids	Spray neem oil-garlic emulsion (2%) or lemon grass/ginger extract (10%)
	Thrips	Spray Kiriyath (*Andrographis paniculata*) extract(10%),
	Mite	Apply neem oil 5% or neem oil + garlic emulsion 2%.Spray diluted rice water once in 10 days against mite.
Chilli & tomato	White fly	Spray *Verticillium lecanae* (10^{10}conidia/ litre) or garlic emulsion (2%). Place Sticky yellow traps.
Brinjal fruit borer	Shoot and	Protect the seedling in the nursery with net. Mechanical hand picking and destruction of the affected part along with the larvae. Place pheromone traps @ 100nos./ha. Spray neem-garlic emulsion (2%). Spray Bt available as Dipel, Delphin, Halt, Bioasp, Biolep (0.7ml/litre). Use S-NPV (250 LE/ha). Spray leaf extract of ailanthus and cashew (10%).
	Red spider mite	Spray water using sprayer. Spray rice gruel water on under surface of leaves. Spray castor oil-soap emulsion or neem oil- garlic emulsion (2%).
	Hopper	Spray neem-garlic emulsion (2%)or products like Nimbicidin/ Econeem/Uneem (2ml/litre). Spraying of lemongrass/ ginger extract (10%) is also effective.
	Epilachna beetle	Spray soap-garlic-castor oil emulsion (2%). Collect and kill all stages of the pests. Spray Clerodendron plant extract 4-8% or Custard apple seed extract 2-5%
Tomato	Fruit borer	Spray Neem seed kernel extract 5%.Use H-NPV (250 LE/ha). Spray Bt. Spray Pongamia oil (2%). Apply Pongamia or neem cake 250 kg/ hectare at planting and repeat 2 or 3 times at 30 to 45 days interval
	Serpentine leaf miner	Spray Neemoil-garlic emulsion (2%) before 8'O clock in the morning. Apply neem cake to soil (250kg/ha). Spray neem oil, marotti oil or illupai oil 2.5% or spray neem seed kernel extract 4%.

Crop	*Pest*	*Control measures*
Chilli, brinjal & tomato	Nematode	Apply Eupatorium and neem leaves, neem cake, rice husk, wood shavings, castor cake @ of 100g/m^2. Apply VAM, Plant Growth Promoting Rhizobacteria, Paceilomyces to soil @ 2kg/ha. Seed treatment with *Bacillus macerans* @ 3% w/w (2.5 kg/ha) and drenching *with B.macerans* @ 3% solution 30 days after sowing.

Table 9.Diseases and their control

Crop	*Disease*	*Control measures*
Chilli, & tomato	Damping off	Sow the seeds in raised beds prepared in brinjal open area during summer months. Pre inoculation of AMF in furrows @ 200g/m^2. Apply lime in nursery bed. Use *Trichoderma*, *Pseudomonas fluorescens* and PGPR mix II. Neem cake can be applied @ 250 kg/hectare to reduce soil innoculant.
	Leaf spot	Spray *Pseudomonas fluorescens* (2%) Spray Bordeaux mixture (1%).
	Bacterial	Cultivate resistant varieties (KAU). Use lime in the field. Cultivate wilt marigold in field prior to tomato cultivation. Soil application of *Pseudomonas fluorescens* or PGPR mix II@ 20g/litre at 15 days interval. Seedling root dip and foliar spray of *Pseudomonas fluorescens* 1-2%.
Chilli	Leaf curl virus	Spray neem based insecticides (2ml/litre) to control the vectors. Grow resistant varieties like Punjab Lal & Pusa Sadabahar.
Tomato		Spray neem based insecticides (2ml/litre) to control the vectors. Grow 5-6 rows of maize around the crop atleast 50 days before transplanting tomato. Keep the plot weed free.

Storage of seeds

Packaging of seeds in polythene cover (700 gauges) increases the storage life upto 7 months. Seeds treated with *Trichoderma* and *Pseudomonas* (each @ 6g/kg seed) can be stored upto 5 months.

LEGUMINOUS VEGETABLES

VEGETABLE COWPEA

Vegetable cowpea includes bush type (*Vigna unguiculata* subsp.*unguiculata***)** and yard long bean (*Vigna unguiculata* subsp.*sesquipedalis***)**

Cowpea can be grown throughout the year under Kerala conditions. It can be grown as a pure crop in single-crop and double-crop rice fallows during *rabi* and summer seasons. Cowpea can be grown in homestead garden throughout the year and in kole lands of Trichur district during summer where rice crop cannot be raised due to water scarcity.

Season

Cowpea can be grown in any season. As a rainfed crop, sowing is done in the month of June. The most suitable time is after the first week of June. During the second crop season, sowing can be done during September-October. During summer, cowpea can be sown during January- February.

Varieties

a. Bush type: Bhagyalekshmy, Pusa Barsathi, Pusa Komal

b. Semi trailing: Kairali, Anaswara, Varun, Kanakamony, Arka Garima

c. Yard long bean: Sharika, Malika, Vaijayanthi, Lola, Vellayani Jyothika

Sowing / Spacing

Plough the land thoroughly 2-3 times and remove weeds and stubbles. For bush vegetable type, spacing of 30 cm between rows and 15 cm between plants is suitable. For semi-trailing varieties, provide a spacing of 45cm x 30 cm. Trailing varieties can be sown in pits (@ 3plants / pit) at 2m x 2 m spacing for trailing on pandal or in channels at 1.5m x 45 cm spacing for trailing on trellis.

Seed inoculation and seed pelleting

Cowpea seeds should be inoculated with Rhizobium and pelleted with lime.

Procedure for Rhizobium inoculation

The content of each packet of Rhizobium inoculum is sufficient for seeds to be sown in the area indicated in the packet (250 to 375 g/ ha). Use the inoculant only for the specific leguminous crop mentioned on packet before the expiry date. Do not expose the Rhizobium culture to direct sunlight or heat. Mix the inoculant uniformly with the seeds by using minimum quantity of either 2.5% starch solution or '*kanjivellam* in order to ensure better stickiness of the inoculant with the seed. Take care to avoid damage to the seed coat. Dry the inoculated seed under shade over a clean paper or gunny bag and sow immediately. The Rhizobium culture or the inoculated seeds should not be mixed with chemical fertilizers. Vermicompost can also be used for coating seeds.

Procedure for lime pelleting

1. Add finely powdered (300 mesh) calcium carbonate to moist fresh Rhizobium treated seeds and mix for 1- 3minutes until each seed is uniformly pelleted. Depending on the seed size, the following quantity of lime will be required.
   a. Small seeds: 1.0 kg/ 10 kg of seed
   b. Medium sized seeds: 0.6 kg/ 10 kg of seed
   c. Large sized seeds: 0.5 kg/ 10 kg of seed
2. Spread out the pelleted seeds on a clean paper to harden. Sow them as soon as possible. However, lime pelleted seeds can be stored up to one week in cool place before sowing.

Note-

i). Lime coating of seeds is required only for seeds that are to be sown in acidic soils.

ii). Ordinary agricultural lime is not good for pelleting because of its large particle size.

iii). Hydrated lime should not be used for pelleting.

iv). The dry pellet should be firm enough to resist moderate pressure. It should appear dry without loose lime on the surface or in the container.

v). The lime pelleted seeds can be mixed with the fertilizer and sown. However, the period of contact between the fertilizer and the pelleted seeds should be as short as possible.

vi). Pelleted seeds should not be sown into a dry field.

Manuring

FYM – 20t/ha

Lime – 250 kg/ha or dolomite 400 kg/ha.

Lime may be applied at the time of the first ploughing.

In addition, apply any of the following combination as supplement

FYM / Cowdung @ 2 t/ha + Rock phosphate 100 kg/ha

Compost @ 4 t/ha + Rock phosphate 70 kg/ha

Vermicompost @ 2 t/ha + Rock phosphate 110 kg/ha

Greenleaf @ 3.5 t/ha + Rock phosphate 100 kg/ha

Poultry manure @ 1.5 t/ha + Rock phosphate 50 kg/ha

(Note: The quantity of Rock phosphate can be reduced to 50% by priming it with the manures and the entire quantity of rock phosphate should be applied as basal dose).

The additional organic manures can be applied in splits at fortnightly interval.

Bio fertilizers: AMF / Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability.

Growth promoters: Foliar application of growth promoters like panchagavyam or vermiwash at fortnightly intervals increases marketable yield.

After cultivation

Hoeing gives adequate aeration to the soil and help the root system to spread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. For yard long bean, provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and fruit set.

Plant Protection

Pests

1. Pea aphid (*Aphis craccivora*)

This is a major sucking pest. Spray Neemazal T/S 1% @ 2 ml / litre at fortnightly intervals for managing pea aphid in cowpea.

The fungus *Fusarium pallidoroseum* can be used for controlling pea aphid. Bran based fungus can be applied @ 3 kg per 400 m^2 immediately after infestation is observed. Only one application is necessary. *Hyptis suaveolens* extract (1 litre) + 60 g soap (in ½ litre water), dilute the mixture 10 times and spray.

General measure: Spray leaf extract of *Strychnos nuxvomica* + soap. Dilute with water and spray.

2. Jassids and white flies

Spray neem seed kernel extract 5%.

3. American Serpentine leaf miner (*Liriomyza trifolii*)

This is the major pest of cowpea. Adoption of the following methods will reduce the infestation of the pest.

Destruction of the weed host plants viz. *Achyranthus aspera, Amaranthus viridis, Cleome viscosa, Heliotropium indicum* and *Physalis minima.*

Need based application of neem oil, marotti oil or illupai oil @2.5 %.

Cultivate tolerant accession (VU-12)

4. Pod borers

Spray diluted cow's urine + asafoetida + bird chilli extract.

Apply neem cake @ 250 kg/ha at flowering.

Apply neem seed kernel extract 5%

5. Leaf folder

Collect leaf folds and destroy the larvae.

6. Pod bugs

Collect with sweep net and destroy different stages of the bug.

Wet the crop canopy to destroy young ones.

Destroy weed host plants.

Spray amruth neem 5ml/ litre.

Spray nimbicidin 2 ml / litre or neemazal 2 ml / litre or neem seed kernel extract 5%.

7. Pea stem fly

Increase seed rate in endemic areas.

8. Red spider mite

Apply neem oil 5% / neemoil garlic emulsion 2% / garlic emulsion 2% / fish oil soap 2.5%

9. Root knot nematode and reniform nematode

Apply neem or *Eupatorium* leaves @ 15 t/ha, two weeks before sowing.

10. Pulse beetle

Smear the seeds with coconut oil or ground nut oil 1:100 (W/W)

Apply dry, powdered rhizome of *Acorus calamus* @1kg/ 100kg seed.

Diseases

1. Soil borne diseases and nematodes

Follow soil solarisation using 150-gauge clear polythene sheets. Cover the soil with these sheets in sunny summer days after slightly moistening the soil. The soil temperature will reach as high as 52°C. Continue the polymulch for 1 week during which the soil temperature will rise and kill the soil borne fungi, bacteria, nematodes and weeds near the soil surface and thereby reduce the soil inoculum load. Soil drenching with 1% Bordeaux mixture or 2% Pseudomonas protects the crop form fungal diseases.

2. Collar rot and web blight (*Rhizoctonia solani)*

Apply neem cake @ 250 kg/ha

Reduce soil moisture

Use organic manure enriched with *Trichoderma viride* and drench with 2% *Pseudomonas*

3. Fusarium wilt (*Fusarium oxysporum*)

Burn trashes in the pit before sowing. Remove and burn the affected plants along with the root system. Seed treatment with *Trichoderma viride* @2 g/ kg seed + soil application of 2.5 kg/ha at 30 DAS coupled with soil application of neem cake @150 kg/ ha at the time of land preparation reduce the incidence of *Fusarium* wilt.Drenching with 2 % *Pseudomonas*

4. Dry root rot

Treat the seeds with *Trichoderma viridae@* 4g/kg, *Pseudomonas fluorescens* @10g/ kg or soil application of neem cake @ 250kg/ ha. Soil drenching with 2 % (20 g /litre) *Pseudomonas*

General

Spray 1% Bordeaux mixture to protect the crop form fungal diseases.

This will also avoid the entry of white flies which transmit the various viral diseases.

DOLICHOS BEAN (*Dolichos lablab*)

Dolichos bean is a hardy crop and suitable for cultivation in homesteads. Pole and bush varieties are available.

Season

The pole types are short day types and sown during July-August. The bush types can be grown throughout the year.

Varieties

Pole type: Pusa Early Prolific, Hima, Grace

Bush type: Arka Jay, Arka Vijay

Sowing

Pole varieties are sown in pits (three plants / pit) at a spacing of 1.25m x 0.75 m and bush types are sown in ridge and furrow system at a spacing of 60cm x 15 cm. The pole types are trailed over pandals, trellis or stakes.

Manuring

FYM – 20 t/ha as base.

In addition, apply any one of the following combinations as supplement

FYM / Cowdung @ 4 t / ha + Ash125 kg / ha + Rock phosphate 300 kg / ha

Compost 8 t / ha + Ash 100 kg / ha +Rock phosphate 200 kg / ha

Vermicompost 4 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha

Greenleaf 7 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha

Poultry manure 3 t / ha + Ash 200 kg / ha + Rock phosphate 150 kg / ha

(Note: The additional organic manures may be applied in several splits at 10-14 days interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers

Seeds should be inoculated with Rhizobium and pelleted with lime. Application of AMF/ Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability

Growth promoters

Foliar application of growth promoters like panchagavyam or vermiwash at fortnightly intervals increases marketable yield.

Aftercultivation

Hoeing gives adequate aeration to the soil and help the root system to spread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. For pole types, provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The control measures recommended for cowpea are effective in this crop also.

WINGED BEAN (*Psophocarpus tetragonolobus*)

Winged bean is suitable for cultivation in homesteads.

Season: The winged bean is a short day crop and sown during August - September. The bush types can be grown throughout the year.

Varieties

Revathy, PT 62, PT 16, PT 2

Sowing / Spacing

Seed rate: 15- 20 kg/ha

Spacing: 1.25m x 0.50m. They are trailed over pandals, trellis or stakes.

Manuring

FYM – 20 t/ha

In addition, apply any one of the following combinations as supplement

FYM / Cowdung @ 4 t / ha + Ash125 kg / ha + Rock phosphate 300 kg / ha

Compost 8 t / ha + Ash 100 kg / ha +Rock phosphate 200 kg / ha

Vermicompost 4 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha

Greenleaf 7 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha

Poultry manure 3 t / ha + Ash 200 kg / ha + Rock phosphate 150 kg / ha

(Note: The additional organic manures may be applied in several splits at 10-14 days interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers

AMF / Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability

Growth promoters

Foliar application of growth promoters like panchagavyam or vermiwash at fortnightly intervals increases marketable yield.

Aftercultivation

Hoeing gives adequate aeration to the soil and helps the root system to spread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. Provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The crop is comparatively free from pests and diseases.

CLUSTER BEAN (*Cyamopsis tetragonoloba*)

Cluster bean is a hardy crop suitable for cultivation under adverse soil and climatic conditions.

Season: The cluster bean seeds are sown during February – March and June – July.

Varieties

Pusa Naubahar and Pusa Sadabahar.

Sowing

Seed rate: 10- 12 kg/ha

Spacing: 45 – 60cm x 20- 30 cm.

Manuring

FYM – 25t/ha

In addition, apply any one of the following combinations as supplement

FYM / Cowdung 2 t / ha + Ash 750 kg / ha + Rock phosphate 200 kg / ha

Compost 4 t / ha + Ash 625 kg / ha + Rock phosphate 140 kg / ha

Vermicompost 2 t / ha + Ash500 kg / ha + Rock phosphate 220 kg / ha

Greenleaf 3.5 t / ha + Ash500 kg / ha + Rock phosphate 200 kg / ha

Poultry manure1.5 t / ha + Ash 825 kg / ha + Rock phosphate 100 kg / ha

(Note: The additional organic manures may be applied in several splits at fortnightly interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers:

AMF / Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability

Growth promoters:

Foliar application of growth promoters like panchagavyam or vermiwash at fortnightly intervals increases marketable yield.

Aftercultivation

Hoeing gives adequate aeration to the soil and help the root system to spread easily.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The crop is comparatively free from pests and diseases.

PERENNIAL VEGETABLE-
DRUMSTICK (*Moringa oleifera* L.)

Drumstick is a traditional multipurpose vegetable of Kerala. It thrives in almost all the soils of Kerala. However, it prefers well drained loamy soils. It is better to avoid heavy clayey soils and water stagnated areas.

Varieties / Cultivars

There are two types

a) Propagated by limb cuttings : MO-144, Jaffna, Palmuringa

b) Seed propagated : AD- 4 (TNAU varieties such as PKM 1 and PKM 2 are suited for adjoining dry border regions of Kerala such as Erithiyampathi, Chittoor, Menonpara)

Seed rate

Cuttings : 625nos. / ha

Seeds : 325 g/ha

Preparation of planting materials

a) Limb cuttings: One-year-old cutting of 1 to 1.5m length and 15-20cm girth is ideal for planting. The fresh cuttings are not advised to plant on the same day of cutting from the mother plant. They are kept under shade for one week in a slanting position so that the basal cut end become dry before planting.

b) Seedlings: For getting good establishment in the main field, healthy seedlings have to be raised. The seeds are sown in the polythene bags filled with potting mixture, kept in open area and irrigated daily. The seeds start germination within a week and the seedlings will be ready for planting about three to four weeks after sowing.

Time of planting in the main field

Pre- southwest monsoon period April- May is most ideal for planting both types of drumsticks

Land preparation and planting

Select the site that receive direct sunlight, as drumstick never tolerates shade. Land is made free of weeds and pits of 60cm x 60cm x 60cm size are made. The pits are partly filled with topsoil and manures and left as such for two weeks before planting. The cuttings/ seedlings are planted in the pits. In the case of seedlings, care should be taken to avoid root damage while removing the polybags. Shade should be given for the seedlings for 3-4 days after planting.

Spacing

Both types of drumsticks can be planted at a spacing of 4m x 4m

Manuring

Apply the following organic manures at the time of planting and repeat the application every year during April – May

Powdered cow dung	10 to 15 kg/ pit
Neem cake	1.5 to 2 kg/ pit
Rock phosphate	0.50kg/ pit
Wood ash	1.0kg/ pit

After cultivation

Irrigate the crop once in a week during summer. Stake the seedling plants if necessary. As far as possible keep the tree basins free of weeds. Mulching the basins with dry leaves is ideal. Avoid irrigation during the pre-bearing periods. After flowering, irrigation increases fruit set and fruit weight. In the case of seed drumstick, the tip of the seedling has to be pinched off after attaining a height of 1 -1.5 m to enhance the production of lateral branches.

Plant protection

Green caterpillar and hairy caterpillar are the common pests which can be controlled by neem based insecticides (2ml/litre) and tobacco decoction.

Stem borer is a problem in some areas and it can be managed by Bt formulations such as Dipel /Delphin / Halt (0.7%).

For the control of *Fusarium* wilt, soil application of *Trichoderma* (2.5kg/ha) and drenching with 2% *Pseudomonas* are effective.

Yield

High yielding drumstick varieties will bear 250 to 275 fruits /tree/year recording 30 to 35 t /ha.

FRUITS

BANANA (*Musa* spp.)

Banana prefers tropical humid low lands and is grown from the sea level to 1000 m above MSL. It can also be grown at elevations up to 1200 m, but at higher elevations growth is poor. Optimum temperature is 27°C. Soils with good fertility and assured supply of moisture are best suited.

Season

Rainfed crop: April - May

Irrigated crop: August - September

Adjust planting season depending upon local conditions. Avoid periods of heavy monsoon and severe summer for planting. Adjust the time of planting so as to avoid high temperature and drought at the time of emergence of bunches (7-8 months after planting).

Varieties

Nendran (clones)

Nedunendran, Zanzibar, Chengalikodan, Manjeri Nendran II*

Table varieties

Monsmarie, Robusta, Grand Naine, Dwarf Cavendish, Chenkadali, Poovan, Palayankodan, Njalipoovan**, Amritsagar, Grosmichel, Karpooravalli**, Poomkalli, Koompillakannan**, Chinali, Dudhsagar*, BRS-1*, BRS-2*, Poovan, Red banana

Culinary varieties

Monthan, Batheesa, Kanchikela**, Nendrapadathy

*Less susceptible to sigatoka leaf spot disease

**Less susceptible to bunchy top disease

Njalipoovan, Palayankodan, Robusta, BRS-1 and BRS-2 are particularly suitable for intercropping in coconut gardens both under rainfed and irrigated conditions. Dudhsagar is highly resistant to major pests and diseases. The variety Boldles Altafort is recommended for high range region.

Preparation of land

Prepare the field by ploughing or digging and dig pits for planting. Size of pits depends upon soil type, water table and variety. In general pit size 50 cm x 50 cm x 50 cm is recommended. In low lying areas, take mounds for planting suckers.

Selection of suckers

Select 3-4 months old disease free sword suckers from healthy clumps. Suckers should be removed one week after the harvest of the bunch. In the case of Nendran variety, cut back pseudostem to a length of 15-20 cm from corm and remove old roots. The portions of corm and roots infected by rhizome weevil (black tunnels) and nematode (darkened lesions) should be removed.

The rhizome should be dipped in hot water (50°C) for 20 minutes to prevent nematode infestation. The rhizomes are to be smeared with cow dung solution and ash and dried in the sun for about 3-4 days and stored in shade up to 15 days before planting. Soaking the suckers in *Pseudomonas fluorescens* solution (2%) for 30 minutes before planting is beneficial.

Table 5. Recommended spacing for different varieties

Variety	Spacing (m)	Suckers/ha
Poovan	2.1 x 2.1	2260
Chenkadali	2.1 x 2.1	2260
Palayankodan	2.1 x 2.1	2260
Monthan	2.1 x 2.1	2260
Nendran	2.0 x 2.0	2500
Grosmichel	2.4 x 2.4	1730
Robusta Monsmarie Dwarf Cavendish	2.4 x 1.8	2310
Tissue culture Nendran banana	2.0 x 3.0 or 1.75x1.75	3332 plants in 1666pits3265 plants/ha

The productivity of banana can be increased by cultivating good quality, uniform, pest and disease free tissue culture plants of selected ecotypes of different varieties.

Planting

Plant suckers upright in the centre of pits with 5 cm pseudostem remaining above soil level. Organic manures and *Trichoderma harzianum* (100:1) should be applied in the pit before planting. Press soil around the sucker to avoid hollow air spaces.

Manuring

1. FYM or compost or green leaves @ 10 kg/plant at the time of planting.
2. 500 g of lime in the pit and allow to weather.
3. Vermicompost @ 2 kg / pit at the time of planting.
4. Groundnut cake/ neem cake @ 1 kg /pit at the time of planting.
5. N, P and K biofertilizer- PGPR mix I @50-100 gm /pit should be applied at the time of planting. The biofertilizer should be mixed with 5 kg FYM. It should be ensured that there is enough moisture in the soil at the time of application.
6. Panchagavya 3% as foliar spray three times at 3rd, 6th, and 9th months after planting

After planting banana, sow sunnhemp /daincha/ cowpea adopting a seed rate of 50 kg/ ha (20gm per plant). Incorporate the crop into the soil 40 days after sowing. Repeat sowing of green manure crop and incorporate into soil 40 days after sowing. Compost made from banana leaves and bunch stalk is rich in potassium content. *Insitu* vermicomposting is a novel technology for organic banana.

Additional nutrient requirement for different varieties

Varieties	Quantity / Plant		
	FYM/Compost (kg)	Rock phosphate (g)	Ash (kg)
Nendran	20	200	1
Palayankodan	10	300	2.0
Other varieties	15	300	1.5

It is preferable to apply organic manures in two equal split doses at 2nd and 4th month after planting.

Irrigation

1. During summer months, irrigate once in three days.
2. Ensure good drainage and prevent water logging.
3. About 6-10 irrigation per crop may be given depending upon soil conditions.
4. Banana var. Nendran (October planting) grown under deep water table conditions (below 2m from ground level) needs 10 mm (40 litres/plant) irrigation once in two days during summer season to ensure higher bunch yield and better water use efficiency. Mulching the basin with 3.5 kg paddy straw (waste quality) will considerably improve the bunch yield.

Weed control

During early stages, complete control of weeds could be obtained by raising cowpea in the inter spaces. Hand weeding by giving 4-5 surface diggings (depending upon weed

growth) will give good weed control. Avoid deep digging. Do not disturb soil after plants start producing bunches. If green manure crop is grown, weeding operations can be reduced to 1-2 diggings. Mulching is an effective practice for controlling weeds.

Desuckering

Remove side suckers produced till the emergence of bunch. Retain one or two suckers produced after the emergence of the bunch.

Inter cropping

Amaranth, colocasia and elephant foot yam can be profitably intercropped with banana by adopting organic method of cultivation for all crops in the field.

Plant protection

Pests

Banana pseudostem weevil (*Odoiporus longicollis)*

Pseudostem weevil is a serious pest of banana. It attacks the crop from 6th month onwards. Adult female weevil inserts eggs into the air cavities of the pseudostem. The grubs which emerge out feed on the internal tissues, weakens the pseudostem and it collapses in due course.

Management

1. Field sanitation – remove all dried leaves over the pseudostem.
2. Remove severely infested plants with rhizome in full and destroy by burning the life stages of the insect.
3. Destroy pseudostem of harvested plants.
4. Remove the loose dry sheaths of the pseudostem of plants from 5th month onwards and follow any of the methods.

a) Swab mud slurry around the pseudostem:

If infestation is noticed, then mix neem oil emulsion @ 3 % in the mud slurry (30 ml/ litre) used for swabbing.

b) Spray neemazal (1% EC) on the psuedostem and fill the leaf axils at monthly intervals starting from 5th month onwards:

Spray application on the pseudostem and leaf axil filling with entomopathogens, namely, *Beauveria bassiana* or *Metarhizium anisopliae* @ 1 x 10^7 spores/ml.

c) Spray entomopathogenic nematode (EPN) @ one billion/ha over the pseudostem or place three cadavers containing EPN s in alternate leaf axils at fortnightly intervals.

d) Place split pseudostem pieces of 2 ft long in the ground when plants are 5 months old. Collect weevils in the trap and destroy daily.

Banana Rhizome Weevil (*Cosmopolites sordidus)*

Adult females puncture the rhizome and insert eggs through the holes. Grubs feed on the tissues and damage the rhizome. When growing point is damaged, the plant is killed. Symptoms are death of unopened pipe leaf, delay in emergence of new leaves and reduction in leaf number and bunch size.

Management

1. Select only healthy, pest free planting material.
2. Deep plough the land so as to remove old rhizomes and expose inner soil layer to sun.
3. Cut and remove outer layer of rhizome (Parring) to remove eggs and young ones of weevils. Dip suckers in a slurry made of cow dung and ash and dry in shade.
4. Keep split pseudostem in the field to attract adult weevils. Collect and destroy the adult weevils daily.
5. Use pheromone trap with Cosmolure / Cosmolure $^{+}$ (an aggregation pheromone) to attract both sexes of weevil. Keep the trap throughout the year, changing the site when the number of weevils collected is reduced. Change pheromone sachet in every 45 days.
6. Drench soil around plants or spray the plants with entomopathogens *Beauveria bassiana* or EPN s (dosage same as for pseudostem weevil). The quantity needed will depend on stage of the crop.
7. Apply crushed neem seed to the pit @ 1kg/plant

Aphid (*Pentalonia nigronervosa)*

Aphid acts as a vector for the transmission of viral diseases of banana. The fungal biocontrol agent *Verticillium lecanii* is pathogenic to the aphids. Spray the spores of *V. lecanii* @ 1 x 10^7 spores/ml, whenever aphid population is noticed.

Nematodes

Major species attacking banana are burrowing nematode (*Radopholus sp)*, root knot nematode (*Meloidogyne incognita)*, root lesion nematode (*Pratylenchus coffeae)* and cyst nematode (*Heterodera oryzicola)*. Reduction in the number of leaves, bunch weight and number of fingers are the symptoms.

Management

1. Pare the rhizomes and dip in hot water at 45 -50°C for 20 minutes will control nematodes.
2. Apply neem cake @ 1kg/plant at the time of planting.
3. Intercrop banana with sunnhemp or marigold to reduce nematode population.

Diseases

Fungal diseases

Sigatoka leaf spot (*Mycosphaerella* sp.)

1. Cut and burn all severely affected leaves.
2. Need based sprayings are to be given depending upon the severity of the disease.
   i) Spray 1% Bordeaux mixture soon after the appearance of the initial symptoms of the disease. The disease appears with the commencement of southwest monsoon.
   ii) Power oil (Mineral oil) 1 % emulsion is effective in controlling the disease.
   iii) Bioagents like *Pseudomonas fluorescens* 20g/litre (2%) or *Bacillus subtilis* 5g/ litre is effective against sigatoka leaf spot disease.
3. Grow reistant/less susceptible varieties such as BRS-1, BRS-2 and Dudhsagar. Among Nendran, the selection Manjeri Nendran II is least susceptible.

Panama Wilt (*Fusarium oxysporum* f. sp. *cubense)*

1. Remove and destroy affected clumps along with corms
2. Apply lime @500g per pit and allow to weather
3. Apply neem cake @1kg per pit at the time of planting and give irrigation.
4. Varieties such as Palayankodan, Robusta and Nendran are less susceptible to the disease
5. Application of soil based inoculum of AMF 500g (soil based inoculum containing 40 spores per gm of soil), *Trichoderma harzianum* (50g) and *Pseudomonas fluorescens* (50g) or PGPR mix 1 is effective.
6. Dip the planting material in 2% *Pseudomonas* before planting

Virus diseases

Bunchy top disease

Virus disease of banana transmitted by aphids

1. Use disease free suckers for planting.
2. Eradicate disease affected plants.
3. Spraying neem based insecticide on the pseudostem to control the vector.
4. The fungal biocontrol agent *Verticillium lecanii* is pathogenic to the aphids. Spray the spores of *V. lecanii* @ $1x10^7$ spores per ml whenever aphid population is noticed.
5. Varieties such as Karpooravally, Kanchikela, Njalipoovan and Koompillakannan are tolerant

Banana Bract Mosaic Disease (Kokkan disease)

Virus disease transmitted by aphids

1. Use disease free healthy suckers for planting.
2. Eradicate disease affected plants as and when noticed .
3. Spray neem based insecticide to control the vector.

Infectious Chlorosis (Cucumber Mosaic Disease)

1. Use disease free suckers for planting
2. Eradicate infected plants.
3. Use neem based insecticide to control the insect vector.
4. Avoid growing cucurbitaceous vegetables as intercrop in banana.

PINEAPPLE (*Ananas comosus*)

Pineapple is mostly grown at low elevations in areas with a temperature range of 15 to 30 ^{0}C. Pineapple is tolerant to drought because of the special water storage cells. They can be grown with a wide range of rainfall from 600-2500 mm / annum, the optimum being 1000-1500mm. Pineapple can be grown in a wide range of soils, but does not tolerate water logging. It can be grown as a pure crop on plantation scale or as an intercrop in coconut gardens.

Varieties

Kew - recommended for processing industry Mauritius - recommended for commercial cultivation for table purpose and distant marketing, due to its shorter duration, better fruit quality, keeping quality and transportability.

Season

Main season of planting is April-May and August-September, but can also be planted in all months except during heavy rain of June-July. The best time for planting is August to get higher yield. During summer months, if there are no summer showers after planting, irrigation should be given three weeks after planting for proper establishment.

Cropping system

Mauritius can be grown as a pure crop in garden land, reclaimed lowlands and wetlands and as an intercrop in coconut and newly planted rubber plantations. In rubber plantation, it can be grown for the first 3-4 years only.

Land preparation

Pure crop

Prepare the land by digging the area to be planted at 90 cm width in rows/ strips, leaving the interspaces undisturbed. However, ploughing can be adopted in level land. Planting

is done in paired rows of 45cm distance between rows and 30cm between suckers. Suckers may be planted in triangular method in the paired rows. Interspace between the paired rows is kept at 120-150cm. Contour planting is ideal in sloppy areas to prevent soil erosion. About 30000 suckers can be planted in one ha.

Intercropping in coconut garden

Land preparation, spacing and planting are the same as described above in pure crop. There can be three-paired rows in between two rows of coconut. Coconut tree basin should be kept free. About 20000-22000 suckers can be planted in one ha.

Intercropping in rubber plantations

System of planting is in paired rows at 45cm x 30cm. Either one or two paired rows can be planted in between two rows of rubber depending on the spacing of the rubber planting. About 20000 suckers can be planted in one ha.

Wetlands / lowlands

Pineapple is highly sensitive to water stagnation and high moisture regimes. Hence it is important to provide good drainage, if grown in wetlands. In paddy lands, pineapple is planted in paired rows at 45cm x 30cm spacing on ridges taken at 60-90cm height, depending on the water table and drainage requirement. The ridges are separated by drainage channels having 60cm width. The width of the ridges varies from 120-150cm. Wherever water stagnation and poor drainage are expected, a wider and deeper channel is given in between ridges. About 25-30000 suckers can be planted in one ha.

Selection of suckers

Suckers are selected from disease and pest free healthy plants. Suckers are to be graded into those having 500-750g and 750-1000g. The graded suckers are planted in different blocks or plots, to get uniformity in growth and flowering. Bigger suckers give early yield.

Planting

After preliminary land preparations, planting is done in small pits of 10-15cm depth at a spacing of 45cm between rows and 30cm between plants in the rows. There is no need to plant the suckers in trenches.

Manuring

Apply compost / FYM @ 500 g per plant at the time of planting. Also apply rock phosphate @ 20 g per plant and bone meal @ 50 g per plant. It will be ideal to apply the compost/ FYM, rock phosphate and bone meal in the pits taken for planting. Six weeks after planting, apply 250 g cowdung or vermi compost, 50 g neem cake, 50 g groundnut cake, one gm azospirillum and one gm phosphobactor or PGPR mix 1 for each plant and mild earthing up is done. Apply 1.5 g of sulphate of potash in liquid form along with cowdung solution at an interval of 6, 10, 14, 18, 22 and 30 weeks after planting for each plant.

Irrigation

Wherever irrigation facilities are available, providing irrigation in summer months at two weeks intervals results in good fruit size and high yield. If there is no irrigation facility, the crop should be scheduled for harvest before summer months (before March).

Weed control

Hand weeding can be adopted in between plants and spade weeding in interspaces. Intercropping with ginger, coleus, brinjal, bhindi etc. in the early stages can control weeds in interspaces. It can also be controlled by sowing green manure crops like sunnhemp or daincha which can be used as green manure for pineapple by 2-3 months.

Flower induction

For inducing uniform flowering, 25 ppm ethephon is applied on physiologically mature plants having 39-42 leaves (7-8 months after planting). The solution for application in 1000 plants is prepared by adding 1.25 ml of ethephon (3.2 ml of 39% ethrel or 12.5ml of 10% ethrel) in 50 litres of cowdung solution. Pour 50 ml of the prepared solution to the heart of the plant during dry weather conditions (when there is no rain during the time of application).

Flowering starts by 30 days and completes within 40 days of growth regulator application. Fruits will be ready for harvest by 130-135 days after the application of growth regulator. Harvest over different months / seasons could be obtained by carefully phasing / planning the planting and growth regulator application.

Plant protection

Sun burn

During summer months it is necessary to protect the fruits from sun scorching by covering with dried grasses, coconut or arecanut leaves.

Pests

Mealy bugs (*Dysmicoccus brevipes / Pseudococcus bromeliae*)

Mealy bug is a serious problem in pineapple. For its control, sanitary measures are to be adopted. The plot should be kept weed free. Apply *Verticillium* @ 1 g per plant in liquid form for the control of mealy bug.

Diseases

Root rot / heart rot / fruit rot

Caused by *Phytophthora* sp., *Pythium sp*., *Fusarium sp*., etc. The fruits at the soil level rot and emit foul smell. The stem at the soil level also show rotting symptoms. Providing drainage is most essential. The water table should be at least 60 cm below the soil surface. Badly affected plants should be destroyed. To prevent disease problems biocontrol agents can be used. Two weeks after planting, apply *Pseudomonas fluorescens* or PGPR mix II as 2% spray and drenching. Repeat its application if any diseases are observed.

Ratoon cropping

The plant crop after harvest can be retained as ratoon crop for two more years. After the harvest of the plant crop, chopping the side leaves of the mother plant should be done for easy cultural operations. The suckers retained should be limited to one or two per mother plant. Excess suckers if any should be removed. Earthing up should be done. Other management practices are same as for the plant crop.

MANGO (*Mangifera indica*)

Mango is adaptable to a wide range of climate and soil conditions and grows well from sea level up to about 1500 m above mean sea level. It withstands both fairly dry conditions and heavy rainfall.

Varieties

Alphonso, Bennet Alphonso, Neelum, Kalapady, Bangalora, Mundappa, Banganapally, Mulgoa, Prior, Suvarnarekha, Muvandan, Chandrakaran

Hybrids

Ratna (Neelum x Alphonso), Hybrid No.45 (Bennet Alphonso x Himayuddin), Hybrid No.87 (Kalapady x Alampur Benishan), Hybrid No.151 (Kalapady x Neelum)

Season

Plant one year old grafts with the onset of monsoon showers so that they get established before the rains. If rainfall is heavy, planting should be done during August-September.

Vegetative propagation

Stone grafting is successful in mango. August is ideal for the operation. Select four month old scion materials. Defoliation of scion shoots 10 days prior to grafting is beneficial. Grafting of 8 cm long scion on rootstocks at a height of 6 to 8 cm is most successful. Softwood grafting using 1- 2 months old rootstocks and Approach grafting with 10 – 12 months old rootstocks also can be followed. The dieback disease of grafts caused by *Colletotrichum* can be controlled by spraying 1% Bordeaux mixture.

Planting

Select good grafts for planting. Planting can be done according to the square system or hexagonal system. Spacing can be 9m (120-125 plants/ha) or 6m (270 – 275 plants / ha, with judicious pruning). Prepare pits of size 1 m^3 one month before planting and allow to weather. Refill pits with mixture of topsoil and 10 kg of compost or FYM per pit to a level higher than the adjoining ground. Plant the grafts at the same depths as they were in the containers, preferably in the late evening. Deep planting results in poor growth of the plant. Ensure that the graft joint is above the soil level. Tie the plants to stakes to prevent snapping at the graft joints. Provide shade if necessary.

Manuring

For organic mango production FYM or compost may be applied along with 50-100 g of PGPR mix I from first year onwards and the quantity should be increased as the tree grows, as shown in the table below.

Age of plant (years)	*FYM / Compost(kg/plant/year)*
1 - 2	15
3 - 5	30
6 -7	50
8-10	75
0ver 10	100

Compost or FYM can be partially or completely substituted with Vermicompost and in this case the quantity required will be only about 50 %.

Green leaves (25 kg / plant), Oil cake (10 kg / plant) and wood ash (10-15 kg / plant) may be applied additionally. Apply organic manures in May-June with the onset of monsoon. Apply the manures in trenches 30 cm deep taken at a distance of 2.5 to 3 m from the base of the tree.

After cultivation

Irrigate twice a week during summer months till the plants are 4-5 years old. Grow vegetables, horse gram, black gram, pineapple and banana as intercrops in young orchards. Carry out intercultural operations by ploughing or digging twice during the year in June and October. For reducing fruit drop and to improve productivity and fruit size, irrigate the plants at 10 – 15 days interval from fruit set stage onwards.

Plant protection

Important pests of mango are hoppers, stem borers, shoot midges, leaf feeding insects, fruit flies and mealy bugs. The common diseases are the powdery mildew, anthracnose and dieback.

Under organic production system, to protect the orchard and the trees, following steps can be practiced.

- Keep the orchard and tree surroundings clean by proper sanitary measures.
- Lime brushing on tree trunks will help to control some of the pests

- Cuts and wounds on plant parts should be pasted with coal tar, used engine oil or Bordeaux paste.
- Smoking in low intensities in the orchard during flowering season will reduce the number of pests including the hoppers.
- Spraying *Pseudomonas fluorescens* (10 g / litre) on trees before flowering and at flushing times will improve the general health, flowering and resistance of the trees.
- To control fruit flies

i) Collect and destroy attacked fruits that rot and drop down.

ii) Banana fruit traps can be used: Trap is prepared by mixing banana fruits (Palayanthodan) and jaggery (3-5 % level) poisoned with 2 ml malathion and kept either in hanging containers or used for swabbing the tree trunks at weekly intervals from flushing time onwards.

iii) Set up methyl euginol trap @ 10 nos/ ha

iv) Spathiphyllum (Peas Lily) plants can be planted as trap crop which attract the insects and they are to be destroyed by manual means

- To control Stem borer: apply paste made of crude carbolic acid (130 ml), soft soap (1 kg) and hot water (3.7 litres) to holes in the bark and plug the holes.
- Against sucking insects (Mealy bugs, Thrips, Mites etc.) spray with neem oil (0.5 to 1%) – soap emulsion. Sticky bands or stem traps with mud slurry, jack latex, vaseline, greece, coal tar or gel will prevent the upward movement of the pests from soil.
- Red ants become serious problem sometimes. If the number of ant colonies is maintained at a moderate level, this will guard the trees from common insect pests. If the number is huge, control to a certain extent can be obtained by introducing predatory ant, *Plagiolepis* (Chonal ants). Mechanical means like breaking the ant nets and sprinkling wood ash or common salt pellets and trapping ants by sticky threads hung with fresh bones from slaughter houses followed by destruction also can be tried.
- To control dieback of twigs and branches, cut the affected twigs below the infected region and spray 1% Bordeaux mixture.
- To control pink disease remove the bark at the point of infection and 30 cm above and below the point of infection and apply 10% Bordeaux paste.

TUBER CROPS

AMORPHOPHALLUS (*Amorphophallus paeoniifolius*)

Amorphophallus requires fairly long growing season and a rainfall of about 150 cm during the crop period. A well-drained soil of medium texture is suited for this crop.

Season

Corm pieces are normally planted during February-March, before the onset of monsoon.

Varieties

Sree Padma: The crop matures in 8-9 months. Cooked tubers are free from acridity.

Land preparation

Dig pits of 60cm x 60cm x 45 cm size at 90 cm apart. Collect the topsoil to a depth of 15-20 cm separately and fill it after the pits are formed. Apply cow dung or compost @ 2-2.5 kg/pit and mix with topsoil.

Preparation of planting material and planting

Corm pieces each weighing about 1 kg are ideal for planting. While cutting the corm, care should be taken to see that each piece contain a portion of the terminal bud. Dip the corm pieces in cow dung slurry enriched with *Trichoderma* and allow to dry under shade before planting. Nematodes associated with amorphophallus can be controlled by seed material treatment with talc based formulation of *Bascillus macerans, Paecilliomyces lilacinus* @ 3 g (10^6 cfu/g) / kg of corms. Plant one corm piece /pit in the upright position. After planting, cover the pits with dried leaves or other mulching materials. About 12,000 corm pieces weighing about 12 t are required for planting one hectare. Most of the seed material will germinate within one month after planting.

Minisett planting

Planting of minisett/cormel transplant gives better yield than traditional method. Cormels/ minisetts each weighing 75-100 g can be planted directly in nursery beds at a spacing of 90cm x 30 cm.

Manuring

Sow green manure seeds (cowpea/ sunnhemp) @30kg/ha at the time of planting setts/ with the receipt of pre monsoon showers. 10 kg P_2O_5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) incorporate the green manure plants, along with 5t FYM / 2t poultry manure/ 2t vermi compost / 2t coirpith compost and 3t of wood ash. If *insitu* green manuring is not possible it can be substituted with 6t/ha of FYM. One month after incorporation do the one more weeding and earthing up. Application PGPR mix I increases the availability of N, P and K.

Plant protection

Mealy bugs usually attack the corm both in the field and store. Avoid planting corms already infested. As a prophylaxis, dip the planting material in *Clerodendron* decoction of 4% strength for 10 minutes.

Harvesting

The crop will be ready for harvest 8-9 months after planting.

COLOCASIA [TARO] (*Colocasia esculenta*)

Colocasia is a crop of tropical and sub-tropical regions and requires a warm humid climate. Under rainfed conditions, it requires a fairly well distributed rainfall around 120-150 cm during the growth period. Well-drained soil is suitable for uniform development of tubers.

Season

Rainfed crop: May-June to Oct-Nov

Irrigated crop: Throughout the year

Varieties

Sree Rashmi, Sree Pallavi and Sree Kiran are the improved varieties

Seeds and sowing

Use side tubers each of 25-35 g for planting. About 37,000 side tubers weighing about 1200 kg are required to plant one hectare.

Plough or dig the land to a depth of 20-25 cm and bring to a fine tilth. Make ridges 60 cm apart. Plant the side tubers at a spacing of 45 cm on the ridges.

Mulching

Soon after planting, cover the ridges with suitable mulching materials for retention of moisture and to control weeds.

Manuring

Apply cattle manure or compost @ 12 t/ha as basal dressing, while preparing the ridges for planting. Sow green manure seeds (cowpea / sun hemp) @30kg/ha at the time of planting with the receipt of pre monsoon showers. 10 kg P_2O_5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) incorporate the plants, along with 4t FYM /2t poultry manure / 2t vermi compost / 2t coirpith compost and 1500kg wood ash. If *insitu* green manuring is not possible, it can be substituted with 5t of FYM + 500kg ash / ha. Biofertlizer PGPR mix I may also apply along with FYM.

After cultivation

Intercultivation is essential in colocasia. Weeding, light hoeing and earthing up are required at 30-45 days and 60-75 days after planting. The leafy parts may be smothered about one month before harvest so as to enhance tuber development.

Irrigation

Ensure sufficient moisture in the soil at the time of planting. For uniform sprouting, irrigate just after planting and one week later. Subsequent irrigation may be given at 12-15 days intervals, depending on the moisture retention capacity of the soil. The irrigation should be stopped 3-4 weeks before harvest. About 9-12 irrigations are required for the crop till harvest. In the case of rainfed crop, if there is prolonged drought, supplementary irrigation is required.

Plant protection

To check the incidence of leaf diseases like blight, give prophylactic spray of *Pseudomonas* 1-2%. For controlling serious infestation of aphids, apply tobacco decoction / *Lantana* decoction + soap solution. Leaf feeders can be controlled by applying *Clerodendron* decoction (4%).

Harvesting

Colocasia becomes ready for harvest five to six months after planting. The mother corms and side tubers are separated after harvest.

Storage of seed material

The side tubers for use as planting materials are to be stored properly. Keep the seed tubers in sand spread over the floor to avoid rotting.

DIOSCOREA (YAMS)

GREATER YAM (*Dioscorea alata*)

Dioscorea alata is predominantly a tropical plant. The crop cannot withstand frost and excessively high temperatures. Temperature around 30ºC and rainfall of 120-200 cm distributed throughout the growth period are ideal. Day length greater than 12 hours during initial stages and shorter day length during the later part of the growing season favour satisfactory tuber formation. Yam requires loose, deep, well-drained, fertile soil. The crop does not come up well in waterlogged conditions.

Season

Seed tubers are normally planted during the later part of the dry season (March-April) and start sprouting with the onset of pre-monsoon showers. If the planting is delayed, yams start sprouting in storage, which is not desirable for planting.

Varieties

Sree Keerthi*:* Suitable for intercropping in mature coconut garden and with banana.

Sree Roopa: Possesses excellent cooking quality.

Indu: This is recommended as a pure crop and also as an intercrop of coconut in the reclaimed alluvial soils of Kuttanad.

Sree Shilpa: This is the first hybrid having good culinary quality. The crop matures early, within 8 months. The tubers have 33-35% dry matter, 17-19% starch, 1.4-2% protein and 0.8-1.2% sugar.

Sree Karthika: High yield, excellent cooking quality. The crop matures within 9 months. The tubers have 21.42% starch, 1.14% sugar and 2.47% crude protein.

Seeds and sowing.

D. alata produces mostly a single big tuber in which only one head end of the tuber is available as good seed material. For getting the head end in maximum number of propagation units, the whole tuber is first cut longitudinally and then horizotally. Each piece should weigh at least 250-300 g. Dip the pieces in cowdung slurry and allow to dry under the shade before planting. About 2500-3000 kg of seed material is required to cover one hectare of land.

Preparation of land

Plough or dig the land upto a depth of 15-20 cm. Dig pits of size 45 cm^3 at a distance of 1m x 1m. Apply 1-1.25 kg cattle manure or compost /pit, mix with topsoil and fill up three fourth of the pits. Plant the cut tuber pieces and completely cover the pits with leafy materials to conserve soil moisture and maintain optimum temperature.

Manuring

Apply cattle manure or compost @10-12 t/ha or 1-1.25 kg cattle manure or compost / pit as basal dose. Sow green manure seeds (cowpea/ sun hemp) @30kg/ha at the time of planting with the receipt of pre monsoon showers. 10 kg P_2O_5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) uproot and incorporate the green manure plants, along with 4t FYM / 2t poultry manure / 2tvermi compost / 2t coirpith compost + Azospirillum & P solublising organisms @ 2 kg/hectare or PGPR mix I. If *insitu* green manuring is not possible it can be substituted with 6t/ha of FYM.

Plant protection

Yam scale and mealy bugs are found to infest the corms both under field and storage situations. As a prophylactic measure, dip the planting material in 4% *Clerodendron* decoction for 10 minutes.

Trailing

Trailing is essential to expose the leaves to sunlight. Trailing has to be done within 15 days after sprouting by coir rope attached to artificial supports in the open areas or to trees where they are raised as an intercrop. When grown in open areas, trail to a height of 3-4 m. Trail the vines properly as and when side shoots are produced.

Harvesting

The crop becomes ready for harvest within 8-9 months after planting. When the vines are completely dried up, dig out the tubers without causing injury.

LESSER YAM (*Dioscorea esculenta*)

It is grown in a similar agro-climatic situation as that of *D. alata*. Planting season and manuring are also similar.

Varieties

Sree Latha: This is a selection from Thiruvananthapuram district with a duration of 8 months. Tubers are oblong to fusiform with creamy white flesh.

Sree Kala: This is an early variety with 7.5 months duration. The tubers have 35-37% dry matter, 23-25% starch and 1-1.3% sugar.

Seeds and sowing

Select medium size tubers weighing about 100-150 g each. Plant the whole tuber, one in each mound and cover completely with soil. Mulch the mounds to maintain optimum temperature and moisture. To plant one hectare, 1800-2700 kg of seed materials are required.

Preparation of land

Plough or dig the land to a depth of 15-20 cm. Prepare mounds at a spacing of 75cm x 75 cm. Incorporate cattle manure @ 1 kg per mound.

Manuring

The manure dose and schedule of application are the same as that of *D. alata*.

Trailing

Trail the vines by fixing small poles attached with coir rope and direct 4-6 plants per pole.

Harvesting

The crop is ready for harvest by about 7-8 months time. Tuber yields of 20-25 t/ha can be obtained by following the improved methods of cultivation.

WHITE YAM *(Dioscorea rotundata)*

White yam or African yam is a new crop species of edible yam introduced from Nigeria.

Varieties

Sree Subhra: The tuber contains 27-28% dry matter, 21-22% starch and 1.8-2% protein. It is drought tolerant with 9-10 months duration.

Sree Priya: The tuber contains 25-27% dry matter, 19-21% starch and 2-2.5% protein. It is drought tolerant and duration is 9-10 months. It is suitable for intercropping in mature coconut garden and with banana.

Sree Dhanya: It is the first dwarf variety. The tubers have 28-30% dry matter, 22-24% protein and 0.3-0.5% sugar.

Cultivation practices are the same as that for greater yam.

Rapid seed yam production (minisett technique)

In this method clean and healthy yam tubers weighing about 1 kg are cut into cylindrical (disc-like) pieces, each about 5 cm thick. From each such piece, 2-4 small pieces (30 g) could be obtained by cutting the disc longitudinally or along the two perpendicular diameters. Such a piece is called a "minisett". The minisetts are then spread out under light shade for an hour with cut surface facing up before planting them in the nursery seedbeds. The minisett takes 2-3 weeks for sprouting. At this stage, they are transplanted to the main field at a spacing of 50 cm on ridges taken 1 m apart.

SWEET POTATO (*Ipomoea batatas*)

Sweet potato requires a warm humid tropical climate with a mean temperature of about 22 ºC. Though sensitive to frost, it can also be grown in the hills up to an altitude of 1500-1800 m as a summer crop. Under rainfed conditions the crop requires a fairly well distributed annual rainfall of 75-150 cm. Being a photosensitive crop, sunny days and cool nights are favourable for better tuber development.

The crop can be grown on a variety of soils having good drainage, but grows best in fertile sandy loam soils. Heavy clayey and very light sandy soils are not suitable for proper tuber development.

Season

Rainfed crop: June-July, September-October

Irrigated crops: October-November (for uplands) and January-February (for low lands)

Varieties

Improved varieties: H-41, H-42, Sree Nandini, Sree Vardhini, Sree Retna, Sree Bhadra, Kanjanghad, Sree Arun, Sree Varun

Local varieties: Badrakali Chuvala, Kottayam Chuvala, Chinavella, Chakaravalli, Anakomban,

Preparation of land

Work the soil to a fine tilth by ploughing or digging to a depth of 15-25 cm. Take ridges 25-35 cm high, 60 cm apart for planting vines.

Seeds and sowing

Sweet potato is propagated by means of vine cuttings. To obtain vine cuttings, raise nurseries from selected tubers using the following method. 80 kg of medium sized weevil free tubers (each of 125-150 g) are required for planting in the primary nursery area (100 m^2 to plant one hectare).

Plant the tubers at a spacing of 30-45 cm on ridges formed 60 cm apart in the primary nursery and multiply by planting the cuttings after 45 days on ridges in secondary nursery of

about 500 m^2 area at a spacing of 25 cm. Apply 25 kg of poultry manure /100 m^2 about 15 days after planting in the primary nursery. To ensure better plant growth in the secondary nursery, 80 kg of poultry manure or 40 kg of poultry manure + cow dung slurry has to be applied in two split doses on 15th and 30th day after planting. Vines obtained from the freshly harvested crop can also be multiplied by planting in the secondary nursery to obtain sufficient planting material. Cuttings from the apical and near apical portions of the vines are preferred for planting in the main field. Sweet potato vine cuttings with intact leaves are bundled, dipped in water, covered with banana leaves and kept under shade for two days prior to planting. Irrigate the nursery on every alternate day during the first 10 days and once in 10 days, thereafter. Vines will be ready for planting on the 45th day.

In the main field, plant vine cuttings of 20-25 cm length on ridges 60 cm apart and at a spacing of 15-20 cm between the vines. The cuttings can also be planted on mounds taken at a spacing of 75cm x 75 cm. On the top of each mound, 3-4 cuttings can be planted. Plant the vine cuttings with the middle portion buried deep in the soil and the two cut ends exposed to the surface. Ensure sufficient moisture in the soil for early establishment of the planted cuttings. Provide adequate drainage and prevent water logging.

Manuring

Apply cattle manure or compost @ 10t / ha at the time of preparation of ridges or mounds and 7.5t FYM / 3t poultry manure / 4t vermi compost / 4t coirpith compost + 1 t ash / ha along with *Azospirillum* (2kg/ha) and P solublising organisms (2kg/ha) or PGPR mix I (2.5 kg/ha) in two equal split doses at 2weeks and 5 weeks after planting. Inoculate AMF at the time of planting and dip vines in PGPR mix I before planting.

Irrigation

When grown as irrigated crop, provide irrigation once in 2 days for a period of 10 days after planting and thereafter once in 7-10 days. Stop irrigation 3 weeks before harvest. But one more irrigation may be given 2 days before harvest.

Aftercultivation

Conduct two operations about 2 weeks and 5 weeks after planting. The top dressing with organic manures (2 t/ha) may be done along with the second weeding and earthing up. Prevent development of small slender tubers at the nodes by turning the vines occasionally during active growth phase.

Rotation and mixed cropping

Under irrigated condition , sweet potato can be rotated with rice and planted during December-January after harvest of the second crop of rice. As a mixed crop, it can be grown along with colocasia, amorphophallus etc. Under rainfed conditions, green manure crops such as kozhinjil and sunnhemp can be grown after the harvest of sweet potato and later incorporated into the soil at the time of land preparation for the succeeding crop.

Plant protection

Sweet potato weevil

1) Remove and destroy the crop residues of the previous crop.
2) Use healthy and weevilfree planting materials.
3) Apply *Eupatorium odoratum* leaves as mulch @ 3 t/ha at 30DAP.
4) Trap adult weevils using sweet potato tuber pieces (of about 6 cm diameter) of 100 g size, kept at 5 m apart during 50 to 80 DAP at 10 days interval. Tubers may be cut and kept inside wire cages to avoid rat damage.
5) Use pheromone traps (3Z Dodecenyl 2E butenoate).

Harvesting

The duration of the crop depends on the variety; but in general, the crop can be harvested in about 3.5-4 months after planting. Harvest the crop when leaves begin to turn yellow and the tubers mature. The maturity of tuber can be ascertained by cutting fresh tubers. The cut surface will dry clear if the tuber is mature and becomes dark green if immature. Harvest the crop by digging out the tubers without causing injury.

TAPIOCA [CASSAVA] (*Manihot esculenta*)

Tapioca grows and produces best under warm humid tropical conditions where rainfall is well distributed and fairly abundant. It can also be grown under irrigation where rainfall is low. Its outstanding characteristic in terms of moisture requirements is the ability to withstand fairly prolonged periods of drought. However, at the time of planting there must be sufficient moisture for the plant to establish itself. The crop cannot withstand cold and is killed by frost.

The crop grows well in well-drained laterite, gravelly and sandy loam soils. Heavy and rocky soils are less suitable because they restrict root development. The crop cannot survive waterlogged conditions and in such areas, it must be planted on mounds or ridges that permit drainage. The crop can also be gown on hill slopes and on wastelands of low fertility.

Varieties

M-4*:* This is an erect type with excellent cooking quality having 10 months duration. The starch content is 29%.

H-97: This is a semi-branching variety, tolerant to mosaic disease with duration of 10 months. But the harvest can be prolonged even up to 16 months. The starch content is 30%.

H-165: This is a non-branching type with poor cooking quality having eight months duration. It is tolerant to mosaic but susceptible to wilt disease. The starch content is 24.5%.

H-226: This is a semi-branching type with medium cooking quality having 10 months duration. It is moderately susceptible to mosaic. The starch content is 29%.

Sree Visakham: This is a semi-branching type with yellow coloured flesh having 10 months duration. It shows high tolerance to mosaic and low susceptibility to pests like red mites, scale insects, thrips etc. The starch content is 26% and vitamin A 466 IU.

Sree Sahya: This is a predominantly semi-branching type with 10 months duration. It shows high tolerance to mosaic and low susceptibility to pests like red mites, scale insects, thrips etc. The starch content is 30%.

Sree Prakash: This has seven months duration and the yield potential is 30-40 t/ha.

Kalpaka: This is a non-branching type with six months duration and is suited as an intercrop of coconut in reclaimed alluvial soils of Kuttanad.

Sree Jaya: This is an early variety with seven months duration and excellent cooking quality. Tuber contains 24-27% starch and is low in cyanogens.

Sree Vijaya: This is an early variety with 6-7 months duration and excellent cooking quality. Tuber contains 27-30% starch and is low in cyanogens.

Sree Harsha: This has 10 months duration and good cooking quality. Tuber contains 34-36% starch. They are non-bitter and ideal for culinary purposes and the high starch content makes it suitable for preparing dried chips.

Nidhi: This is a high yielding early variety with 5.5-6 months duration. It is tolerant to mosaic and moisture stress. Tuber contains 26.8% starch and 20 ppm HCN.

Vellayani Hraswa*:* High yielding early variety with 5-6 months duration. It cannot tolerate drought. The cooking quality is very good. Tubers contain 27.8% starch and 53 ppmcyanogen.

Sree Rekha: It is a top cross hybrid with 10 months duration. Tubers contain 28.2% starch with excellent cooking quality.

Sree Prabha: It is a top cross hybrid with 10 months duration. Tubers contain 26.8% starch with good cooking quality.

Sree Padmanabha: This is a mosaic tolerant variety.

Preparation of land

Plough the field 2-3 times or dig to a depth 25-30 cm depending upon soil type to establish a deep porous field in which the setts are to be planted.

Planting material

Tapioca is propagated from stem cuttings. Harvested stems of the previous crop are to be stored vertically under shade in well-aerated places. At the time of planting, select mature healthy stems free from pests and diseases. Discard about 10 cm of the lower mature end and about 30 cm of the upper immature end. Cut the stems into setts of 15-20 cm length using a sharp knife. About 2000 stems are required for planting one hectare.

Season and planting

The main planting seasons are April-May with the onset of southwest monsoon and September-October with the onset of northeast monsoon. Planting can also be done during February-April, provided sufficient moisture can be made available through irrigation. For maximum tuber production, April-May planting is preferred because the crop can effectively utilize both the monsoons. The second best season is September-October.

Pit, flat, ridge or mound method of planting can be adopted depending upon soil type, topography of land and elevation so that water logging is avoided. Pit followed by mound is found to be the best method of planting. Plant the cuttings vertically after smoothening the lower cut end, at a depth not exceeding 4-6 cm. Adopt square method of planting at a spacing of 90cm x 90 cm @ one cutting per pit / mound. It is preferable to adopt 75cm x 75 cm spacing for non-branching varieties like M-4.

Gap filling should be done within 15 days after planting preferably with longer setts of 40 cm length. Sree Visakham is a variety suitable for as intercropping in coconut gardens.

Manuring

For local varieties, along with cattle manure or compost @12.5t/ha, *Azospirillum* (2kg/ ha) and P solublising organisms (2kg/ha) may be applied at the time of planting the setts.

For high yielding varieties, cattle manure or compost may be applied @ 12.5 t/ha during the preparation of land or while filling up the pits so as to provide about 1 kg of organic manure per plant. *Azospirillum* (2kg/ha) and P solublising organisms (2kg/ha) or PGPR mix I have to be applied along with FYM at the time of planting the setts. In low lands, FYM@ 12.5t/ha can be replaced by poultry manure@ 5t/ha. Sow green manure seeds (cowpea/ sunnhemp) @ 30kg/ha at the time of planting the setts with the receipt of pre monsoon showers. 10 kg rock phosphate/ha has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) uproot and incorporate the green manure plants, along with 5t FYM / 2t poultry manure / 2.5t vermi compost / 2.5t coirpith compost + 500 kg ash. If *insitu* green manuring is not possible it can be substituted with 6.25 t FYM and 500 kg ash per ha. Inoculate AMF at the time of planting.

In laterite soils, rock dust from quarry @ 3t/ha along with 12.5t/ha FYM can meet the full requirement of nutrients for cassava.

After cultivation

Keep the field free of weeds and maintain soil loose by 2-3 shallow diggings or hoeing upto 90 days after planting followed by light earthing up. Retain two shoots on each plant in opposite directions and remove excess shoots about 30 days after planting.

Irrigation

Under conditions of well-distributed rainfall, tapioca grows well as a rainfed crop and irrigation is not necessary. However, the crop has to be irrigated to provide sufficient moisture under conditions of prolonged dry periods after planting. For high yield irrigate the crop

Intercropping in tapioca

Tapioca is planted at a spacing of 90cm x 90 cm and it takes about 3-3.5 months to develop enough canopy to cover the land. So it is possible to have an intercrop of groundnut during the early stages of tapioca crop. Bunch varieties of groundnut like TMV-2, TMV-7, TG-3, TG-14 and Spanish Improved are preferred for intercropping in tapioca. The best season for sowing groundnut is May-June. Immediately after planting of tapioca setts, groundnut seeds are sown at a spacing of 30 cm between rows and 20 cm within rows, so that two rows of groundnut can be accommodated in between two rows of cassava. A seed rate of 40-50 kg/ha is recommended for dibbling one seed per hill. Only well-matured and bold seeds are to be selected for sowing. In acid laterite soils of Kerala, apply lime @1000 kg/ha of as basal dressing. Apply cattle manure or compost @12.5 t/ha + *Azospirillum* 2kg/ ha +Phosphorus solubilsing micro organism 2kg/ ha at the time of planting. One month after sowing of the seed, earthing up may be done. Once pod formation has started (i.e., 40-45 days after sowing) the soil should not be disturbed, as it will affect the pod development adversely. The groundnut crop matures in 105 to 110 days. After the harvest of pods, the haulms are incorporated in the soil. By adopting this practice, 20-25% additional income can be obtained.

In sandy areas intercropping tapioca with cowpea / groundnut / black gram / green gram may be recommended giving a spacing of 20 cm on both sides of the ridges. The non-trailing grain cowpea variety V-26 is recommended as a companion crop along with tapioca. For a pure crop of tapioca or for a cropping system involving tapioca as the main crop and the pulse crop suggested above, the field may be irrigated once in 36 days to a depth of 5 cm. This recommendation is for shallow water table situations. For deep water table situations, the crop may be irrigated once in 24 days to a depth of 5 cm.

Plant protection

Pests

Red spider mite and scale insects

Red spider mites in the field and scale insects under storage are important pests of tapioca. Under field conditions light infestation of mites can be controlled effectively by spraying the crop with water at 10 days interval from the onset of mite infestation. In the case of very severe infestation, spray *Clerodendron* decoction of 2% strength at monthly intervals from the time of appearance of mites.

Scale insects

As a prophylactic measure, the stem may be sprayed with *Clerodendron* decoction of 4% strength, before storing.

Termites

In places where termite attack is expected, use neem leaf along with FYM at the time of mound formation. Planting of arrowroot along ridges and mounds is a good repellant.

Rodents

To ward off rodents, plant *Plumbago* (Citraka) cuttings randomly on mounds. Along the borders planting two rows of ginger/turmeric to ward off rodents. Also practice baiting and trapping.

Diseases

Cassava mosaic disease (CMD)

The disease is transmitted by a white fly *Bemisia* sp. Alternate light and green patches are seen on the foilge. The affected leaves become crinkled and distorted. As a rule, only stem cuttings from disease free plants should be used for planting to minimize the spread of the virus disease. For this purpose, tagging of disease free healthy plants for selection as planting materials must be practiced from September to December. All plants showing even very mild symptoms must be rejected. Mosaic tolerant varieties such as H-97 and Sree Padmanabha may be used to minimize economic loss of tubers.

Production of disease free planting material of tapioca through nursery techniques

Setts with 3 to 4 nodes from apparently disease free plants are collected and planted in the nursery at a very close spacing of 4cm x 4 cm so that about 500 setts can be accommodated in one square metre land. Daily watering of the setts has to be done for the first 10 days and on alternate days thereafter. Screening of CMD symptoms may be started 10 days after planting. Setts showing even mild symptoms are to be removed and burnt. This must be continued up to 20-25 days, by that time healthy sprouted cuttings can be transplanted to the main field. Supplementary irrigation may be given in the transplanted field till they get established. Screening for disease symptoms and rouging of infested plants may be continued in field at weekly intervals up to harvest. The selected healthy stems are again cut into minisetts and subjected to nursery and field screening. By adopting this technique it is possible to produce healthy plants.

Leaf spot

Spray 1% Bordeaux mixture for control of leaf spot.

Bacterial blight

Bacterial blight is a disease noted in severe proportion in certain parts of Kerala. Use of resistant or tolerant varieties is the only method of control. Among improved varieties, H-97, H-226, H-1687 and H-2304 are tolerant to the disease while H-165 is highly susceptible. Among the local varieties, M-4, Paluvella, Pichivella, Parappilppan, Anamaravan etc. are tolerant to the disease.

Harvesting

Tapioca becomes ready for harvest 9-10 months after planting. Hybrid varieties like H-226, H-97 and H-165, when grown under recommended management practices have recorded yields up to 40-50 t/ha of raw tuber. The local varieties and M-4 yield on an average 12-14 t/ha of tuber.

Management of storage pests of cassava

Treating chips with granular salt (3%), sun drying thoroughly and storing in gunny bags in godown are very effective against *Araecerus fasciculatus* and *Sitophilus oryzae*.

COLEUS (*Solenostemon rotundifolius*)

Coleus thrives well in tropical and subtropical regions. A well –drained medium fertile soil is suitable for its cultivation.

Season

Plant the cuttings in the main field between July and October.

Variety

Nidhi and Sreedhara

Nursery

Raise the nursery approximately one month before planting. An area of 500 to 600 m^2 is sufficient to produce cuttings required for one hectare of main field. Apply 125 to 150 kg FYM in the nursery area. Plant the seed tubers at a spacing of 15 cm on the ridges taken 30 cm apart. About 170 to 200 kg of tubers is required to raise the nursery. Take the vine cutting to a length of 10-15 cm from the top portion after three weeks from planting.

Preparation of main field

Plough or dig the land to a depth of 15-20 cm and from ridges at 30cm apart or raised beds of 60-90 cm width.

Planting

Plant the vine cuttings collected from the nursery on ridges at a spacing of 30 cm or on raised beds at 30cm x 15 cm spacing.

Manuring

Apply cattle manure or compost @10 t/ha at the time of preparation of ridges and 6t FYM / 2t poultry manure/ 2t vermi compost / 2t coirpith compost + 2 t ash /ha at 45 DAP along with PGPR mix I (2.5 kg).

Application of rock dust 10t/ha along with FYM 10t/ha can be recommended as basal dose for coleus in red soils of Kerala without any additional quantity of manure.

After cultivation

Conduct weeding and earthing up at 45 days after planting along with topdressing. Cover a portion of the vine with soil to promote tuber formation.

Plant protection

Root-knot nematode

Plough the field deeply in summer and destroy root residues and other plant parts by burning. Adopt crop rotation with tapioca or sweet potato. Application of neem cake is suited for this crop to reduce the incidence of root knot nematode

Harvesting

Harvest the crop 5 months after planting.

ARROW ROOT (*Maranta arundinacea*)

Rhizomes are used for the production of starch. Starch grains are small and easily digestible. Hence it can be used as food for infants. It has also medicinal value against dysentery etc.

Propagation

It is propagated vegetatively by rhizomes. Healthy disease free rhizomes with at least one germinated sprout are the planting material. Take small pits at 50cm x 30 cm spacing on the seed bed and plant seed rhizomes with germinated sprout facing upwards. Cover the rhizomes with farm yard manure and mulch the bed with leaves or straw. Weeding is done 2 or 3 times along with earthing up and mulching.

Planting arrowroot rhizome pieces under partially shaded condition as existing coconut garden during May-June at a spacing of 30cm x 15 cm on raised flat beds results in higher rhizome yield (45.00t/ha) and starch yield (7.00t/ha). Mulching using locally available plant materials like green leaves, dried leaves or coconut fronds immediately after planting improves yield.

Apply cattle manure or compost @ 10 t/ha at the time of land preparation and 5t FYM / 2t poultry manure / 2t vermi compost / 2t coirpith compost + 1 t ash /ha along with *Azospirillum* and P solublising organisms each @2kg/ha or PGPR mix I.

The crop matures in 7 months. Drying up of leaves is the indication of maturity. Dig out rhizomes without damage. Remove the dry leaves and roots. The cleaned rhizomes are either marketed or dried and stored.

PLANTATION CROPS AND SPICES

COCONUT (*Cocos nucifera*)

Coconut requires an equatorial climate with high humidity. The ideal mean annual temperature is 27ºC with 5-7ºC diurnal variation. The palm does not withstand prolonged spells of extreme variations. A well-distributed rainfall of 1300-2300 mm per annum is preferred.

Coconut is grown in different soil types such as laterite, coastal sandy, alluvial, and also in reclaimed soils of the marshy lowlands. It tolerates salinity and a wide range of pH from 5.0-8.0. Organic farming practices have to be adopted to suit the varying climatic and soil conditions.

Selection of site

Select sites with deep (not less than 1.5 m depth) well drained soil. Avoid shallow soils with underlying hard rock, low-lying areas subject to water stagnation and heavy clayey soils.

Cultivars

1. West Coast Tall (WCT)
2. Lakshadweep Ordinary (Chandrakalpa)
3. Philippines Ordinary (Kerachandra)
4. Andaman Ordinary
5. Java
6. Cochin China
7. Kappadam
8. Komadan

Hybrids

1. Lakshaganga (Lakshadweep Ordinary x Gangabondam)
2. Anandaganga (Andaman Ordinary x Gangabondam)
3. Keraganga (West Coast Tall x Gangabondam)
4. Kerasankara (West Coast Tall x Chowghat Orange Dwarf)
5. Chandrasankara (Chowghat Orange Dwarf x West Coast Tall)
6. Kerasree (West Coast Tall x Malayan Yellow Dwarf)
7. Kerasoubaghya (WCT x SSA)
8. Chowghat Green Dwarf x West Coast Tall
9. Chandralaksha (Lakshadweep Ordinary x Chowghat Orange Dwarf)

***Tender nut variety*: Chowghat Orange Dwarf**

Note: (1) Hybrids Anandaganga, Keraganga and Kerasankara are recommended for general cultivation both under rainfed and irrigated conditions.

(2) Other hybrids especially Chandrasankara are recommended for ideal situations and where good management practices are adopted.

(3) Since the performance of Chandrasankara is markedly superior to that of WCT in root (wilt) affected areas, cultivation of Chandrasankara is preferred in such areas.

(4) Chandralaksha, Lakshaganga and Chandrakalpa are recommended for cultivation under drought prone areas.

Selection of mother palms

Select mother palms having the following characters:

1. Regular bearing habit and yielding not less than 80 nuts / annum.
2. Age 20 years or more (5 years after reaching full bearing capacity).

   If the mother palms are the progeny of elite planting material and gives consistently higher yields for a period of not less than 6 years, seed nuts can be collected from such palms. There is no need for insisting 20 years as minimum age for mother palms in such conditions.
3. More than 30 fully opened leaves with short strong petioles and wide leaf base firmly attached to the stem.
4. Bearing at least 12 bunches of nuts with strong bunch stalks.
5. Bearing nuts of medium size and oblong shape.
6. Husked nuts should weigh not less than 600 g.
7. Mean copra content of 150 g per nut or more.

Avoid palms which

(i) have long, thin and pendulous inflorescence stalks

(ii) produce long, narrow, small sized or barren nuts

(iii) show shedding of immature nuts in large numbers and

(iv) are grown under favourable environmental conditions.

Collection and storage of seed nuts

Collect mature nuts (above 11 month old) during the period from December to May. Lowering of bunches by means of ropes may be done when the palms are tall and ground is hard. Discard nuts, which show improper development or other undesirable features. Store seeds in shade for a minimum period of 60 days prior to sowing in nursery. For storing, arrange the seed nuts with the stalk-end up over an 8 cm layer of sand in a shed and cover with sand to prevent drying of nut water. Up to five layers of nuts can be arranged one over the other. The nuts can also be stored in plots, provided the soil is sandy and the ground is sufficiently shaded. In the case of nuts harvested in May, heap them in partial shade, till husk is well dried and then sow them in the nursery.

Selection and preparation of site for nursery

Nursery sites should be well drained with light textured soil and with adequate but not too much shade. In open areas, provide shade during summer. Prepare beds of 1.5 m width and of convenient length with 75 cm space between beds. In areas where drainage is poor, prepare raised beds.

Before planting, examine seed nuts and discard those without nut water and rotten kernels. Sow the nuts in the nursery after commencement of southwest monsoon during May-June.

Spacing of nuts

Plant the seed nuts at a spacing of 30 cm (between rows) x 30 cm (between nuts) with four or five rows per bed.

Method of planting seed nuts

Plant the seed nuts in the beds in trenches 25-30 cm deep and cover with soil so that top portion of husk alone is visible. The nuts may be planted either horizontally with the widest of the segments at the top or vertically with stalk-end up. Vertical planting is preferable on account of convenience in transporting and lesser risk of seedling injury.

Care and management of nursery

Provide protective fencing to the nursery if it is located in open area. If the soil is sandy, provide mulching immediately after the cessation of monsoon rain. Irrigate the nursery once in two days during summer months. Keep the nursery beds free of weeds by periodic weeding. If termite is noticed, remove soil in the affected area up to a depth of about 15 cm and dust soil and nuts with small quantity of sodium chloride. Repeat if attack persists. Periodically spray the plants with 1% Bordeaux mixture to prevent fungal infection.

Selection of seedlings

Remove seed nuts, which do not germinate within 6 months after sowing as well as those with dead sprouts. Select only good quality seedlings (9-12 months old) by a rigorous selection based on the following characteristics.

1. Early germination, rapid growth and seedling vigour.
2. Six to eight leaves for 10-12 month old seedlings and at least four leaves for 9 month old seedlings.
3. Collar girth of 10-12 cm.
4. Early splitting of leaves.

Note: The recovery of quality seedlings will be about 60-65%. Since early germination is one of the criteria for the selection of seedlings, the storing and sowing of seed nuts should be in lots rather than in a staggered manner.

Removal of seedlings

Remove seedlings from the nursery by lifting with spade and cutting the roots. Keep the seedlings in shade and do not expose to sun. Plant seedlings as early as possible after removal from nursery. Never allow lifting the seedlings from the soil by pulling the leaves or stem.

Preparation of land and planting of seedlings

The nature of preparation of land before planting depends upon topography of land, soil type and other environmental factors. On slopes and in areas of undulating terrain, prepare the land by contour terracing or bunding. In low-lying areas and rice fields, form mounds to a height of at least 1m above water level. In reclaimed kayal areas, planting can be done on the field bunds. The size of pits for planting would depend upon soil types and water table. In loamy soils with low water table, pit size of 1m x 1m x 1 m is recommended. In laterite soils with underlying rock, take larger pits of size 1.2m x 1.2m x 1.2 m. In sandy soils, the size of pits may be 0.75m x 0.75m x 0.75 m. The pits may be filled up with topsoil to a height 60 cm below the ground level. In low lying lands, take shallow pits and as the plant grows, raise the ground level by adding silt and sand so as to cover the entire bole of the palm. The same procedure can be adopted when planting is done on mounds or bunds. Burial of two layers of husks in the floor of the pits will be useful for moisture conservation. The husk is to be buried in layers with concave surface facing upwards. After arranging each layer, sprinkle common salt on the husk to prevent colonization by termites.

Note: In lateritic areas, common salt at the rate of 2 kg per pit may be applied on the floor of the pit to improve soil conditions. Common salt is to be applied about six months prior to planting.

Spacing

Spacing depends upon the planting system, soil type etc. In general, the following spacings are recommended under different systems in sandy and laterite soils. In lateritic gravelly soils, under rainfed conditions of north Kerala, a closer spacing to accommodate 250 palms per ha is more economical.

Table 10.Spacing for coconut

Planting system	Spacing	Approximate number of plants/ha
Triangular	7.6 m	198
Square	7.6 to 9 m	170-120
Single hedge	5 m in the rows 9 m between the rows	220
Double hedge	5m x 5m in rows 9 m between pairs of rows	280

In the hedge system of planting, the rows should be aligned in north-south direction and the seedlings planted as in the triangular system.

Time of planting

Planting the seedlings during May, with the onset of pre-monsoon rains is ideal. Under assured irrigation, planting can be done during April also. In low-lying areas, plant the seedlings in September after the cessation of heavy rains.

Shading and irrigation

For the first two years from planting, irrigate @ 45 litres of water per seedling, once in 4 days, during dry summer months. Provide adequate shade to the transplanted seedlings.

Weeding and interculture

Keep the pits free of weeds by periodical weeding. Remove the soil covering the collar of seedlings. As the seedlings grow and form stem, fill up the pits gradually by cutting the sides. Proper intercultivation provides control of weeds and creates soil mulch. Any tillage system (ploughing, digging, raking or forming mounds) that provides soil mulch and control weeds may be followed depending upon local conditions. For laterite, sandy and red sandy loam soils give two ploughings or diggings in May-June and September-October and one raking in January. In areas where surface run off is more, form mounds in September-October and level them in November-December.

Drought management in coconut gardens

Coconut produces nuts round the year. Therefore, adequate supply of water is essential for its unhindered growth. Soil moisture is essential for the absorption of nutrients by roots. Moisture stress leads to stunted growth, drooping of leaves, immature nut fall and decreased yield. Importance may be given on the following aspects so as to ward off stress.

1. ***Husk burial for moisture conservation***

Burying of fresh or dried coconut husk around the palm is a desirable practice particularly for moisture retention. The husk can be buried either in linear trenches taken 3 m away from the trunk between rows of palms or in circular trenches taken around the palm at a distance of 2 m from the trunk. The trenches may be of 0.5 m width and depth. The husks are to be placed in layers with concave surface facing upwards and covered with soil. The beneficial effect of husk burial will last for about 5-7 years. Instead of husk, coconut pith can be buried @ 25 kg / palm / year.

2. *Mulching*

Mulching is an effective method of conserving soil moisture. Mulch the coconut basins with green / dry leaves at the close of northeast monsoon (October-November). Mulching also adds organic matter to the soil and reduces the soil temperature. Do not disturb soil in the coconut garden during summer months. In level lands, during rainy seasons excess water may be conserved in small trenches dug out in the plantation. In sloppy areas, land may be terraced and trenches dug across. This will facilitate maximum percolation of rainwater and water storage. For moisture conservation, lowermost 3-5 leaves may be cut and removed. Provide adequate shade for the transplanted seedlings for 1-2 years. To minimize the heat load on the stem, application of lime solution on the trunk up to a height of 2-3 m at the start of the summer season is recommended.

3. ***Green manure and cover crops***

Green manure and cover crops recommended for cultivation in coconut gardens are:

(a) Green manure crops: *Crotalaria juncea* (sunn hemp), *Tephrosia purpurea* (kolinji), *Indigofera hirsuta*, *Pueraria phaseoloides*.

(b) Cover crops: *Calapagonium muconoides, Mimosa invisa, Stylosanthes gracilis*

(c) Shade-cum-green manure shrub: *Tephrosia candida*

Sow green manure and cover crop seeds during April-May with the onset of pre-monsoon rains. The green manure crops should be ploughed in and incorporated into the soil during August-September. This will increase the water holding capacity of soil. *Calapagonium* can be grown either as green manure or cover crop. *Tephrosia* is especially suited for planting around seedling pits for summer shade and as a source of green manure in the rainy season.

Manuring of adult palms

Apply FYM /cowdung 50kg + ash 5kg + *Azosprillum* 200 g / palm / year or PGPR mix 1.

Note: 1. Under irrigated conditions, manures can be applied in 3-4 equal split doses.

2. In the case of low-lying areas, apply manures in one single dose after water table recedes or in two split doses as conditions permit.

3. The application of organic materials such as forest leaves, cattle manure, coir dust or coconut shredding @ 10 kg per pit along with PGPR mix I (100-200g) in the first three years will be useful to obtain better establishment of coconut palms in sandy soils and in coastal situations.

Time, frequency and method of application

Apply 1/3rd of the total dose during first year, 2/3rd during second year and full dose from third year onwards.

Under rainfed conditions, apply manures in two split doses, 1/3rd at the time of early southwest monsoon showers in April-June and 2/3rd in September-October.

Under irrigated conditions, apply manures in three or four equal doses in April-May, August-September, December and February-March.

Apply lime or dolomite during April-May, magnesium sulphate during August-September. For an adult palm 1 kg dolomite or 1 kg lime + 0.5 kg $MgSO_4$ is required per annum.

Apply manures in circular basins at a radius of 2.0 m from the base of the palm and 10 cm deep, opened after the onset of southwest monsoon. Split doses can be applied with irrigation water in summer months.

Recycling of palm waste

Recycling of palm waste is very much beneficial especially for maintaining the availability status of micronutrients and trace elements. Palm wastes like coconut leaves, crown waste,

dried spathes, husk etc. may be deposited in a small trench of convenient length, 0.5 m to 0.75 m wide and 0.3 to 0.5 m deep at a distance of 2-2.5 m away from the base of the trunk. Fill up this trench with the palm wastes along one side of the palm (say north) in one year, opposite side (south) in the next year, east in the third year and so on. This practice of organic recycling of waste has been found to improve the growth and productivity of the palms.

Intercropping and mixed cropping

Schedules for inter/mixed cropping may be drawn up based on the canopy size, age and spacing of palms. In general, palms in the age group of 8-25 years are not suitable for inter and mixed cropping. However, cereals and tapioca are recommended as intercrops in young coconut plantation up to 3-4 years. Since ginger and turmeric are shade tolerant crops with shallow roots, they can be intercropped in coconut garden even in the age group of 15-25 years. It ensures better land utilization, solar energy harvesting, efficient water use, utilization of soil nutrient resources, more returns and an insurance against crop failure. Under conditions of wider spacing i.e. beyond 7.6 m, intercropping is possible irrespective of the age of the palms.

The following crops are recommended as intercrops:

Cereals: Rice, maize

Legumes and pulses: Groundnut, horsegram, cowpea

Tubers: Tapioca, sweet potato, yams, colocasia

Spices: Ginger, turmeric, chilly, pepper, nutmeg, cinnamon, clove

Fruit plants: Banana, pineapple, papaya (Banana variety Palayankodan is recommended in the reclaimed soils of Kuttanad. Three suckers per clump have to be retained).

Beverage crop: Cocoa

Fodder grasses: Hybrid Napier, guinea grass

In all cases, separate application of adequate manures to the individual crop is essential.

Crop cafeteria for multiple cropping in coconut garden

Perennials: Cocoa, nutmeg, pepper, clove, lemongrass and cinnamon.

Annuals:

(a) *Kharif*: Rice, maize, groundnut, ginger, turmeric, chilli, yams, colocasia,redgram, vegetables, sweet potato, tapioca, banana, pineapple, papaya and fodder grass.

(b) *Rabi*: Sesame, horsegram, redgram, vegetables, cowpea, sweet potato and banana.

(c) Summer: Vegetables

Irrigation

Irrigate the palms during summer months in basins around palms as shown below:

Table 11.Irrigation requirement of coconut

Parameters	Soil texture			
	Sandy	Sandy loam	Loam	Silty clay
Available soil moisture (cm/m)	8	12	17	21
Quantity of water / irrigation / palm in litres in a basin of 1.8 m radius	600	900	1300	1600
	Frequency of irrigation (days)			
All areas in Kerala except north eastern portion of Thrissur and Palakkad districts	3-4	5	7-8	9
North eastern portion of Thrissur and Palakkad districts	2-3	3-4	5-6	6-7

Note: In coastal sandy soils, seawater can be used for irrigation. In irrigated gardens, interruption of irrigation would lead to serious set back in yield and general condition of palms. Hence, when once started, irrigation should be continued regularly and systematically. In sandy loam soil, irrigating the crop with 500 litres of water through basin taken at 1.5 m radius at an interval of 15 days is most economical. Do not irrigate seedlings and very young palms with seawater.

Drip irrigation

In the traditional system of irrigation followed in coconut gardens such as flood irrigation, basin irrigation etc. irrigation efficiency is only 30 to 50 per cent due to considerable wastage of water. In addition, cost on inputs like labour and energy in adopting these systems are high. Scarcity of water and increasing cost of labour and energy are deterrents in adopting these traditional irrigation systems. Under these circumstances, drip irrigation is the most suitable system of irrigation to coconut. Some of the major advantages of drip irrigation are: it saves water, enhances plant growth and yield, saves energy and labour, most suited for soils having low water holding capacity and undulating terrain, reduces weed growth and improves efficiency of fertilizers. For coconut, generally, three to four drippers are given per palm. The water requirement for an adult palm is 40 to 50 litres per day.

D x T hybrid production

The following guidelines are suggested for large-scale production of D x T hybrid seedlings. Assisted pollination should be done to get maximum hybrid nut production. As far as possible use prepotent palms as parents in the hybridization programmes.

Selection of mother palms

Palms with the following phenotypic character combination may be selected for hybridization work.

1. Nuts without ridges and having yellow, orange or red colour.
2. Palms with overlapping female and male phases.
3. Small crown and canopy compared to that of tall palm.
4. Narrow stem without any bulging at the base with close leaf scars.

Hybridization

1. Use mixed pollen from identified tall palms.
2. Emasculate the inflorescence by cutting the male flowers with scissors and stripping if necessary within 5-7 days of opening the spathe.
3. Cloth bags made of very close mesh should be used for covering the inflorescence.
4. Dusting of pollen-talc mixture in 1:9 proportion using pollen dispensers is recommended.
5. Assisted pollination for at least 3-5 days on each inflorescence till last female flower becomes receptive and fully pollinated.
6. Remove bags after the seventh day of pollination of the last female flower.

Nursery

The nuts should be harvested before it is tree-ripe and sown immediately in the bed without storage. Nursery beds should be mulched or shaded and watered regularly and adequately.

Plant protection

Button shedding

The shedding of buttons in the coconut is attributed to the following reasons.

1. Pathological conditions
2. Attack of insect pests
3. Nutritional deficiencies
4. Soil and climatic variations
5. Defects in pollination and fertilization
6. Structural defects in the flower
7. Abortion of embryos
8. Limited capacity of the tree to bear fruits
9. Unfavourable conditions such as deficit of moisture, waterlogging and lack of aeration.

The causes of button shedding may be identified and appropriate remedial measures adopted.

Pests

Rhinoceros beetle *(Oryctes rhinoceros)*

Symptoms

The adult beetle bores into the unopened fronds and spathes. The attacked frond when fully opened shows characteristic triangular cuts.

Prophylactic / control measures

1. Provide field sanitation to prevent breeding of beetles.
2. Hook out the beetles from the attacked palms by using beetle hook
3. The topmost three leaf axils around the spindle may be filled with 250g neem cake or marottti (*Hydnocarpus wightina*) cake mixed with equal volume of sand in the innermost 2-3 leaf axils as a prophylatic measure. This treatment is to be done twice, ie, during April-May before the onset of south-west monsoon and during September-October after the south –west monsoon.
4. Dust manure pit walls with lime powder and plaster with cow dung.
5. Boil castor cake and groundnut cake with a little quantity of water. Keep in earthern pots near light source to attract beetles, which can be collected and killed.
6. Mix sand (250g) and neem seed powder (100g) and fill inner leaf sheaths of youngest leaves.
7. Apply roots, shoots, leaves and flowers of *Clerodendron infortunatum (peruvalam)* with cowdung in manure pits. Fresh plant or shade dried plant mixed with cowdung in the ratio 1:10.
8. Release *Baculovirus oryctes* infected adults @ of 10-15 / ha to bring down the pest population.
9. Inoculation of breeding sites with entomopathogenic fungus *Metarrhizium anisopliae var. major* (@ 5×10^{11} spores / ml) gives effective control.

Red palm weevil *(Rhyncophorus ferrugineus)*

Symptoms

The diagnostic symptoms are the presence of holes on the stem, oozing out of a viscous brown fluid and extrusion of chewed up fibrous matter through the hole, longitudinal splitting of leaf base and wilting of central shoot. Sometimes the gnawing sound produced by the feeding grubs inside will also be audible.

Control

1. Field sanitation should be given prime importance.
2. Avoid making steps or any other injury on the tree trunks to reduce the loci of infestation.

3. Leaf axil filling as suggested in the case of rhinoceros beetle will be useful against the red palm weevil also.
4. When green leaves are cut from the palms, stumps of not less than 120 cm may be left on the trees in order to prevent successful inward movement of the grubs through the cut end.
5. Clean the crown periodically before and after rain.
6. Mix sand and nerium seed powder and fill the bore holes.
7. Coconut log traps with fermenting toddy or pineapple or sugarcane activated with yeast or molasses can be set in coconut plantation to attract and trap the free floating population of red palm weevil. Incorporate any of the insecticides to each trap to kill the weevils trapped.
8. Use of pheromone trap for attracting and killing adult weevils @ one trap per 2 ha.

Leaf eating caterpillar *(Opisina arenosella)*

Symptoms

The caterpillar feeds on green matter from the lower leaf surface, remaining within galleries of silk and frass. The attack will be severe during summer months from January-May.

Control

1. As a prophylatic measure, the first affected leaves may be cut and burnt during the beginning of the summer season.
2. Arrange for the release of larval / pupal parasitoids, *Goniozus nephantidis, Elasmus nephantidis* (brown species) and *Brachymeria nosatoi.*
3. Mix extract of 2 kg neem seed kernel and 200 g soap in 200 litres of water and spray followed by the release of larval pupal parasites.

Cockchafer beetle *(Leucopholis coneophora)*

Symptoms

The soil inhabiting white grubs cause damage to the roots of coconut palm. The attack is common in sandy tracts. The infested palms turn pale yellow and there will be considerable reduction in yield.

Control

1. Collection and destruction of adults during the monsoon period from adjacent vegetation (in the evening).
2. Plough or dig the infested soil synchronizing with pre-monsoon showers.
3. Apply sugar solution in coconut basin near root zone.

4. Leaf loppings of *Anacardium occidentale, tamarindus indica* and *tectona grandis* and drenching with cashew nut shell liquid (CSNL) solution (2% v/v) is effective against root grub.

Note: Wherever possible, light traps may be set up to attract and trap adult beetles.

Coried bug *(Paradasynus rostratus)*

Symptoms

The attacked buttons become deformed with characteristic crevices on the husk below the perianth with gum exudations and the tender nuts become barren.

Control

Grow neem as alternate host to attract the bugs and destroy the bugs.

Coconut eriophyid mite *(Aceria [Eriophyes] guerreronis)*

Coconut eriophyid mite is a microscopic worm like mite infesting young buttons colonizing under the perianth.

Symptoms

The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth. Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk. Uneven growth results in distortion and stunting of nuts leading to reduction in copra yield. In severe cases, the losses are compounded because the quality of fibre is reduced and distorted nuts increase the labour requirements for dehusking.

Management

1. Collect and destroy all the fallen buttons of the affected palm.
2. Apply 2% neem oil + garlic emulsion or commercial neem formulation Azadirachtin 0.004% (Neemazal T/S 1% @ 4 ml per litre of water) or micronized wettable sulphur 0.4 % in the crown on young bunches. When rocker sprayer is used 1.0 to 1.5 litres of spray fluid per palm is required. If a hand sprayer is used, the spray solution required may be about 500 to 750 ml. Spraying has to be done on second to seventh bunch from top avoiding unpollinated inflorescence. Care should be taken to see that spray fluid reaches the perianth region of third, fourth and fifth bunch since these bunches harbour maximum number of mites. Three rounds of spraying are recommended in a year viz., March-April before the onset of southwest monsoon, in August-September during the dry spell between the southwest and northeast monsoons and in December-January after the northeast monsoon so that all the emerging bunches in the vulnerable stage receive one round of spraying.

As per the recommendation of the National Level Steering Committee, a holistic approach has to be adopted in the management of the coconut eriophyid mite. Hence, in addition to the plant protection measures mentioned above, the following measures can be adopted:

1. Improving nutrient status by applying organic manure at the rate of 50 kg and neem cake 5 kg per palm per year. Also apply the recommended dose of fertilizers in two split applications.
2. Growing compatible intercrops / mixed crops.
3. Providing adequate irrigation.

Mealy bug

Symptoms

Mealy bugs infest the unopened heartleaf and inflorescence. As a result, the leaves become highly stunted, suppressed, deformed and present a crinkled appearance. It is often confused with the leaf rot symptoms. The affected inflorescences are malformed and do not open. Even if they open, they do not bear nuts.

Button mealy bugs colonize under the perianth lobes of tender nuts. Infested nuts harbouring gravid mealy bugs remain on the spadix and the nuts never grow to proper size.

Control

Remove and destroy all dried up inflorescence and unproductive buttons. Neem garlic emulsion 2% applied on infested bunches checks button mealy bugs.

Rodents

Rats damage tender nuts by forming characteristic holes. Shed nuts can be seen at the base of the palm.

Control

1. Boil 10kg wheat and two large pieces of Glyricidia bark and broadcast in field as bait.
2. Mix gypsum and sugar and keep in places as bait where rats are frequent.
3. Take 1 part nerium seed powder + 9 parts rice +1 part coconut pulp + a little oil. Mix well and use as a bait.
4. Mix shrimp powder and cement (dry) and keep as bait. Pre baiting with shrimp powder alone will be more effective.
5. Use tin barrier around tree trunk to prevent rat damage.

Diseases

Bud rot *(Phytophthora palmivora)*

Symptoms

Palms of all age are liable to be attacked but normally young palms are more susceptible, particularly during monsoon when the temperature is low and humidity is very high. In seedlings, the spear leaf turns pale and comes off with a gentle pull. In adult palms, the first visible symptom is the colour change of the spear, which becomes pale and breaks at the base and hangs down. The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting a foul smell. The rotting slowly progresses downwards, finally affecting the meristem and killing the palms. This is accompanied by drooping of successive leaves. Even then, nuts that are retained on the palm may grow to maturity. The disease proves fatal if not checked at the early stages, before damage of the bud.

Management

1. In early stages of the disease (when the heartleaf starts withering) cut and remove all affected tissues of the crown.
2. Burn all disease-affected tissues removed from the palm.
3. Spray 1% Bordeaux mixture on spindle leaves and crown of disease affected as well as neighbouring palms, as a prophylatic measures. 4.Drench crown with *Pseudomonas fluorescence* 2% suspension or PGPR mix II.
5. Adopt control measures for rhinoceros beetle.
6. Provide adequate drainage in gardens.
7. Adopt proper spacing and avoid over crowding in bud rot prone gardens.

Mahali *(Phytophthora palmivora)*

Symptoms

Shedding of female flowers and immature nuts are the common symptoms of the disease. Lesions appear on the young fruits or buttons near the stalk, which later lead to the decay of the underlying tissues and endosperm.

Control

Spray 1% Bordeaux mixture on the crown of palms, once before the monsoon and once or twice later on at intervals of 40 days.

Root (wilt) disease

Symptoms

The characteristic symptom is the ribbing and flaccidity of leaflets. Yellowing of outer whorl of leaves, necrosis of leaflets and deterioration and decay of root system are other

salient features of the disease. The leaflets curve inwardly to produce ribbing so that the whole frond develops a cup like appearance. Abnormal shedding of buttons and immature nuts are also noticed.

Management

Coconut root (wilt) is a non-lethal debilitating disease and the affected palms survive for a long period giving a reasonably good yield. The root (wilt) affected palms are susceptible to diseases like leaf rot and pests like rhinoceros beetle and red palm weevil. So there is a chance of confusing the pests and disease symptom with the root (wilt) disease. Negligence on the management aspects aggravates the malady. Efficient management of palms suspected to be affected by coconut root (wilt) disease demands control of all pests and diseases and imparting natural resistance and health to the palms through proper manuring and agronomic practices. A package of practices for the effective management of root (wilt) disease is given below:

1. Rogue out palms that are affected severely by root (wilt) and that yield less than 10 nuts / palm / year and those, which have contracted the disease before flowering. Replant with disease tolerant material / high yielding hybrids (Chandrasankara).
2. Growing green manure crops like sunn hemp, sesbania, cowpea and calapagonium in the coconut basin and their incorporation *in situ* is beneficial as the practice reduces the intensity of the root (wilt) and increases the nut yield. The ideal green manure crops for the sandy and alluvial soils are cowpea and sesbania, respectively.
3. Apply manures in 10cm deep circular basins at a radius of 2 cm from the bole of the palm.
4. When the crop is grown under the bund and channel system, desilt the channel and strengthen the bunds during summer months.
5. Ensure proper drainage in the field during rainy season.
6. Follow strictly all the prescribed prophylactic measures against leaf rot disease, red palm weevil, rhinoceros beetle etc. so as to ensure that the palms are not debilitated. To maintain the productivity of the palms, prophylactic measures are of great importance. Apply Trichoderma + *Pseudomonas fluoroscence* so as to enhance the soil health. Irrigate the palms in soil month.

Package for severely affected areas

Apply FYM 25kg + coirpith compost 25kg + wood ash 5kg + kayal silt (if available) per coconut basin. Sow 35g of cowpea seeds per basin of 1m width and incorporate the biomass in the soil. Bury coconut husks of 25 coconuts in the basins and apply water.

Leaf rot *(Colleototrichum gleosporiodes, Exserohilum rostratum and Fusarium* spp.*)*

Symptoms

Appearance of water-soaked brown lesions in the spear leaves of root-wilt affected palms is the initial symptom. Gradually these spots enlarge and coalesce resulting in extensive rotting. As the leaf unfurls, the rotten portions of the lamina dry and get blown off in wind, giving a 'fan' shape to the leaves. Some times, the symptom becomes very acute and the spear fails to unfurl.

Management

1. Remove the rotten portions from the spear and the two adjacent leaves.
2. Spray crowns and leaves with 1% Bordeaux mixture in January, April-May and September. While spraying, care has to be taken to spray the spindle leaf.
3. Application of *Pseudomonas fluorescence* 2% suspension in the leaf at the initial stage of infection.

Stem bleeding (*Thielaviopsis paradoxa)*

Symptoms

Exudation of the reddish brown liquid through the growth cracks mostly at the basal part of the trunk above one meter from the basin are characteristic symptoms. One or more lesions, lying close by, may coalesce to form large patches. The liquid that oozes out dries up and turns black. The tissues beneath the bleeding points decay and become yellowish. The lesions spread upwards as the disease progresses. In advanced stages, the leaf size reduces leading to reduction in crown size. The rate of leaf production slows down. The production of bunches is affected and nut shedding takes place. The trunk gradually tapers towards the apex. The progress of the disease is faster during July to November.

Control

1. Chisel out the affected tissues completely and paint the wound with Bordeaux paste.
2. Destroy the chiseled materials by burning. Avoid any mechanical injury to trunk.
3. Apply neem cake @ 5 kg per palm in the basin along with other organics. Irrigate the palm during summer season and avoid water stagnation during rainy season.
4. Apply *Trichoderma* @ 50g/palm along with FYM.

Grey blight (*Pestalotia palmarum)*

Symptoms

Symptoms appear in the mature leaves of the outer whorl as yellow specks encircled by a greyish band which later become greyish white. The spots coalesce into irregular necrotic patches causing extensive leaf blight. In advanced stages, the tips and margins of the leaflets dry and shrivel giving a burnt appearance.

Control

Remove severely affected older leaves and burn. Spray the trees with 1% Bordeaux mixture.

Tanjore wilt (*Ganoderma lucidum)*

Symptoms

The characteristic symptom of the disease is the rotting of the basal portion of the stem. The bark turns brittle and often gets peeled off in flakes, leaving open cracks and crevices. The internal tissues are discoloured and disintegrated, emitting a bad smell. Mild bleeding occurs on the basal region. The tissues on the bleeding spots are soft to touch. Extensive damage of the root system following root rotting has been observed. Ultimately the palm dies off.

Control

1. Apply organic manure @ 50 kg / palm.
2. Apply neem cake @ 5 kg / palm / year.
4. Drench the basin with 40 litres of 1% Bordeaux mixture to soak soil up to 15 cm depth at quarterly intervals.
5. Avoid flood irrigation in order to prevent the possible spread of the pathogen through soil.
6. Isolate the affected palm from the healthy ones by digging a trench of size 1 m deep and 50 cm wide, 1.5 m away from the bole of the infected palm.
7. Avoid growing leguminous crops in and around the garden.

Safe storage of copra

Copra obtained from commonly cultivated varieties / cultivars is attacked by various insect pests in store. Among these ham beetle *Necrobia rufipes* and saw toothed grain beetle *Oryzaphilus surinamensis* are of major importance, which can cause more than 15% loss to copra when stored for more than six months.

Following precautions are to be taken for the safe storage of copra for more than three months:

(1) Dry the produce to four per cent moisture content.

(2) Avoid heap storage, which causes maximum damage.

(3) Store copra in netted polythene bags or gunny bags.

Shell fired copra dryer

A new type of dryer working on indirect heating and natural convection principles using coconut shell as fuel has been designed and developed by CPCRI. The overall dimension of the dryer is 2.25m length, 105m breadth and 1.5m height. The capacity of the dryer is 1000-1200 nuts per batch. The dryer has two heating chambers which are arranged in parallel. Specially developed rolling in type of fuel trays are used for burning the fuel. The dryer consists of a drying chamber, a burning chamber, a plenum chamber and ventilation holes. Each full tray produces heat for 6 hours, with a temperature of about 80-82o C. Generally after 6 hours, when the temperature drops below 600C, the fuel trays are removed from the dryer, cleaned and reloaded with fuel, refired and replaced into respective burning chambers. About 4 loads of fuel are required with a capacity of 80 shells per tray to dry the copra to about 6.25% moisture content. The total drying time is 24 hours. the cost of the dryer is approx. Rs 35,000/-. farmers and entrepreneurs interested to purchse this dryer can contact, Agricultural Technology Information Centre (ATIC), Central Plantation Crops Research Institute, Kasargode for further details.

CASHEW (*Anacardium occidentale*)

Cashew is adapted to warm humid tropical conditions. It can be grown in almost all types of soils from sandy to laterite and up to an elevation of 600-700 m including wastelands of low fertility. It grows and yields best in well-drained red sandy loams and light coastal sands. Heavy clay soils, poor drainage conditions, very low temperature and frost are unsuitable for the crop.

Selection of site

Organic cashew orchards, whether planted new or converted from existing orchards, should be isolated from the conventional orchards by a minimum distance of 500 m. Being a tree crop, a minimum period of three years is required for converting an existing cashew plantation in to organic. Since newly planted trees take 2-3 years for yielding, the nuts collected from the first harvest itself can be considered as organic.

Varietal choice

High yielding varieties recommended for the region is to be selected for new planting and re-planting. The varieties recommended for cultivation in Kerala are presented Table.By principle, preference is to be given for pest and disease resistant/ tolerant varieties. Unfortunately, none of the improved varieties are found to be resistant to major pests of cashew. However, Damodar is apparently tolerant to Tea Mosquito Bug. Likewise, Goa-11-6 (Bhaskara), released by National Research Centre for Cashew, Puttur is reported to perform well even under un-sprayed situations. A grouping of released cashew varieties according to their susceptibility to tea mosquito bug is furnished inthe table

Table 12. Varieties according to their susceptibility to tea mosquito bug

Varieties/ hybrid/types	Mean yield (kg/tree/ year)	Nature of bearing	Susceptibility status to TMB
Anakkayam-1 (BLA 139-1)	12.00	Early	Susceptible
moMadakkathara-1 (BLA 39-4)	13.80	Early	Moderately susceptible
Vridhachalam-3 (M 26/2)	11.68	Early	Moderately susceptible
Kanaka (H-1598) (BLA 139-1 x\H 3-13)	12.80	Mid	susceptible
Dhana (H-1608) (ALGD 1-1 x K 30-1)	10.66	Mid	Moderately susceptible
K-22-1	13.20	Mid	Moderately susceptible
Dharasree (H-3-17) (T 30 x Brazil 18)	15.02	Mid	Moderately susceptible
Priyanka (H-1591) (BLA 139-1 x K-30-1)	16.90	Mid	susceptible
Amrutha (H-1597) (BLA-139-1 x H 3-13)	18.35	Mid	Moderately susceptible
Anagha (H-8-1) (T 20 x K30-1)	13.73	Mid	Highly susceptible
Akshaya (H 7-6) (H4-7 x K30-1)	11.78	Mid	Moderately susceptible
Madakkathara-2 (NDR 2-1)	17.00	Late	susceptible
Sulabha (K 10-2)	21.90	Late	Moderately susceptible
Damodar (H 1600) (BLA 139-1 x H3-13)	13.36	Mid	Apparently tolerable
Raghav (H 1610) (ALGD-1-1 x K-30-1)	14.65	Mid	Moderately susceptible
Poornima (BLA 139-1 x K 30-1)	14.10	Mid	-

Planting materials

Cashew can be propagated by seedlings, air layers and softwood grafts. Since it is a cross-pollinated crop, vegetative propagation is recommended to obtain true to type progeny. Field establishment of air layers have been found to be poor. Hence softwood grafts, which give a high rate of establishment and early flowering, are recommended for planting.

1. Propagation by seedlings

Selection of mother trees

Select mother trees having the following characteristics:

(1) Good health, vigorous growth and intensive branching habit with panicles having high percentage of hermaphrodite flowers.

(2) Trees of 15-25 years of age.

(3) Bearing nuts of medium size and weight (5-8 g/nut) with an average yield of 15 kg nuts per annum.

(4) Bearing 7-8 nuts per panicle.

Selection of nuts

Select mother trees in February and collect seed nuts in March-April. Select good, mature, medium sized nuts, which sink in water as seeds after drying in sun for two to three days.

Raising seedlings

Raise seedlings in polythene bags during May. Use bags of size 20 cm x 15 cm and fill the bags with garden soil, leaving a gap of 1 to 1.5 cm above. Soak seed nuts in water for 18 to 24 hours to hasten germination. Sow the pre-soaked seed nuts in bags filled with garden soil at a depth of 2-3 cm with the stalk end up. Seeds germinate in seven to ten days.

2. Propagation by air layering

Prepare air layers during February-March, so that they will be ready for planting in June-July. Select 9-12 month old pencil-thick terminal shoots. Remove carefully a strip or ring of bark, 0.6 to 1.2 cm thick by using a sharp knife without injuring the underlying wood. Wind a string around the cut area and cover it with moist moss or wood shavings or sand and saw dust mixture or ordinary potting mixture and wrap round with 150-200 gauge polythene film of size 23 x 15 cm. Secure loose ends of film with jute fibre. When roots emerge from the ringed portion in 40-60 days, give a 'V' cut at lower end of treated shoot. After about 15 days, deepen the cut slightly. Cut and separate rooted shoot about 7 days later. Pot the layers immediately after separation from the tree into containers of size 15cm x 15 cm made from coconut husk and keep them in shade. Avoid excessive watering. Plant the layers along with the container in the prepared pits with the onset of southwest monsoon. Provide shade and mulch with dry leaves to reduce sun-scorch in tender plants. It is advisable to defoliate the layers two weeks before separation from the mother plant.

3. Propagation by grafting / budding

Different methods of grafting viz., epicotyl grafting, softwood grafting, veneer grafting, side grafting, patch budding etc. have been tried in cashew with varying degrees of success. Among them, softwood grafting was found to be the best for commercial multiplication of cashew.

Softwood grafting

Selection of seednuts

(1) Seed nuts may be collected during the peak period of harvest (February-March) and sun-dried for 2-3 days.

(2) Fresh seed nuts are to be used for raising rootstock. Seed nuts stored for more than one year may be avoided.

(3) Quality seed nuts may be selected by immersing in water or 10% saline solution. Seeds, which sink in water, may be selected.

(4) Medium sized nuts (7-9 g) may be selected to get vigorously growing seedlings.

Raising of rootstocks

1. Use polythene bags (size 25 cm x 15 cm, 300 gauge thickness) for raising root stocks
2. Make holes in the bags to ensure good drainage.
3. Prepare the potting mixture (1:1:1 ratio of red soil, river sand and compost) mixed with rock phosphate @ 5 g per 2 kg potting mixture. Perfectly solarised soil is to be used for the preparation of potting mixture. For the production of healthy grafts in the organic systems, it is advantageous to use 2 g *Trichoderma viride,* PGPR mix I (5g) and 10 g Mycorrhiza per bag. Combination of sand: soil: cowdung potting mixture mixed with PGPR mix I or *Azospirillum*+ PSB+AMF @ 10 g per bag is better for production of vigorous root stocks. Fill the bags up to the brim of the bag.
5. Sow the pre-soaked nuts in the centre of the bag with stalk end up, at a depth of 2.0-2.5 cm.
6. Water the bags immediately after sowing and daily thereafter. Avoid excess irrigation.
7. Nuts usually germinate within 15-20 days after sowing during monsoon months and within 8-10 days during dry months.
8. Nuts should be sown at weekly intervals to get continuous supply of rootstocks.
9. During summer, provide partial shade to the seedlings till they change their bronze colour to green and then keep them in the open.
10. The seedlings will be ready for grafting in 50-60 days after germination.
11. Prevent damage to germinating nuts from squirrels, birds etc.

Selection of rootstock

Select 50-60 day old healthy seedlings having single main stem grown in the centre of the bag, as rootstock.

Selection of scions

(1) Select a high yielding variety of cashew as a mother plant to collect adequate number of scions.

(2) Select 3-5 month old non-flowering lateral shoots of current season's growth.

(3) The selected scions should be 10-12 cm long, straight, uniformly round and pencil thick with brown colour having dormant plumpy terminal bud. The top 4-5 leaves should be dark green in colour indicating proper maturity of the scion.

Pre-curing

(1) Pre-cure the selected scions by clipping off three fourth portion of leaf blades.

(2) Scions will be ready for grafting in 7-10 days after leaf removal.

Collection of scions

(1) The pre-cured scions are to be cut early in the morning to avoid desiccation.

(2) The scions should be collected before the terminal buds sprout.

(3) Wrap scions in moist cloth and put in polythene covers as soon as they are cut from the mother tree and bring them to the nursery for grafting. If necessary, they can be stored for 3-4 days and used for grafting.

Preparation of rootstock

(1) Retain two pairs of bottom leaves and remove others from the selected seedlings using a sharp knife.

(2) Give a transverse cut on the main stem, 15 cm above ground level.

(3) A cleft of 4-5 cm deep is made in the middle of the decapitated stem of the seedling by giving a longitudinal cut.

Preparation of scion

(1) Select a matching scion stick (same thickness as that of the rootstock).

(2) The cut end of the scion is shaped to a wedge of 4-5 cm long by chopping the bark and wood from two opposite sides.

Grafting

1. The wedge of the scion is inserted into the cleft of the rootstock, taking care to ensure that the cambium layers of stock and scion are in perfect contact with each other.
2. The graft joint is secured firmly by polythene tape (1.5 cm wide and 30 cm long).
3. The scion of the graft is to be covered with a wet polythene cap (15cm x 12.5 cm, 100 gauge thickness) and tied at the bottom to maintain humidity inside and to protect the apical bud from drying. The polythene cap should not touch the terminal bud.
4. The grafted plants are to be kept under shade for 10-15 days to enable sprouting of the terminal buds.
5. The polythene caps are to be removed and the grafts shifted to open place. The successful grafts show signs of growth within 3-4 weeks after grafting.
6. The grafts will be ready for planting 5-6 months after grafting.
7. The success in softwood grafting is more during the period from March to September under Kerala conditions.

Care in the nursery

1. The grafts are to be watered regularly using a rose can or micro-sprinkler.
2. Remove new sprouts emerging from rootstock at frequent intervals.
3. Panicles, if produced by the grafts, may be removed as and when observed.
4. Shift the grafts frequently from one place to another to prevent them from striking roots into the ground.
5. Soil application of 100ml of decanted extract of fermented (two days) groundnut cake improves growth and vigour of grafts.

Graft production under polyhouse

Softwood grafts can be prepared almost throughout the year with a mean graft success of about 60-70%. Higher success is achieved during the monsoon season. For this, low cost polyhouses (prepared from casuarina / bamboo poles / areca reapers / GI pipes / PVC pipes and covered with high density polythene sheet of convenient dimensions, preferably 20 m long and 6 m wide) may be utilized for graft production. The height of the polyhouse should be 2.5 m in the middle and 1.0 m on both sides. The plants may be watered using hose. Misting units can also be fitted at appropriate points and switched on for about 5-10 minutes at an interval of two hours from 10 a.m to 6 p.m during summer season. This reduces the temperature build up inside the polyhouse. Raising of rootstock seedlings, grafting of rootstocks and maintenance of grafts can be done inside the polyhouses. These polyhouses give protection to the seedlings and grafts during heavy rains and reduce the mortality. Again during summer months the seedlings / grafts can be maintained in these polyhouses by covering with HDPE shade nets (35-50% shade).

Planting and management of grafts

The softwood grafts will be ready for planting in 5-6 months after grafting. The pits are filled with topsoil and 5-10 kg of compost or dried cowdung / pit and the grafts are planted after carefully removing the polythene bags. Care should be taken while planting to see that the graft union is 2.5 cm above the ground level. The polythene tape is to be carefully cut and removed subsequently. Staking should be done immediately after planting to protect the grafts from damage.

Planting and management of plantation

Plant softwood grafts in pits of size 50cm x 50 cm during June-July. Planting may be done at a spacing of 7.5 m for poor and 10 m for rich and deep soils and sandy coastal area. On very sloppy lands, the rows may be spaced 10-15 m apart with a spacing of 6-8 m between trees in a row.

Depending upon the weed growth, weeding operation may be done during August-September. Mulch the plant base with dry leaves to reduce sun-scorch to tender plants.

Initial training / shape pruning

The sprouts coming from the rootstock portion of the graft that is from the portion below the graft joint should be removed frequently during the first year of planting. Initial training and pruning of young cashew plants during the first 3-4 years is essential for providing proper shape. Thereafter, little or no pruning is necessary. The plants should be allowed to grow by maintaining a single stem up to 0.75-1.00 m from ground level. This can be achieved by removing the side shoots or side branches gradually as the plants start growing from the second year of planting. Weak and criss-cross branches can also be removed. Branches growing unwieldy may also be cut off. Proper staking of the plants is required to avoid lodging due to wind during the initial years of planting. Initial training and pruning of cashew plants facilitate easy cultural operations such as terrace making, weeding, fertilizer application, nut collection and plant protection. The flower panicles emerging from the grafts during the first and second year of planting should also be removed (deblossoming) in order to allow the plant to put up good vegetative growth. The plants are allowed to flower and fruit only from the third year onwards.

General pruning

In older cashew plantations, removal of dried or dead wood, criss-cross branches, water shoots etc. should be attended to at least once in 2-3 years. This allows proper growth of the canopy and receipt of adequate sunlight on all the branches. Pruning of cashew plants should be done during May / June.

Nutrient management

Cashew is generally grown in soils with low fertility status and water holding capacity. To ensure supply of sufficient nutrients leading to optimum growth and yield in organic cashew, an integrated approach consisting of growing leguminous green manure/ cover crops, recycling of crop residues, application of organic mixtures and bio-fertilizers is to be followed, which is agronomically and economically effective. If all the organic materials available in the orchard are fully utilized, it can meet a major portion of the nitrogen and a part of other macro and micro nutrient needs. The organic materials available in the plantation can be best used through composting, more efficiently through vermi-composting. It was found that the leaf litter and cashew apple residue could be effectively used for vermicomposting which will be ready in 95 days. Since the pH of the vermicompost is neutral to alkaline, it is ideal as an ameliorant for acidic soils of Kerala.

Growing of leguminous cover/ green manure crops are highly beneficial particularly in young plantations where intercrops are not raised. Apart from its positive effect on soil fertility status, by contributing dry matter to the tune of 2 to 4 tonnes/ha, cover cropping prevents soil erosion and conserves water; also suppresses weed growth in early years.

When organic manures are used, around 25 kg poultry manure, 60 kg FYM or 30 kg vermicompost may be used per adult tree. Apply $1/5^{th}$ dose of the organic manure during the first year, $2/5^{th}$ dose during second year and progressively reaching full dose from fifth year onwards.

Combined application of *Azotobacter* and *Azospirillum* each @ 150 g or PGPR mix I per adult tree is beneficial for increased yield.

Weed management

Use of chemical herbicides is prohibited in organic farming. Manual weeding can be done within 2 m radius of the trunk. In large plantations weeding in the interspaces can be done effectively and economically using tractor-mounted rotary weed slashers. The slashed materials and weeds can be used for mulching, which reduces further infestation. Intercropping also helps in controlling weeds substantially. Mature trees on attaining full canopy can smother weed growth to an appreciable extent.

Intercropping

Pineapple is the most profitable intercrop in cashew plantation in the early stages of growth. It can be planted between two rows of cashew in trenches opened across the slope. Paired row of pineapple suckers can be planted in each trench at 60 cm between rows and 40 cm between two suckers within the row. These trenches can be opened at

1 m between two rows of cashew. Ginger, lemongrass and tapioca are also suitable as intercrops and the intercrops are also grown organically.

High density planting

High density planting is a recent technique recommended for enhancing the productivity of cashew plantations. This technique involves planting more number of grafts per unit area and thinning at later stages. Instead of the normal planting density of 64 to 177 plants per hectare (spacing ranging from 7.5 to 10 m in the square system of planting) or 74 to 204 plants (spacing ranging from 7.5 to 10 m in the triangular system of planting), 312 to 625 grafts will be planted per hectare, initially. During later years, as the canopy develops, plant population is to be regulated by selective felling to minimize competition.

While adopting a high density planting technique, grafts may be planted initially at a spacing of 4m x 4m or 8m x 4m so that there will be 625 or 312 plants respectively. This population can be retained for a period of seven to nine or ten years depending upon the canopy expansion rate. If the soil is very rich the canopy development rate will be faster. High density planting would be more useful in poor soils where the rate of canopy expansion is slow. Considering the fertility status of the soil, the level of management in terms of manuring, irrigation, the initial plant population etc. are to be decided carefully for every agro-climatic condition. Later, after monitoring the canopy pressure between adjacent plants, the alternate plants are to be removed. Finally, when the plants attain full growth, the spacing between the plants will be 8m x 8 m.

If uniform management practices are adopted, during early years of yield, the per tree nut yield will be more or less the same with all the trees, in both the conventional system of planting and in high density planting. But the per hectare yield will be more from high-density plantations (due to higher plant populations) compared to the normal density plantations. During later years, when the plant population is equalized to that of normal

density plantation, the productivity of both the plantations would be more or less the same. The bonus yield obtained during the early years of yield would be substantial in high-density plantations.

In addition to obtaining higher yields, substantial quantities of firewood can be obtained during thinning, which may fetch additional revenue to the farmer. The weed growth in the interspace can be effectively checked to a greater extent.

Top working

Top working is a technique evolved to rejuvenate unproductive and senile cashew trees. Top working can successfully rejuvenate poor yielders in the age group of 5-20 years. The unproductive trees are to be beheaded at a height of 0.75 to 1.00 m from ground level. The stem should be cut with a saw to avoid stump splitting. The best season for beheading trees is May-September. Soon after beheading, the stumps and cut portions should be given a swabbing with Bordeaux mixture and neem oil 5%. Sprouts emerge 30-45 days after beheading. Sprouting will be profuse in young trees. New, 20-25 days old shoots should be grafted with scions of high yielding varieties using softwood grafting technique. To ensure at least six or seven successful grafts, 10-15 grafting are to be done on the new shoots of every tree. The best season for grafting is July-November. Thinning of the extra shoots arising from the stumps should be done to obtain better growth of the grafts. Removal of sprouts below the graft joint and removal of polythene strip from the graft joint should be done. Top working is simple and can be done by farmers after getting proper training.

The top worked trees start yielding right from the second year after top working. Thus precocity can be considered as one of the best advantages of this technique. The major disadvantage associated with top working is the huge casualty of trees due to stem borer attack. Intensive care and management to ward off stem borer is essential. As such, adoption of top working on a larger scale would be difficult.

Plant protection

Pest management

The following aspects require special emphasis for organic pest management in cashew.

Maintenance of hygiene

Timely pruning can keep the tree in a hygienic manner and thereby avoids the incidence of pests and diseases, particularly in old plantations.

Regular burning of the residues of the plantation at periodic intervals from the flushing time to harvest can systematically eliminate many of the insect pests especially that of caterpillars, thrips, leaf and plant hoppers as well as some of the bug and beetle species. They are positively attracted to light or bonfires and thus get killed.

Prompt monitoring and pest-surveillance

If the pest infestation is detected and located at the correct time, local and limited treatments, which are ecologically safe, can take care of the issues.

Smoking

Smoking the plantation is found repelling many insect species harmful to the crop. Smoking the plantation with organic wastes during flushing, flowering and fruiting phases will keep TMB infestation low.

Mechanical

Mechanical destruction of sluggish and congregating stages of the insect-pest are advisable.

Tea Mosquito Bug (TMB)

This is the most serious pest affecting cashew. The pest usually appears with the emergence of new flushes and panicle. Drying of inflorescence and dieback of shoots are the symptoms.

1. Spray either neem oil (0.5-1%) or *Pongamia* oil (2%) during flushing, flowering and fruiting phases. Add teepol/soap. Repeated sprayings at fortnightly intervals may be required in specific situations such as heavy infestations or young plantations.
2. Trees which harbour large populations of predator ants and spiders being natural enemies of TMB and other pests, can provide protection. So promote predator ant and spider colonies. Since cashew is entomophily, ants can act as pollinators. However, care should be taken while encouraging ants, as they also help in spreading mealy bugs and scales.
3. It is frequently observed that dieback is associated with TMB. To manage the TMB-anthracnose complex, Bordeaux mixture (1 %) may be sprayed as prophylactic along with the control measure for TMB. The affected plant parts are to be removed. The recommendation for combined sprays against tea mosquito bug and anthracnose in endemic areas is given in Table 13.

Cashew stem and root borers

This is a serious pest, which is capable of destroying the cashew tree. Main symptoms of attack are yellowing of leaves, drying of twigs, presence of holes at the base of stem with exuding sap and frass.

Prophylactic measures

1. Phytosanitary measures such as removal of dead and dried branches of trees, dead trees and trees at advanced stages of infestation at least once in six months help in reducing the spread of stem and root borers.
2. Roots should not be left exposed in the field.
3. Swab mud slurry or coal tar and kerosene (1:2) for adult trees or neem oil 5% (50 ml neem oil in 1 litre of water + 5 g of bar soap) on the tree trunk up to 1.0 m height, thrice in a year, from September onwards, at an interval of two months. Commercial formulations may also be used in place of neem oil, after ensuring their quality.

4. Smearing of lime on the bark crevices.
5. Application of wood ash (15-20 kg/tree) and common salt at the base reduces the pest infestation. The wood ash preferably mixed with tea waste is to be applied during July-August while manuring the plants.

Curative measures

Early stage of attack can be detected from the chewed wood observed at the base of the tree. If the infestation is detected early, the grubs should be mechanically removed by carefully examining the bark. While removal, care should be taken not to exceed 50% of the stem girth.

Minor pests

Local and spot treatments are to be taken for mealy bugs, aphids etc. as they often appear in isolated trees/patches. Neemoil garlic emulsion (2%) applied on infested branches checks mealy bug menace.

Dust powdered ash during flushing period to control sucking pests.

Diseases

Anthracnose

Symptom

The disease affects all young tissues, viz., tender leaves, twigs, inflorescence, shoots, nuts and apples. Appearance of reddish brown, shiny water soaked lesions followed by resin exudation on the affected parts is the initial symptom. On tender leaves, the disease develops as brown circular to irregular spots with dark coloured margin. In severe cases the lesions coalesce resulting in defoliation. Infection on the tender stem results in the development of reddish brown spots, which later coalesce and spread downwards finally, resulting in die back. On inflorescence, the floral peduncles show blackening and the affected flowers turn black, wither and fall off. The infection on the inflorescence may reach the shoots and finally shows die back..

Control

1. Regular plant sanitation to check the disease spread. Remove and destroy the affected plant parts.
2. Give a prophylactic spray of 1% Bordeaux mixture.
3. Since tea mosquito attack pre-dispose cashew to anthracnose, it is better to have a combined spray of the above fungicides with neem oil (Table 13).
4. Planting wind breaks like *Casuarina* or *Eucalyptus* check the spread of disease from one plantation to another.

Dieback or pink disease

Symptom

Appearance of white patches on branches followed by drying of twigs from the tip

Control

1. Chisel out the affected parts and apply Bordeaux paste.
2. Give prophylactic sprays of 1% Bordeaux during May- June and October.

In plantations, occurrence of diseases like gummosis, red rust and leaf blight can be combated by application of 1% Bordeaux mixture. Sooty mold (often seen associated with mealy bugs and aphids) can be managed by 1% Bordeaux mixture or 2% starch application.

Note: For grown up trees, 5 litres of spray fluid is required at high volume discharge rate. For spraying, rocker sprayer with Hi-tree lance is preferable.

Table 13.Recommendation for the control of tea mosquito bug and anthracnose in endemic areas

Product	Dose (per litre) 50 ml neem oil	Frequency
Neem oil (0.5-1%) + Copper oxychloride 0.2 to 0.3%	(5 ml of neem oil in 1 litre of water with 5 g of bar soap or 2 ml Teepol) + 2g Copper oxychloride	Fortnightly interval (depending on infestation)

Diseases affecting cashew nursery

Damping off, seed rot, seedling blight and root rot are the diseases that cause serious damage in the nursery, particularly during rainy season, which can be effectively managed with integrated control measures as given below.

1. The seedling diseases could be prevented by providing proper drainage facilities in the nursery. Provide enough drainage holes on the bags used for raising seedlings.
2. Raise seedlings in solarised potting mixture. Potting mixture has to be solarised for one month using 150 gauge transparent polythene sheets.
3. After filling the potting mixture in the polythene bag, use *Trichoderm*a enriched manure for potting mixture.
4. Incorporate *Mycorrhiza* @ 10g/kg and PGPR mix I 5g/kg potting mixture before sowing the seeds.
5. Remove and destroy the disease affected seedlings.
6. Never re-use contaminated potting mixture.
7. Provide sufficient spacing in the nursery to ward off excess humidity.
8. Never raise cashew nurseries in heavily shaded areas.

9. Drench the nursery bag with 1% Bordeaux mixture or Copper oxychloride (0.2%) or. While drenching, care should be taken to drench sufficient quantity of fungicide to soak the entire potting mixture in the polythene bag. Selection of the above fungicides should be based on the type of the pathogen.

10. Spray the seedlings with 1% Bordeaux mixture as a prophylactic measure to prevent aerial infection.

Utilisation of cashew apple

Cashew apple is a valuable source of sugars, minerals and vitamins especially vitamin C and B_2. It can be eaten raw as a fresh fruit. Either whole apples are consumed or they can be cut into small pieces, mixed with table salt and eaten.

Cashew apple can be used for the preparation of various products like squash, syrup, pickle, wine, liquor and vinegar, but commercial production is possible only with the use of chemical preservatives. However, organic processing of cashew apple is possible with out the use of chemical preservatives at domestic level, provided refrigerated storage is possible.

COCOA (*Theobroma cacao*)

The cocoa tree flourishes in the dense shade of warm rain forests in its natural habitat and hence can be cultivated in all similar climatic conditions. The tree cannot withstand high winds, drought or sudden fall in temperature. The crop requires well-distributed rainfall. The minimum requirement of rainfall is about 100-150 cm per annum. Situations where the temperature falls below 10°C or rises above 38°C are unfavourable although minor deviations from the above limit can be adjusted by shade and irrigation. High wind velocity causes considerable mechanical damage to trees.

Cocoa is grown at altitude up to 900 m above MSL though it is possible to grow the crop even in much higher elevations under sheltered conditions.

The best soil for cocoa is forest soil rich in humus. The soil should allow easy penetration of roots and capable of retaining moisture during summer. Clay loams, loams and sandy loams are suitable. Shallow soils should be avoided.

Varieties

Though three varietal types viz., Criollo, Forastero and Trinitario are recognized, only Forastero types are known to perform well under Indian conditions. Cocoa is highly cross pollinated and growing of different varieties adjacent to each other must be encouraged so as to achieve maximum fruit set and yield realization.

Table 14. Improved varieties and salient features

Varieties/hybrids	Salient features
CCRP-1	Selection, tolerant to VSD
CCRP-2	Selection, tolerant to VSD
CCRP-3	Selection, tolerant to VSD
CCRP-4	Selection, tolerant to VSD
CCRP-5	Selection, tolerant to VSD
CCRP-6	Selection, tolerant to VSD
CCRP-7	Selection, tolerant to VSD
CCRP-8	Hybrid, tolerant to VSD
CCRP-9	Hybrid, tolerant to VSD
CCRP-10	Hybrid, tolerant to VSD

Selection of site

Cocoa is usually planted under coconut and arecanut plantations in India. Shade levels under coconut canopy are highly variable depending mainly on the spacing of coconut, extent of canopy development and age of palms. It is estimated that light infiltration through coconut canopy ranges from about 30 to 80 per cent depending upon these factors. Based on this, the general recommendation is as follows:

1. If a choice is possible, a coconut plantation that will let in more light through the canopy may be chosen for raising cocoa.

2. If the light infiltration is over 50 per cent, it may be beneficial to provide additional shade using temporary shade plants like banana.

Preparation of land

The seedlings / budded clones are usually planted in the interspaces of coconut / arecanut. Give a spacing of 3 to 4.5 m. The crop is best grown with 50 per cent light intensity in the early stages. In the early life of the plants, planting of quick growing plants like banana and tapioca can provide temporary shade.

Planting materials

Cocoa can be propagated by seed and vegetative means.

Seed propagation

It is desirable to collect seeds from biclonal or polyclonal seed gardens involving superior self-incompatible parents to ensure genetic superiority of planting materials. Polyclonal and biclonal seed gardens have been established at CCRP farm of the Kerala Agricultural University, Vellanikkara and Kidu farm of CPCRI and seeds and seedlings are being supplied to growers. If seeds cannot be procured from such seed gardens, mother plants for collection of seeds may be selected based on the following criteria:

(1) Trees of Forastero type having medium or large pods of not less than 350 g weight or 400 cc volume, green in colour when immature, having smooth or shallow furrows on the surface without prominent constriction at the neck should be selected. Yield of pods should be not less than 100 per year.

(2) Husk thickness of pods to be not more than 1 cm.

(3) Pod value (number of pods to give 1 kg wet beans) to be not more than 12.

(4) Number of beans per pod to be not less than 35.

(5) Bean dry weight to be not less than 1 g.

Seeds lose viability within a week of harvest of pods. Seeds are to be sown immediately after extraction from the pods. Viability of the beans can be extended for some more days if freshly extracted seeds are stored in moist charcoal and packed in polybags. Other alternative is extracting beans, removing the testa and packing in polythene bags.

Time of sowing

Though the seeds will germinate at any time of the year, seeds may preferably be sown by December-January, so that 4-6 month old seedlings become available for planting by May-June.

Method of sowing

Seeds are to be sown with hilum-end down or to be sown flat. Sowing is to be as shallow as to just cover the seeds with soil. Removal of pulp may enhance the speed of germination, but the extent of additional advantage is only marginal. Seeds start germination in about a week and germination may continue for another one week. Percentage of germination may be around 90.

Cocoa nursery is to be located in a heavily shaded area, which allows only 25-50 per cent sunlight. Regular watering is necessary to keep the soil moist.

Seedlings are transplanted after 4-6 months. Only vigorous seedlings are to be used and based on height and stem girth, 25% poor seedlings may be rejected. When seedlings are grown under heavy shade, hardening for 10 days by exposing to higher illumination may be necessary before transplanting.

Vegetative propagation

In view of the high variability exhibited by seedling progenies, vegetative propagation is preferred for large scale planting. Though vegetative propagation of cocoa by budding, rooting of cuttings and grafting are feasible, the widely accepted method in India is budding.

Scions for budding are to be collected from high yielding, disease resistant elite plants. Shoots having brown bark and just hardened leaves are selected as bud wood. Scions are preferably procured by cutting off lamina of all the leaves of the selected scion shoot to a distance of about 30 cm from the tip. After 10 days when the petioles have fallen off, these scion shoots are cut and used for budding immediately. Bud wood can be stored by dipping in benzyl chloride followed by washing in water and then sealing the cut ends using molten wax. Bud wood is then wrapped in moist cotton wool and in turn in wet tissue paper or blotting paper and packed in boxes with wet packing material. The packet is then covered using polythene sheets. Storage life of the bud wood can be extended up to 10 days by this method. As far as possible, bud wood is to be collected from chupons as those produced from fans may develop into bushy plants with spreading habit. Rootstock, six to twelve months old may be selected in such a way that scion and rootstock are of the same thickness. Different successful methods include T, inverted T, patch, and modified Forkert methods. Patch budding is adopted in the Kerala Agricultural University.

Patch budding method consists of removing a patch of about 2.5 cm length and 0.5 cm width from the rootstocks, preparing a bud patch of 2.5 cm length and 0.5 cm width from the bud wood and inserting it into the rootstock and tying firmly with polythene tape. After three weeks, if there is bud-take, polythene tape is removed; a vertical cut is made half way through the stem above the bud and is snapped back. The snapped root stock portion is cut back after the bud has grown to a shoot and at least two leaves have hardened. It is then allowed to grow for a further period of three to six months after which they are transplanted. Under normal conditions, success can be around 70-90 per cent.

Selection of planting materials

When seedlings are used for planting, select only vigorous and healthy seedlings produced from polyclonal seed garden or selected mother plants as described earlier.

When budded plants are used, select two or more clones for planting as the use of a single clone can lead to poor production due to the existence of self-incompatibility in cocoa.

Time and method of planting

Raising cocoa as a pure crop is not recommended especially in Kerala due to high pressure on land. Cocoa is planted as an intercrop in coconut and arecanut gardens. In coconut, depending upon the spacing adopted, one or two rows of cocoa can be planted in between two rows of coconut i.e., two rows where the spacing is more than 8 m and one row otherwise, the plant distance for cocoa being 2.7 to 3 m. When two-row system is adopted, the seedlings may be planted in zigzag or triangular manner.

In arecanut where the normal spacing is 2.7 m, cocoa is planted at the centre of four areca palms along alternate rows of interspaces only. Pits of 50cm x 50cm x 50cm are dug, allowed to weather for one month and refilled with topsoil and 15-20 kg of compost or farm yard manure to ground level. The planting hole should be sufficient to hold the soil ball of the polybag. Remove the bag carefully, place the soil ball with the seedlings in the planting hole with minimum disturbance and press the soil around firmly. Planting should coincide with the onset of monsoon, but in places where irrigation is resorted to, flexibility in the time of planting is possible.

Shaping of clonal plants derived from fan shoots

Budded plants from fan shoots have diffuse branching system and bushy growth habit. This type of growth causes difficulties in carrying out cultural operations and harvesting. If a better shape of the plant is desired, appropriate formation pruning may be necessary. This involves identification of a chupon arising from a fan shoot, allowing it to grow and removing the original, lower fan-like shoots in stages. This, however, has to be done slowly as an early drastic pruning will inhibit growth.

Manuring

Upto 4-5 years, growing green manure crops like *Mimosa invisa, Calapagonium* and *Pueraria* in open patches and along coconut basins can provide about 5-6 tonnes of green leaf for cocoa. These can be cut at regular intervals and incorporated in the basins. With increasing age, the canopy of cocoa closes, and the quantum of light falling on to the ground becomes so small that raising these cover crops has to be restricted to the coconut basins and some scattered patches reducing the green leaf yield to 2-3 tonnes.

Border planting of *Glyricidia* for the supply of green leaf manure.

Regular pruning of trees and depositing the prunings in the basins.

In situ composting of pod husk (3600 kg/ha) and incorporation into the basin

@ 7.2 kg/plant is beneficial.

Apply farm yard manure @ 40 kg/plant or fresh vermicompost 20 kg per plant in four equal split doses in May, September, December and February under irrigated condition or in two equal splits in April - May and September - October under rainfed condition.

Apply wood ash @1.0 kg /plant.

Apply biofertilizer PGPR mix I as enriched organic maure. Inoculate with AMF in the nursery and field at the time of planting.

After cultivation

During the first three or four years after planting, it is essential to keep the field free from weeds. Maintenance and regulation of shade should be carried out promptly. During the establishment phase of the crop particularly in summer, provide mulching with materials

like chopped banana sheath, coconut husk, cocoa husk etc. to conserve moisture in conditions of direct insolation. A mature cocoa plantation should form a proper canopy, which will be dense enough to prevent weed growth. Operations such as pruning and regulation of shade should be attended to in time.

Pruning and training

Cocoa grows in a series of storeys, the chupon or vertical growth of the seedling terminating at the jorquette from where four to five fan branches develop. Further vertical growth is continued through a side chupon that arises from a point just below the jorquette which again jorquettes after growing to some height. Left for it, the plant will grow to a height of 8-10 m repeating this process of jorquetting and chupon formation 3-5 times. When cocoa is grown as an intercrop in coconut and arecanut plantation, it is desirable to restrict the growth to one tier formed at a convenient height preferably above the head level of the workers. When jorquetting takes place at lower levels this can be raised by nipping off all the fan branches and allowing one chupon to develop and grow further to jorquette at the desired height. After this is achieved, further vertical growth is arrested through periodical removal of chupons.

The intensity of pruning is to be decided by the nature of growth of individual trees, shade intensity, growth of the companion crops etc. In the early stages, pruning is done to give a particular shape to the tree. After the establishment of the trees in the garden, prune them to the extent of retaining only the required number of leaves (20-30 leaves per developing pod). Removal of secondary branches from the centre should be restricted only to those trees growing in excess shade.

Irrigation

Cocoa grows well as a rainfed crop under conditions of well-distributed rainfall and irrigation is not necessary. If sufficient moisture is not present in the soil due to prolonged drought or failure of rains, irrigation is to be given once in five days. Irrigation, however, helps in better growth of plants and precocity in bearing.

Top working

This technique is useful to rejuvenate old and unproductive cocoa plants and also to convert genetically poor yielders to high yielders. This consists of snapping back the desired trees below the jorquette after cutting half way. The snapped canopy continues to have contact with the trunk. A number of chupons would arise below the point of snapping and this is triggered by the breakage of apical dominance and continued connection with the snapped canopy. Patch budding as described earlier may be done on three to four vigorous and healthy shoots using scions from high yielding, disease resistant clones and the remaining chupons are removed. The polythene tape is removed three weeks after budding and the stock portion above the bud union is snapped back. The snapped portion is removed after two hardened leaves develop from the bud. When sufficient shoots are hardened, canopy of

the mother tree can be completely removed. Because of the presence of an established root system and the trunk with reserve food, the top worked trees grow much faster and give prolific yield one year after the operation. Though top working can be done in all seasons, it is preferable to do it in rain-free period in irrigated gardens. For rainfed situations, it may preferably be done after the receipt of pre-monsoon showers.

Top worked trees start yielding heavily from the second year onwards. About 50 per cent improved yield is obtained in the second year and about 100 per cent improved yield in the third year. Loss of crop for one year during the operation is compensated by bumper crop in the coming years. The main stem will continue to belong to the older plant and fruits borne on this area belong to the poor yielder. Better yields are however obtained from the fan branches of the high yielding clone used for top working.

Plant protection

Pests

Among the pests infesting cocoa, the major ones are the red borer, tea mosquito bug, mealy bug, grey weevil, cock chaffer beetle. These pests are not of very disastrous and these can be effectively controlled by mechanical means.

Rats and squirrels cause considerable damage to ripening pods. Continuous trapping using attractants will be effective to check the squirrel and rat population in the field. As these cause damage to ripe fruits only, damage can be reduced by harvesting regularly and not allowing the ripe pods to remain on the trees for long periods. Adopt rat control measures as in coconut.

Disease

Among the diseases affecting mature plants, black pod caused by *Phytophthoa palmivora* and Vascular Streak Dieback caused by *Oncobasidium theobromae* are important.

The measures recommended to control black pod disease are

1. Periodic removal and destruction of infected pods.
2. Cultural practices like proper pruning and regulating the overhead shade to reduce humidity and to improve aeration.
3. Spraying Bordeaux mixture one per cent at 15 days intervals starting from the onset of monsoon along with periodic removal of infected pods.
4. Extracts of *Allium sativum, Cinnamomum zeylanicum, Lawsonia inermis* and *Adenocalymma allicea* is effective in inhibiting lesion development on detached cocoa pods.
5. Periodical spraying and drenching of 2% *Pseudomonas fluorescensP1* is very effective in checking the disease.

6. Quarantine measures are important in Vascular Streak Dieback since the pathogen is systemic in nature.

Cocoa nurseries should not be maintained near diseased trees because young plants are easily affected by the disease. Regular pruning of infected branches is recommended to maintain a very low level of infection. During pruning, the branches should be split open to detect the extent of streaking in the wood. The branches are then to be cut 30 cm below the last detectable streak. Eradicative pruning will be more effective if carried out at least one month prior to the wet season. Removal of prunings from the cocoa field is not necessary because the fungus cannot survive or produce spores in the dead wood.

Genetic resistance offers good prospects of controlling Vascular Streak Dieback. From Kerala Agricultural University, 10 disease resistant clones have been released, the budded plants of which offer a considerable degree of resistance. The hybrid seedlings produced from the clonal gardens of the University are also tolerant to this disease.

Harvesting

It takes about 170 days for a cocoa pod to develop from formation to maturity. During the period from 70-140 days after pollination, the size of pods and their fat and sugar content increase rapidly. Ripening takes about 25 days, during which, the pods change colour depending on the variety. Pods remain suitable for harvesting for fairly long time after they have ripened. Hence, it is possible to have harvest of sufficient number of pods at a time by either delaying the harvest of early-ripened pods or harvest of pods, which are fully ripened. Harvesting should be done at regular intervals rather than daily, once in 7-10 days. Avoid over-ripening of pods. The discards at the harvest can be left in the garden either in the open during summer or in pits at different sites in the rainy season, or they can be incorporated in the compost. Pod husks from the fermentary can also be used similarly as a good source of organic manure.

Pods are removed by cutting with a sickle-sharp knife, without damaging the cushion from which it is developed. After 2-3 days, they are split by banging them against some hard objects. Opening the pods with a knife damages the beans. During the period between harvesting and splitting, pre-fermentation activity inside the pod is hastened, which improves later fermentation. Beans from the split pods are scraped out with fingers. Portions of placenta, and broken, germinated, caked, parthenocarpic and undeveloped beans are removed. On an average, 10-12 pods give 1 kg of wet beans and 3 kg of wet beans (from 30-36 pods) give 1 kg of fermented and dried beans.

Fermentation

During fermentation, the pulp or mucilage covering the fresh beans is removed and characteristic chocolate flavour is imparted to the final produce. The process is simple but must be carried out properly in order to get beans of good quality. Heat is produced by keeping the fresh beans compactly and this heat must be conserved so that chemical changes inside the bean can be completed.

The four methods of fermentation usually employed involve the use of baskets, heaps, boxes and trays for filling up the wet beans.

Tray method

The best method suitable for small quantities of beans is the tray fermentation. Wooden trays, 10 cm deep with slatted / split cane bottoms are divided into a number of sections by means of wooden partitions that fit into appropriate grooves at required distances. The capacity of the tray can be adjusted depending upon the availability of beans by keeping the wooden plank in the appropriate grooves. A convenient tray can be 25 cm wide and 60 cm long. Wet beans are filled in the tray and levelled. About 10 kg of wet beans may be required to load one tray fully.

A single tray of beans will not ferment properly and at least four or five trays are needed for successful fermentation. The trays are stacked one over the other in such a manner that the cocoa filled portions are in a single row one above the other. The top tray is covered with plantain leaves. After 24 hours, a close fitting sack is put to cover the stack to keep the beans warm. Mixing or stirring of beans is not necessary and fermentation gets completed in 4 to 5 days, whereas 6 to 7 days are required for other methods of fermentation.

Basket method

In this method, bean lots ranging from 2-6 kg can be fermented successfully. Mini baskets may be made of bamboo matting, closely woven and should have a diameter of 20 cm and height of 15 cm for a capacity of 2 kg. For slightly larger lots, proportionately deeper baskets may be used (e.g., for 6 kg, the depth may be about 40 cm). The baskets are lined with one or two layers of torn banana leaves to facilitate drainage of sweatings. Wet beans are then filled, compacted and covered with banana leaves. The baskets are placed on a raised platform to allow the flow of drippings. After 24 hours, it is covered with gunny-sack and applied weights (bricks). The beans are to be taken out and stirred well 48 hours and 96 hours after the initial setting. Fermentation will be completed in six days and the beans can be taken for drying on the seventh day.

A number of factors influence the duration of fermentation. Weather changes and season are important through their influence on temperature and atmospheric moisture. Ripening also affects fermentation. Beans from unripe pods cannot be fermented. Beans of Criollo ferment more quickly than those of Forastero. During the early stages of fermentation, heat is produced by the action of anaerobic microorganisms. The beans are killed by the combined effect of heat and acetic acid and the cocoa aroma and flavour potential are developed.

Judging the end point of fermentation

Well-fermented beans will be plumpy and filled with a reddish brown exudate. The testa becomes loosened from the cotyledons. When cut open, the cotyledons will have a bleached appearance in the centre with a brownish ring in the periphery. When above 50% of beans in a lot show the above signs, it can be considered as properly fermented.

Drying

On completion of fermentation, beans are dried either in the sun or by artificial means. Sun drying can be done in thin layers 2-3 cm deep and stirring from time to time. Under normal sunny weather, drying can be completed in four to five days. While drying in mechanical driers, care must be taken to avoid exposure of the beans to smoke, fumes etc. The most common method of determining bean dryness is to take a sample and compress this in the palm of the hand and listen for the characteristic sound, which is associated with correctly dried cocoa. The more scientific method is to use a moisture meter.

Storage

The dried beans with moisture content of 6-8% may be packed in polythene bags or polythene lined gunny bags. Some special conditions have to be provided in storage in order to maintain the quality of the cured beans. Properly dried beans can be kept in 200-300 gauge polythene covers if only small quantities are involved or in polythene lined gunny bags in the case of larger stocks. Beans should be cleaned of flat, broken and other defective beans before storing. The store should be sufficiently ventilated and the bags should be kept on a wooden platform with air space of about 15-20 cm below the wooden planks set over the floor. The humidity should not exceed 80% so as to prevent mould development and pest incidence in the beans. As cocoa beans can absorb and retain permanently any odour from its surroundings, other food-stuffs should not be kept with cocoa. So also, smoke or kerosene fumes should be prevented from entry.

BLACK PEPPER (*Piper nigrum*)

Pepper requires a warm and humid climate. Though an annual rainfall of 250 cm is ideal for the proper growth of the crop, it can also come up well in low rainfall areas, if the pattern and distribution of rainfall are conducive. About 70 mm of rainfall within a period of 20 days may be sufficient for triggering of flushing and flowering process in the plant, but once the process is set on, there should be continuous, though not heavy, rainfall until fruit development starts. Any dry spell, even for a few days, within this critical period will result in substantial reduction of yield. Very long spells of dry weather are unfavourable for the crop growth.

The plant tolerates a minimum temperature of 10 ºC and maximum of 40 ºC, the optimum being 20-30 ºC. It can be grown from sea level up to an altitude of 1200 m but lower altitude is preferable.

Pepper prefers a light porous and well-drained soil rich in organic matter. Water stagnation in the soil, even for a very short period, is injurious for the plant. So, heavy textured soils in locations where drainage facilities are inadequate should be avoided.

Varieties

Local varieties: Kottanadan, Kuthiravaly, Arakulam Munda, Balankotta, Kalluvally

Table 15. Salient features of high yielding varieties of black pepper

No.	Variety	Piperine	Essential oil (%)	Oleoresin (%)	Drying %	Dry yield kg/ha	Potential yield (kg/ha)	Other features
1	Panniyur-1	5.3	3.5	11.8	35.3	1242	8800	Do not tolerate shade
2	Panniyur-2	6.6	3.4	10.9	35.7	2570	3313	Shade tolerant.Suitable for inter cropping
3	Panniyur-3	5.2	3.2	12.7	27.8	1953	3269	Performs well under open condition
4	Panniyur-4	5.0	3.1	9.2	34.7	1277	2443	Shade tolerant. Stable yielder
5	Panniyur-5	5.3	3.8	12.3	35.7	2352	7600	Suitable for both mono and mixed cropping
6	Panniyur-6	4.94	1.3	8.3	32.9	2127	3359	Tolerant to drought. Suitable for open and shade
7	Panniyur-7	5.57	1.5	10.6	33.6	1410	2770	Tolerates adverse climate
8	Sreekara	5.1	5.0	13.0	35.0	2677	4200	Suitable for intercropping
9	Subhakara	3.4	5.0	12.4	35.0	2352	4487	Suitable for intercropping
10	Panchami	4.7	3.4	12.5	34.0	2828	6528	Suitable for high elevations
11	Pournami	4.1	3.4	13.8	31.0	2333	5326	Tolerant to root knot nematode and shade
12	Palode-2	3.0	4.8	15.4	-	2475	4732	Suitable for plains and higher elevations
13	IISR Thevam	1.6	3.1	8.2	32.5	2437	-	Field tolerant to Phytophthora,Suited for high altitude areas
14	IISR Malabar Excel	2.4	2.8	11.7	32.3	1453	-	Suited for high altitude areas
15	IISR Girimunda	2.2	3.4	9.7	32.0	2880	-	Suited for high altitude areas
16	IISR Sakthi	303	3.7	102	33.0	2400	-	Field tolerant to Phytophthora, Suited for high altitude areas

Select locally adaptable high yielding and high quality varieties for planting.

Selection of site

Sites with slight to moderate slope are ideal for pepper cultivation, as they promote drainage. Slopes facing south are to be avoided as far as possible. When such slopes are to be used for cultivation, the young plants may be sufficiently protected from the scorching sun during summer.

Selection of mother plants

Cultivate only varieties, which are proven to be highly productive. Select mother plants, which give regularly high yields and possess other desirable attributes such as vigorous growth, maximum number of spikes per unit area, long spikes, close setting of berries, disease tolerance etc. Selected mother plants should be in the age group of 5-12 years. Mark and label selected mother plants in October-November.

Raising of rooted cuttings

Pepper is propagated vegetatively from cuttings. Select runner shoots produced at the base of mother plants and keep them coiled and raised to prevent from striking roots in the soil. Separate them from the vines in February-March. The middle one-third portion of runner shoot is preferred for planting. Very tender and too hard portions of the shoots are to be avoided. The shoots are cut into pieces with 2-3 nodes in each. Leaves, if any, are to be clipped off leaving a small portion of the petioles on the stem. Cuttings are to be treated with *Pseudomonas /* PGPR mix II culture by dipping base of cuttings in slurry of *Pseudomonas* (250g in 750 ml of water) for 20 min. Plant the cuttings in nursery beds or preferably in polythene bags or baskets filled with potting mixture. The potting mixture is prepared by mixing two parts of fertile topsoil, one part of river sand and one part of well rotten cattle manure. Spread this mixture on a leveled ground to a height of 15 – 20 cm. Moisten with water using a rose can and cover the soil with ploythene sheet (transparent 150 gauge) and solarize for 20-30 days. After solarization the mixture can be used for potting. Use bio-degradable containers to the extent possible. When poly bags are used, keep them away from the field after use. The cuttings should be planted at least one node deep in the soil. The cutting after planting should be kept under good shade. In large nurseries, pandals are to be constructed for this purpose. The cuttings are to be well protected from direct sunlight and frequent watering is recommended in the nursery to maintain a humid and cool atmosphere around the cuttings. Watering 2-3 times a day is sufficient. Heavy watering, which makes the soil slushy and causes waterlogging is to be avoided.

Planting

Planting of standards is to be taken up in April-May with the onset of pre-monsoon showers. Murukku (*Erythrina indica*), karayam or killingil (*Garuga pinnata*), *Ailanthus* sp., subabul (*Leucaena leucocephala*) etc. are suitable standards for growing pepper. In high altitude areas, dadap (*Erythrina lithosperma*) and silver oak (*Grevillea robusta*) can be successfully used as standards for pepper. Seedlings of subabul and silver oak are to be planted 2-3 years before planting pepper. The cuttings of standards are to be planted in

narrow holes of 40 to 50 cm depth. The spacing recommended is 3m x 3 m on plain lands and 2 m between plants in rows across the slope and 4 m between rows on sloppy lands. The soil should be well pressed around the standards to avoid air pockets and keep the standards firm in the soil.

For planting pepper, prepare pits on the northern side of standards, 15 cm away from it. The pit size should be 50cm x 50cm x 50 cm. Fill the pits with a mixture of topsoil and compost or well rotten cattle manure @ 5 kg/pit. With the onset of southwest monsoon in June-July, plant 2-3 rooted cuttings in the pits at a distance of about 30 cm away from the standards. Press the soil around the cuttings to form a small mound slopping outward and away from the cuttings to prevent water stagnation around the plants. The growing portions of the cuttings are to be trailed and tied to the standards. Provide shade to the plants if the land is exposed and if there is a break in the rainfall. When pepper is grown on coconut or arecanut trees, the pepper cuttings are to be planted 1-1.5 m away from the trunk of the trees. Trail the pepper vines on a temporary stake for 1-2 years. When they attain sufficient length to reach the tree trunk, remove the stake without causing damage to the vines and tie the pepper plants on to the tree trunk and trail them on it.

Management after planting

If the terrain of the land is sloppy or uneven, carry out contour bunding or terracing to prevent soil erosion. Digging should be avoided and weeds removed by slashing according to necessity and removed weeds should be recycled back. In the early stages, tie the vines to the standards.

Where pepper is grown on a plantation scale, growing of cover crops like *Calapagonium muconoides* is recommended. When such cover crops are grown, they are to be cut back regularly from the base of the plants to prevent them from twining along with the pepper vines. Lowering of vines after one year's growth will promote lateral branch production.

Intercropping of pepper gardens with ginger, turmeric, colocasia and elephant foot yam is advantageous. In the early years, banana as intercrop provides shade to the young plants and protects them from drying up during summer months.

When pepper is grown in open places, shading and watering of the young seedlings may be done during summer months for the first 1 to 3 years according to necessity. The young plants 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. Saw dust, arecanut husk and dry leaves are suitable mulching materials. Removal of unwanted terminal shoot growths and hanging shoots should be done as and when necessary.

Prune and train the standards in March-April every year to remove excessive overgrowth and to give them a proper shape. The effective height of the standard is to be limited to about 6 m. A second pruning of the standards may be done in July-August, if there is excessive shade in the garden.

Under planting

After regular bearing for about 20 years, the vines of most varieties start declining in yield. The age of decline in yield varies with variety and agroclimatic and management factors. 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 can be removed 3-5 years after under planting depending up on the growth of the young vines.

Manuring

Manuring for pepper vines is to be done in basins taken around the plant, 10-15 cm deep and 50-75 cm radius, depending up on the growth of the plants. Apply 10 kg cattle manure / compost / green leaves , 0.5 kg ash and one kg neem cake / plant just at the onset of southwest monsoon and 5 kg FYM , 0.5 kg ash and one kg neem cake / plant at the onset of northeast monsoon and cover lightly with soil. Farmyard manure can be partially or completely substituted with vermicompost, in that case, the quantity neede will be half. It is desirable to apply lime at the rate of 500 g/vine in April-May, with the receipt of pre-monsoon showers, in alternate years.*Apply biofertilizer combination of* Azospirillum *(25g/plant) and Phosphobactor (25g/plant) and PGPR mix I along with FYM application. Apply biofertilizers in a circle of radius 30 cm around the vine in the case of plants trailed on live or dead standard.*

Irrigation

Irrigating pepper plants of Panniyur-1 variety at IW/CPE ratio of 0.25 from November / December till the end of March and withholding irrigation thereafter till monsoon break, increases pepper yield by about 50%. The depth of irrigation recommended is 10 mm (100 litres of water per irrigation at an interval of about 8-10 days under Panniyur conditions). The water is to be applied in basins taken around the plants at a radius of 75 cm. The basins may be mulched with dry leaves or other suitable materials.

Plant protection

Pests

a) Pollu beetle *(Longitarsus nigripennis)*

1. Neem oil + Garlic 2% or Neem oil garlic 2% + Karanj oil 1%, as 3 sprays at spike emergence, berry formation and berry maturation stage.
2. Spray neem gold 0.6%

b) Root knot nematode *(Meloidogyne incognia)*

Application of talc based formulation of *Bacillus macerans* @ 10 g/ vine in basins (10^6 cfu /gm) at the time of planting of vines or just before monsoon period in established plantations.

Diseases

Nursery diseases (rotting and fungal pollu)

Use solarized soil and enrich the organic manure (cowdung) with native isolates of *Trichoderma* and apply.

Treat the pepper cuttings with *Pseudomonas fluorescens* P_1 suspension (20 gm / l of water)for 15 minutes before planting.

Spray and drench the plants at fortnightly interval with 2% *Pseudomonas fluorescens.*

Inoculate the cuttings with AMF at the time of planting in the nursery.

Main field diseases (foot rot and anthracnose)

Remove all infected or dead vines and burn it. The organic manure used for main field planting should be enriched with native isolates of *Trichoderma.*

Inoculate with native arbuscular mycorrhiza in the main field at planting.

Give drench and foliar spray with *Pseudomonas fluorescens* P_1 suspension (2%) / PGPR mix II (2%) during May- June and October.

The frequency of application may be adjusted based on disease incidence and intensity.

Phytophthora foot rot *(Phytophthora capsici)*

For controlling the disease, adopt the following management practices:

Phytosanitation

All infected or dead vines along the root system are to be removed and burnt. Wherever water stagnation is a problem, effective drainage of both surface and sub-soil is to be ensured. To avoid soil splash and consequent disease initiation and spread, a legume cover in the plantation should be ensured. Runner shoots are to be pruned or tied back to vines before the onset of monsoon. At the onset of monsoon, the branches of support trees may be lopped off to allow penetration of sunlight and avoid build up of humidity.

Apply 1 kg lime and 2 kg neem cake per standard per year as pre-monsoon dose in three split dose. The application of neem cake should be four weeks after lime application. Ensure moisture at the basins.

Curative measures

For the control of *Phytophthora* foot rot, any of the following measures can be adopted.

1. After the receipt of monsoon showers (May-June), all the vines are to be drenched over a radius of 45-50 cm with 0.2 % copper oxychloride at the rate of 5-10 litres per vine. This varies according to the age of the plant. A foliar spray with 1 % Bordeaux mixture is also to be given. Drenching and spraying are to be repeated just before the northeast monsoon. A third round of drenching may be given during October if the monsoon is prolonged.

Bio-control

Inoculate pepper vines with native arbuscular mycorrhizal fungi, *Trichoderma* as enriched organic manure and *Pseudomonas fluorescens* or PGPR mix II at the time of planting in the nursery and field, and apply during the pre-monsoon period in the established plantations to control foot rot. In the field, apply the biocontrol agents around the base of the vine (see the chapter on biocontrol agents against plant pathogens).

Note: In *Phytophthora* sick fields, adopt control measures as prophylactic.

Replanting / rejuvenation

Total replanting has to be undertaken in gardens where the mortality is 50-60% or above. Where the mortality is below 50%, timely plant protection measures as described above should be given to all the existing vines as prophylactic measure and gaps filled up. Gap filling or replanting should be taken up only after a period of one year. At the time of replanting, soil drenching with Bordeaux mixture or copper oxychloride should be given. While replanting, farmers should be encouraged to use tolerated varieties.

Fungal pollu (Anthracnose)

For the control of fungal pollu or anthracnose caused by *Colletotrichum gloeosporioides*, spray 1% Bordeaux mixture, once before flowering starts (late June and early July) and then at berry formation stage (late August). Minimize shade in the garden. Also spray with 2% *Pseudomonas* / PGPR mix II.

Wherever *Phytophthora* foot rot management is undertaken properly, separate control measures for pollu disease may not be necessary.

Note: Since Bordeaux mixture application for pepper is to be given mostly at a time when the monsoon is very active, it is to be ensured that a sticker is added to the fungicide. The cheapest and most effective sticker is rosin washing soda mixture.

Rotting disease

For control of rotting disease of seedlings in the nursery, VAM and *Trichoderma* can be applied in the potting mixture. For the control of foliar infection apply potassium phosphonate @ 3 ml/litre / Pseudomonas 2% at fortnightly interval. In case, biocontrol agents are not incorporated in the potting mixture, 1% Bordeaux mixture spray at weekly interval may be resorted to. When the cuttings start germination, ensure good aeration in the nursery. Heavy watering, which causes water stagnation is to be avoided. Instead, light and frequent watering should be resorted to. Remove shade as soon as continuous rain sets in.

Phyllod

In certain pockets, instead of normal spike with berries, leaf-like structures are produced. This is caused by phytoplasma. Such vines, if noticed, must be uprooted and destroyed. Planting material should not be collected from such vines.

Stunted diseas

The symptoms due to this disease include shortening of internode and narrowing of leaves with mottling. Such leaves also become leathery and deformed. This is caused by a virus. Since the disease is systemic and transmitted through planting materials, extreme care should be taken to avoid collecting planting materials from such vines. Once it is noticed, it is better to uproot the vines even at the cost of losing some yield to avoid further spread.

Harvesting and processing

The harvest season extends from November to January in plains and January to March in hills. During harvesting, the whole spike is hand picked when one or two berries in the spike turn bright orange red. At the time of harvesting no chemicals should be applied to ward off red ants.

Black pepper

Black pepper of commerce is produced from whole, unripe but fully developed berries. The harvested berries are piled up in a heap to initiate browning. Then they are spread on the suitable drying floor after detaching the berries from the stalk by threshing. During sun-drying, berries are raked to ensure uniform colour and to avoid mould development. Drying the berries for 3-5 days reduces the moisture content to 10-12 per cent. The dried berries are garbled, graded and packed in double lined gunny bags.

Blanching the berries in boiling water for one minute prior to sun drying accelerates the browning process as well as the rate of drying. It also gives a uniform lustrous black colour to the finished product and prevents mouldiness of berries. But prolonged blanching should be avoided since it can deactivate the enzymes responsible for browning process.

White pepper

White pepper is prepared from ripe berries or by decorticating black pepper. Bright red berries, after harvest are detached from the stalk and packed in gunny bags. The bags are allowed to soak in slow running water for about one week during which bacterial rotting occurs and pericarp gets loosened. Then the berries are trampled under feet to remove any adhering pericarp, washed in water and then sun dried to reduce the moisture content to 10-12 per cent and to achieve a cream or white colour. White pepper is garbled, sorted and packed in gunny bags. Approximately 25 kg white pepper is obtained from 100 kg ripe berries.

Improved CFTRI method

Fully mature but unripe berries are harvested and boiled in water for 10-15 minutes to soften the pericarp. After cooling, the skin is rubbed off either mechanically or manually, washed and sun dried to obtain white pepper. Since no retting operation is involved, the product will be free from any unpleasant odour. However, white pepper produced by this method gives pepper powder of light brown colour due to gelatinisation of starch in contrast to pure white powder obtained by traditional method.

Decorticated black pepper

This is a form of white pepper produced by mechanical decortication of the outer skin of black pepper. This is generally done when white pepper is in short supply. The appearance of decorticated kernel is inferior to traditionally prepared white pepper, but is satisfactory when ground. Also the milling operation requires considerable skill to avoid excessive volatile oil loss.

Dehydrated green pepper

In this method, under-mature berries are harvested and subjected to heat treatment for inactivating the enzymes responsible for browning reaction. Then the berries are dehydrated under controlled conditions wherein maximum retention of green colour is obtained. Dehydrated green pepper after reconstitution in water resembles freshly harvested green pepper. The advantage is that the season of availability can be extended and the berries could be stored for a year or more. Dry recovery comes to 20 per cent.

Canned green pepper

Green pepper after harvest is preserved in two per cent brine solution and the product is heat sterilized. This product has the additional advantage over dehydrated green pepper in that it retains the natural colour, texture and flavour.

Bottled green pepper

Green pepper is preserved without spoilage in 20 per cent brine solution containing 100 ppm SO_2 and 0.2 per cent citric acid. Addition of citric acid prevents blackening of berries.

Cured green pepper

To overcome the disadvantages of poor texture and weak flavour of dehydrated green pepper and the high unit weight and packing cost of canned and bottled green pepper, cured green pepper has been developed. Berries are thoroughly cleaned in water, steeped in saturated brine solution for 2-3 months, drained and packed in suitable flexible polyethylene pouches.

Freeze-dried green pepper

Most of the moisture from fresh tender green pepper is removed by freezing the berries at -30ºC to -40ºC under high vacuum. The colour, aroma and texture of freeze-dried green pepper are superior to sun dried or mechanically dehydrated green pepper. Freeze-dried green pepper has 2-4 per cent moisture and is very light.

Pepper oil

Black pepper is crushed to coarse powder and steam distilled to obtain 2.5 to 3.5 per cent colourless to pale green essential oil which becomes viscous on ageing. It is used in perfumery and in flavouring. Oil can also be distilled from white pepper but high price of white pepper and low oil yield do not favour its commercial production.

Pepper oleoresin

Extraction of black pepper with organic solvents like acetone, ethanol or dichloro-ethane provides 10-13 per cent oleoresin possessing the odour, flavour and pungent principles of the spice. The content of the pungent alkaloid piperine ranges from 4 to 6% in dry pepper and 35 to 50% in oleoresin. When freshly made, pepper oleoresin is a dark green, viscous, heavy liquid with a strong aroma. One kg of oleoresin when dispersed on an inert base can replace 15 to 20 kg of spice for flavouring purpose.

CARDAMOM (*Elettaria cardamomum*)

The habitat of small cardamom is the evergreen forests of Western Ghats. It is grown in areas where the annual rainfall ranges from 1500-4000 mm, temperature ranging from 10-35^{o}C and an altitude ranging from 600-1200 m above MSL.

Cardamom is generally grown in forest loam soils rich in available phosphorous and potassium. These soils are generally acidic in nature, with pH ranging from 4.2 to 6.8. The crop is raised mainly on well drained, deep, good textured soils rich in humus.

Varieties

Table 16. Salient features of improved varieties

Varieties	Salient features
Mudigere 1	Malabar type, for high density planting, tolerant to thrips
Mudigere 2	Malabar type, for high density planting
PV-1	Malabar type
PV-2	Vazhukka type, bold capsules, tolerant to stem borer and thrips, suitable for 1000 – 1200 m above MSL
ICRI-1	Malabar type
ICRI-2	Mysore type, tolerant to azhukal disease
ICRI-3	Malabar type, tolerant to rhizome rot
IISR-suvasini	Malabar type, suitable for high density planting, tolerant to pests
IISR-Vijetha	Malabar type, field tolerant to thrips, borer and mosaic
IISR-Avinash	Malabar type, tolerant to rhizome rot Njallani green gold Farmers selection, vazhukka type, extra bold capsules, suitable for 1000-1200 m above MSL

Propagation method

Cardamom is propagated through seedlings and suckers, the former is cheaper and the later gives earliness in bearing

Seed propagation

Seed propagation is favoured because the seedlings are free from the viral disease as well as plenty of planting materials are obtained from a small quantity of seed.

Nursery

Ripe capsules of the desired cultivar are collected from high yielding plants during September-October. The seeds are extracted by gently pressing the capsules. The extracted seeds are washed in cold water four times to remove the mucilaginous coating. The washed seeds are drained and mixed with ash and allowed to dry in shade for 2 or 3 days. The seeds should be sown in the nursery within a fortnight. Sowing in September is the best for high germination. Sowing during southwest monsoon and winter should be avoided.

When it becomes necessary to store the seeds, it is advisable to store them in capsule form. It can be preserved in this form for one month, without deterioration of viability. Polythene lined gunny bags can be used for this.

In Kerala and Tamil Nadu, 18 month old seedlings are used for planting. The seeds are sown in primary nursery from where the young seedlings are transplanted to a secondary nursery and maintained for one year before planting in the main field.

Primary nursery

The nursery site is selected in open, well-drained areas, near a source of water. The land is dug to a depth of 30 cm, cleared of all stubbles and stones; and clods are broken. Beds of size 6m x 1m x 0.3 m are then prepared. Jungle soil is spread in a thin layer over the nursery bed. Seeds are sown on the bed in lines. For an area of 1 m^2, 10 g of seed is required. Sixty grams of seeds will be required for a nursery bed of 6 m^2. The seeds are covered with a very thin layer of fine soil. The nursery bed is mulched with dry grass. Potha grass (*Grenetia stricta*) commonly seen in high range areas is a suitable material for this purpose. Grass is spread to a thickness of about 2 cm. Paddy straw can also be used for mulching. After sowing, beds have to be watered every day in the morning and evening. The mulch should be removed on commencement of germination. The seedlings have to be protected by providing shade pandals. Regular watering, weeding and protection from pests and diseases are to be attended to. During June-July, seedlings from the primary nursery are transplanted to the secondary nursery.

Secondary nursery

After preparing the site properly, form nursery beds of 6m x 1m x 0.3 m. Mixing of well decomposed cattle manure and wood ash with the top layer of the soil will help the seedlings to establish well and to grow vigorously. During June-July, the seedlings from the primary nursery are transplanted at a spacing of 25-30 cm. Shade pandals should be provided before transplanting. Overhead pandals or individual pandals for each bed may be erected. Mulching the bed with dry leaves will help to conserve soil moisture. Regular watering during dry months, weeding, application of fertilizers, control of pests and diseases and mulching are the essential operations for the maintenance of the secondary nursery. One month before uprooting, the pandal should be removed to encourage better tillering.

Polybag nursery

Polybags can be used for raising secondary seedlings. For such nurseries, seeds are to be sown in beds in primary nurseries in September and transplanted to polybags in December-January. These seedlings would be ready for planting in June-July. In this case, nursery period could be reduced by 6 to 7 months.

Vegetative propagation

vegetative propagation techniques have become popular among cardamom planters due to earliness in bearing and also resulting in 30-40 percent higher yield than seedlings. For vegetative propagation, a portion of the rhizome with one old and one young sprout contributes a planting unit that are easily separated from the established clumps. This method ensures propagation of high yielding lines.

Planting

Field is cleaned and terraces are made across the slopes at suitable planting distances. Spacing of 2m x 2m is recommended for Malabar, 3m x 3m for Mysore and Vazhukka. Pit size of 45cm x 45cm x 30cm is dug during April-May, filled with a mixture of surface soil and compost or well rotten farm yard manure. This has to be done two months in advance of planting of seedlings for establishment and good growth. Best time for planting is with the commencement of south west monsoon prior to the onset of heavy rains. Cloudy days with slight drizzles would be ideal for planting resulting in early and maximum percentage of establishment. Deep planting should be avoided as it results in suppression of the growth of new shoots that may cause decaying of under ground stem. A small mound may be formed inside the pit to cover the rhizome and immediately after planting, mulching should be given and plants should be supported by stakes in order to prevent them from being damaged or blown over by wind. Inoculate AMF at the time of planting and use Trichoderma enriched manure.

Weed management

Cardamom is a surface feeder, therefore two- three rounds of weeding is necessary in a year. The first round of weeding is to be carried in May-June, the second in August-September and third in December-January and weeds can be used as mulch. Normally slash weeding is performed in cardamom plantations.

Trashing

Trashing consists of removing senile and dried shoots of plants once in a year with the onset of monsoon. The trashed leaves and leafy stems may be heaped between the rows and allowed to decay or used for composting. From second year after planting, trashing is to be carried out every year. Trashing facilitates better sunlight penetration and aeration, there by promoting good tiller initiation and growth as well as reduction in thrips and aphids population. It also helps in better pollination by honeybees.

Earthing up

Earthing up of plant base and root zone with top soil is recommended during October-December. While doing this operation, care should be taken to ensure that only top soil is used and it is evenly spread at the base covering only half of the bulb portion of the rhizome.

Water management

Cardamom is generally grown as a rainfed crop, and cardamom tracts of India experience a dry spell of about 5-6 months. Often terrain of cardamom estates is undulating with moderate to steep slopes. Run off from the cardamom watersheds can be collected in farm ponds and small check dams or underground water tapped through dug wells. Effective mulching is also recommended during summer period so as to protect the root zone microflora from UV radiation and conservation of moisture.

Soil and water conservation

Soil and water resources should be handled in a sustainable manner and appropriate measures are to be adopted for their conservation. In sloppy land the soil may be disturbed to bear minimum in all agricultural operations. Contour bunding may be resorted in sloppy lands to conserve soil and water.

Manuring

It is estimated that an average of 5-8 tones of dry leaves fall from shade trees annually in a hectare of land in cardamom plantations adding 100-160 kg N, 5-8 kg P, 100-160 kg potassium, 10-16 kg calcium and 25-40 kg magnesium per hectare.

Application of organic manures such as FYM, cowdung or compost @ 5 kg/plant or neem cake @ 1-2 kg/plant and 100 g bonemeal / per plant may be done during June-July and during September/October. Application of *Azospirillum* and phosphate solubilizing bacteria @ 50 g/ plant or PGPR mix I along with 5kg of FYM was found to be effective in enhancing the yield.

Shade

Cardamom is a pseophytic plant that performs very well beneath the forest trees. Cardamom thrives well in moderate shade (50-60% of light intensity-). Trees having distributed branching and small leaves are ideal for cardamom. In newly established plantation where shade is inadequate, fast growing species of *Vernonia arborea* may be planted along with the other trees. Some of the good shade trees suitable are *Vernonia arborea* (Karana), *Cedrella tuna* (Red ceder), *Cassia fistula* (Kanikonna), *Diospyros malabaricum* (Vellakail), *Terminalia tomentosa* (Thempavu), *Hopea parviflora* (Thambakam), *Acrocarpus fraxinifolia* (Balangi), *Mesopsis eminii* (Elangi) and *Artocarpus integrifolia* (Jack). Shade trees like red cedar, which shed their leaves in monsoon, provide natural shade regulation. Protection from sunlight by maintaining an overhead tree shade is essential for cardamom in the initial stages of growth to enhance tillering. In order to provide adequate sunlight during the rainy season, excess shade should be regulated before the onset of monsoon. It is

desirable to maintain a mixed population of medium sized shade trees, that facilitate shade regulation, and to maintain more or less optimum conditions through out the year. Trees that carry crowd crown of canopy are undesirable as shade trees as they hardly allow filtered sunlight.

Bee keeping

The main pollination agent in cardamom is honey bee (*Apis cerana indica*). Maintaining four bee colonies per hectare during flowering season is recommended for increasing fruit set and production of capsules. In some gardens pollination is also effected by rock bee, *Apis dorsata* that occur naturally in the forest ecosystem.

Plant protection

Pests

1) Cardamom thrips (*Sciothrips cardamomi)*

Cardamom thrips are minute fringe winged clawless greyish brown insects that breed on plant parts such as unopened leaf, spindles, leaf sheath, flower bracts and floral tubes persistently. Nymphs and adults puncture the tissues on the ovary and young capsule. The injured tissues form a corky layer on the capsule surface due to host reaction, which appears as scabs. Such capsules appear malformed, shrivelled and cankerous. This condition is known as “Cardamom itch”.

The feeding injury by thrips affects the yield by two ways. Firstly, the stunting of panicles and shedding of flowers reduce the number of capsules formed. Secondly, scabbing on capsules lowers their quality, quantity and therefore fetches reduced market price. Thrips population is high during December to May when the temperature is high. With the onset of monsoon, the population of thrips shows a gradual decline and attains minimum coinciding rainy season. Malabar type cardamom with prostrate panicles is more tolerant to infestation by thrips than Mysore and Vazhukka types with erect and semi-erect panicles respectively owing to chemical constituents and disposition of panicle. The extent of damage in terms of quality and quantity of the produce ranges from 30-80%. Cardamom capsules infested by thrips (“Itch”) were found not inferior in essential oil content and composition and therefore can be preferred in oil industry.

Management

1) Removal of dry drooping leaves as well as dry leaf sheath (Trashing) during January-February.
2) Destruction of collateral host plants such as *Amomum, Alpinia, Curcuma, Colacasia* in the immediate vicinity of cardamom plantations.
3) Conservation and innundative release of natural enemies such as *Chrysoperla carnea* is very important for enhancing effective predation.
4) Apply fish oil soap (Na) 2.5% plus tobacco extract 2.5%
5) Malabar type cardamom with higher 1, 8-cineole content was preferred in endemic tracts.

2) Shoot and capsule borer (*Conogethes punctiferalis)*

The caterpillars bore into stem of seedlings, young tillers, panicles and capsules. Early stage larvae bore the panicles leading to drying up of the entire panicle and also bore the immature capsules, feed on the seeds and empty the capsules. The late stage larvae feed on the central core of the stem, affect the xylem vessels interrupting the passage of food materials to the growing parts and lead to the drying of central leaf known as "dead heart" symptom. The conspicuous oozing out of excreted frass at the mouth of the bore holes is an indication of the presence of larvae within.

Management

1) Malabar type having prostrate panicle and lanky stem was found tolerant to borer damage.
2) Removal and destruction of alternate hosts such as castor, ginger, turmeric in the immediate vicinity.
3) Roguing and destruction of infested tillers during September-October.
4) Encouragement of golden backed woodpecker and crow-pheasant in the plantation and installation of bird perches to attract birds of economic importance in biological control.
5) Application of *Steinernematid* entomopathogenic nematodes @ 100IJ/larvae or *Bacillus thuringiensis* when early-instar larvae are found in capsule or panicle or unopened lead buds *ie.*, within 20 days of adult moth emergence.
6) Use of pheromones in the monitoring of the pest and therefore correct timing of application of biorationals shall be recommended.

3) Root grub (*Basilepta fulvicorne)*

The grubs congregating on the root zone of cardamom clumps feed and cause irregular patch on the roots. As a result, reduction in uptake of nutrients leading to crop loss ranging from 29-66%. As the pest is subterranean, damage on roots may not be known until the symptom is reflected on the foliage (yellowing of leaves) or soil sampling done to assess grub population. Secondary infection by clump rot fungus is also observed in severely infested gardens. The damage is very severe in gardens with inadequate shade. Two peaks of adult emergence were noticed one after the pre-monsoon rains (March-April) and another during September-October.

Management

1) Collection and destruction of adult beetles during their peak period of emergence.
2) Raking the soil and removal of dried leaves before drenching of entomopathogenic nematode (EPN) suspensions.
3) Use entomopathogenic fungi *Metarrhizium anisopliae* and entomopathogenic nematode *Heterorhabditis indica*. Application of entomopathogenic nematode *Heterorhabditis indica* @ 100 IJ/grub.

4) Avoid planting of jack, mango, fig etc as shade trees as these trees are alternate host of the pest.

5) Ensure adequate shade of 65-70% in endemic areas and irrigate the crop before attaining critical period.

6) Control measures against clump rot fungus should be followed immediately after the management of root grub.

7) Proper phosphatic nutrients (readily absorbable compost/vermicompost) are required for rejuvenation of cardamom roots damaged by root grub.

8) Mulching of plant base with leaves of wild *Helianthus* sp. to prevent egg laying of adult beetles.

4) Whitefly (*Singhiella cardamomi)*

This pest of minor importance has assumed major status owing to unjudicious use of insecticides.

Colonies of nymphs and adults desap the lower surface of the leaves. Chlorotic patches appear initially on leaves, which in turn become yellow and necrotic in the advanced stages. The adult is a soft bodied insect about 2 mm long having two pairs of white wings.

Management

1) Monitoring and trapping the adults using yellow sticky traps coated with viscous castor oil. The traps can be placed between rows of cardamom plants or on the shade trees.

2) Application of 0.5% neem oil on the undersurface of the leaves. Spray fluid need not be applied on the panicles and cardamom stem.

5) Lace wing bug (*Stephanitis typicus)*

Both nymphs and adult bug with lace like wing desap from undersurface of cardamom leaves gregariously. Greyish yellow spots develop at the feeding site and in severe cases the plant growth is retarded and yield affected.

Management

1) Destruction and removal of alternate hosts such as banana, *Colacasia etc.* from the field

2) Provide adequate shade to the plantation.

Diseases

1) Capsule rot / *Azhukal* disease (*Phytophthora nicotianae* var. *nicotianae)*

The disease appears during the rainy season. Malabar varieties are more susceptible to *azhukal*. The diseases is more severe on the capsules. On the infected leaves, water soaked lesions appear first followed by rotting and shreding of leaves along the veins. The infected capsules become dull greenish brown and decay. This emits a foul smell and

subsequently shed. Infection spreads to the panicles and tillers resulting in their decay. High incidence of the disease is seen during the months of heavy and continuous rain fall and high relative humidity especially during July – August.

2) Clump rot or rhizome rot (*Pythium vexans*, *Rhizoctonia solani* and *Fusarium* sp)

Symptoms: Decayof the tillers starting from the collar region and toppling of tillers. Affected tillers can be pulled out with little force and the discoloration of the basal portion of clump can be seen.

3) Chenthal disease (*Colletotrichum gloeosporioides)*

Symptoms*:* Initially the symptoms appear as small water soaked rectangular lesions on the leaves which, later elongate to form parallelly arranged streaks and turn to yellowish brown to orange red in colour. The central portions become necrotic.

4) Leaf blotch disease (*Phaeodactylium alpiniae)*

Symptoms*:* The disease is characterized by the appearance of large blotches of irregular lesions with alternating shades of light and dark brown necrotic leaves. This is mainly observed on mature leaves.

5) Leaf rust (*Phakospora elettariae)*

Symptoms: The symptoms are white or ash coloured pustules on the undersurface of the leaves and yellowish orange discolouration on corresponding upper surface of the leaves. This disease is noticed mainly on older leaves.

6) Stem rot / stem lodging (*Fusarium oxysporum)*

Symptoms: The pathogen attacks middle portion of the tiller and produce pale discoloured lesions on the tillers leading to dry rotting. The tiller is weakened at this portion and leads to partial breakage. The partially broken tillers bend downwards and hang from the point of infection.

7) *Cercospora* leaf spot (*Cercospora zingiberi)*

Symptoms: The symptoms appear on the leaves as water soaked linear lesions, which are rectangular and parallelly arranged along the veins. On the upper leaf surface, lesions turn dark brown with dirty white long patches in the centre. In advanced stages, lesions become greyish brown in colour and later dry off.

8*) Phytophthora* leaf blight (*Phytophthora meadii)*

Symptoms: The infection starts on the young middle aged leaves in the form of elongate or ovoid, large, brown coloured patches which soon become necrotic and dry. These necrotic dry patches are seen mostly on leaf margins and in severe cases the entire leaf area on one side of the midrib is found affected.

9) Viral diseases

a) *Katte* or mosaic

The virus is transmitted by banana aphid *Pentalonia nigronervosa* and through infected rhizomes.

Symptoms: The first visible symptom appears on the youngest leaf of the affected tiller as slender chlorotic flecks. Later these flecks develop into pale green discontinuous stripes. These stripes run almost parallel to each other from the mid- rib to the margin of the leaves, which form a mosaic pattern symptoms. The infected clumps will be smaller in size with fewer tillers.

b) Cardamom vein clearing or *Kokke kandu*

Symptoms: Because of its characteristic symptom "hook- like tiller" it is locally called as "*Kokke Kandu*". The affected plants declined rapidly. Yield reduction is to the extent of 62-84 per cent in the plants with different stages of infection. The characteristic symptoms are continuous or discontinuous intraveinal clearing, stunting, rosetting, loosening of leaf sheath, shredding of leaves and clear mottling on stem. Clear light green patches with three shallow grooves are seen on the immature capsules. Cracking of fruits and partial sterility of seeds are other associated symptoms.

c) Cardamom necrosis / Nilgiri necrosis

Symptoms: The symptoms are seen on young leaves as whitish to yellowish continuous or broken streaks preceeding from the midrib to the leaf margins and later turn reddish brown. Often leaf shredding is noticed. The affected plants are stunted and fail to bear the panicles and capsules.

Management of fungal diseases

1) Expose the area of cultivation to the hot sunlight before planting to destroy the propagules of the pathogens. Apply the Trichoderma enriched organic manure and inoculate AMF at the time of planting.
2) Use of healthy and disease free planting materials.
3) Mulch the basins with green leaves and other organic materials during summer months to protect and conserve the native beneficial microflora and soil moisture. Mulching and application of biocontrol agents can be coupled to protect the cardamom plants against pathogen infection.
4) Destroy the disease caused palnts. Use helathy rhizome for planting. Destroy other host plants of virus like *Amomum connecarpum, Alpinia mutica, Curcuma neilgherrensis.*
5) Prophylactic foliar spray and drenching with 1.0 % Bordeaux mixture before onset of monsoon. Continue the spraying and drenching operations two or three times up to November- December according to the intensity of the disease. Adequate drainage should be provided in the garden.

6) Avoid excess shade during monsoon season to restrict the spread of the disease. Pre-monsoon application of *Trichoderma* enriched organic manure and spraying, drenching with Pseudomonas 2%/ PGPR mix II are effective for the management of the capsule and clump rot diseases of cardamom.Application of Trichoderma and *Pseudomonas fluorescens* / PGPR mix II during the onset of NE monsoon. Frequency of aplication of Pseudomonas / (Oct-Nov) PGPR mix II may be adjusted with intensity of disease.

Harvesting and processing

Cardamom plants start bearing fruits (capsules) from second year after planting and satisfactory yield are obtained from third year onwards. It takes 110 days from flowering to become mature fruits (brown to black seeded stage). Capsules just before full ripening are harvested to get maximum green colour during curing. Harvesting season is in August-December, peak harvest is during October-November. Capsules are harvested at an interval of 15-20 days at Karnataka and 30 days in Kerala and harvesting completed in about seven-eight rounds.

Post harvest operations consist of washing, curing (drying), cleaning, polishing, sorting, grading and packing. The capsules immediately after harvest are washed in water to remove the adhering soil. After harvest, cardamom capsules are dried in sun and graded according to size and colour. The hand picked fruits are dried in special curing chambers under controlled temperature to retain the delicate flavour and green colour. Heat required for drying is produced by burning firewood in the iron kiln, the heat thus produced is passed through pipes made of galvanized iron sheet. Capsules left for drying are spread thinly on wire net trays and stirred frequently to ensure uniform drying and also helps to retain green colour of capsule. They are initially heated to 50^{o}C for first 4 hours and subsequently reduced to 45-50^{o}C by opening the ventilators and using exhaust fan. Finally the temperature is raised to 60^{o}C for one hour. The process of drying takes about 36-48 hours

Dried capsule are rubbed with coir mat/gunny cloth/steel mesh and sieved to remove other plant debris. This process is called polishing. The polished capsules are then graded according to size by passing through sieves of size 7, 6, 5 mm. They are sorted according to size and colour. The percentage of recovery is 20-24%. The graded product is packed in polythene lined gunny bags.

GINGER (*Zingiber officinale*)

Ginger is a tropical plant adapted for cultivation even in regions of subtropical climate such as the high ranges. It prefers a rich soil with high humus content. Being an exhausting crop, ginger is not cultivated continuously in the same field but shifting cultivation is practised. The crop cannot withstand water logging and hence soils with good drainage are preferred for its cultivation. It is shade tolerant / loving crop with shallow roots and therefore suitable for intercropping and as a component in the homesteads where low to medium shade is available.

Preparation of land

Clear the field during February-March and burn the weeds, stubbles, roots etc. in situ. Prepare the land by ploughing or digging. Prepare beds of convenient length (across the slope where the land is undulating), 1 m wide, 25 cm high with 40 cm spacing between the beds. Provide drainage channels, one for every 25 beds on flat lands.

Varieties

Table 17. Salient features of high yielding ginger varieties

No.	Variety	Avg. yld t/ha (fresh)	Salient features	Crude fibre (%)	Essen-tial oil (%)	Oleor-esin (%)	Dry yield kg/ha
1	IISR Varada	22.6	Bold rhizomes, tolerant to diseases maturity 200 days	3.3-4.5	1.7	6.7	19.5
2	IISR Rejatha	22.4	Plumpy and bold rhizomes, maturity 200 days	20.8	4.0	2.4	6.3
3	IISR Mahima	23.2	Plumpy bold rhizomes resistant to nematode (*M. incognita & M.javanica*), maturity200 days	3.3	1.7	4.5	23.0
4	Suprabha	16.6	Plumpy rhizomes, maturity 229 days, wide adaptability	4.4	1.9	8.9	20.5
5	Suruchi	11.6	Profuse tillering, bold rhizomes, maturity 218 days	3.8	2.0	11.0	25.3

Dry ginger: Maran, Wayanad, Himachal, Kuruppampady, IISR-Varada, IISR-Rejatha and IISR-Mahima

Green ginger: Rio-De-Janeiro and Wayanad Local

Rio-De-Janeiro is preferable for extraction of oleoresin

Planting material

Ginger rhizomes are used for planting. For selection and preservation of seeds, adopt the following methods:

Mark healthy and disease free plants in the field when the crop is 6-8 months old and still green. Select best rhizomes free from pest and disease from the marked plants. Handle seed rhizomes carefully to avoid damage to buds. Soak the seed rhizomes in a solution containing *Pseudomonas* @ 20g/litre for 30 minutes and dry under shade by spreading on the floor. Store the treated rhizomes in pits dug under shade, the floor of which is lined with sand or saw dust. It is advisable to spread layers of leaves of *Glycosmis pentaphylla* (panal). Cover the pits with coconut fronds.

Examine the stored rhizomes at monthly intervals and remove the rhizomes that show signs of rotting. This will help to arrest further spread of the disease. Provide one or two holes for better aeration.

Season and method of planting

The best time for planting ginger is during the first fortnight of April, after receipt of pre-monsoon showers. For irrigated ginger, the best-suited time for planting is middle of February (for vegetable ginger).

Plant rhizome bits of 15 g weight in small pits at a spacing of 20cm x 20 cm to 25cm x 25 cm and at a depth of 4-5 cm with at least one viable healthy bud facing upwards. Adopt a seed rate of 1500 kg/ha. Before planting soak the seed rhizomes in a solution containing *Pseudomonas* @ 20g/litre for 30minutes and dry under shade.

Manuring

Apply manures and biofertilizers at the following rates.

FYM / compost @ 25 tonnes as basal and 3t/ha each at 60DAP and 120DAP. Apply FYM, *Trichoderma*, neem cake mixture @ 100 g / planting pit at the time of planting. Vermi compost or coir pith compost may also be used at a reduced dose instead of FYM according to availability.

Apply *Azospirillum* @ 2.5 kg /ha / PGPR mix I as basal. Repeat the same dose at 120 DAP. Inoculate with AMF at the time of planting.

Mulching

Immediately after planting, mulch the beds thickly with green leaves @ 15 t/ha. Repeat mulching with green leaves twice @ 7.5 t/ha first 45-60 days and second 90-120 days after planting. Grow green manure crops like daincha and sunn hemp in the interspaces of beds, along with ginger and harvest the green manure crop during second mulching of ginger beds.

Aftercultivation

Remove weeds by hand-weeding before each mulching. Repeat weeding according to weed growth during the fifth and sixth month after planting. Removed weeds should be recycled by way of mulching. Earth up the crop during the first mulching and avoid water stagnation.

Plant Protection

Pests

Nematodes

Apply neem cake @ 1t/ha at planting.Repeat the same dose at 45 DAP.

Diseases

Rhizome rot and bacterial wilt

Select sites having proper drainage.

Dip the seed rhizome with 5% talc formulated (50g/L) suspension *of Pseudomonas fluorescens* P_1 for 15 minutes before planting.

Treat the seed rhizome with AMF

Apply organic manure enriched with *Trichoderma* at the time of planting.

Spray and drench the plant with *Pseudomonas fluorescens* P_1 / PGPR mix II at 45 days after planting (onset of monsoon).Repeat spraying and drenching at monthly intervals based on disease incidence and intensity

Harvesting and processing

For vegetable ginger, the crop can be harvested from sixth month onwards. For dry ginger, harvest the crop between 245-260 days. After harvest, the fibrous roots attached to the rhizomes are trimmed off and soil is removed by washing. Rhizomes are soaked in water overnight and then cleaned. The skin is removed by scrapping with sharp bamboo splits or such other materials. Never use metallic substances since they will discolour the rhizomes. After scrapping, the rhizomes are sun-dried for a week with frequent turnings. They are again well rubbed by hand to remove any outer skin. This is the unbleached ginger of commerce.

Ginger oil

Ginger oil is prepared commercially by steam distillation of dried powdered ginger. The yield of oil varies from 1.3 to 3.0 per cent. The major use of ginger oil is as a flavouring agent for beverages, both alcoholic and non-alcoholic.

Ginger oleoresin

Oleoresin from ginger is obtained conventionally by extraction of dried powdered ginger with organic solvent, ethanol. Commercial dried ginger yields 3.5-10.0 per cent oleoresin. Ginger oleoresin is a dark brown viscous liquid responsible for the flavour and pungency of the spice.

TURMERIC (*Curcuma longa*)

Turmeric is a tropical herb and can be grown on different types of soil under irrigated and rainfed conditions. Rich loamy soils having good drainage are ideal for the crop. It is a shade tolerant crop with shallow roots suitable for intercropping and also as a component crop in the homesteads where low to medium shade is available.

Preparation of land

Prepare the land to a fine tilth during February-March. On receipt of pre-monsoon showers in April, prepare beds of size 3m x 1.2 m with a spacing of 40 cm between beds.

Seed material

Whole or split mother rhizomes are used for planting. Select well developed, healthy and disease free rhizomes. Store the seeds in cool, dry place or in earthen pits plastered with mud and cowdung.

Varieties

Local varieties: Duggirala, Tekurpetta, Sugantham, Kodur, Armoor, Alleppey, Suvarna, Suguna, Sudarsana

Table 18. Salient features of high yielding turmeric varieties

No.	Variety	Average yield(dry) (t/ha)	Curcumin (%)	Oleoresin (%)	Essential oil (%)	Dry recovery (%)	Duration	Other features
1	Kanthi	7.34	7.18	12.13	5.15	18.7	240-270	Bigmother rhizome with medium bold fingers and closer inter nodes
2	Sobha	5.74	7.39	15.95	4.24	18.30	240-270	Big mother rhizome with medium bold fingers and closer inter nodes. Inner core of rhizome is dark orange. More tertiary rhizomes.
3	Sona	7.05	7.11	18.00	4.40	18.88	240-270	Orange yellow rhizome medium, bold with no tertiary fingers. Best suited for central zone of Kerala. Rhizome medium bold field tolerant to leaf blotch.
4	Varna	6.37	7.87	13.88	4.56	19.05	240-270	Orange yellow rhizome medium, bold tertiary fingers present. Best suited for central zone of Kerala. Rhizome medium bold field tolerant to leaf blotch.
5	IISR Prabha	7.30	6.5	15.00	6.50	19.50	205	-
6	IISR Prathiba	7.23	6.2	16.20	6.20	18.50	225	
7	IISR Alleppy Supreme	6.73	5.55	16.00	-	19.0	210	Tolerant to leaf blotch
8	IISR Kedaram	6.52	5.5	13.60	-	18.90	210	Tolerant to leaf blotch

Season and method of planting

Plant during April with the receipt of pre-monsoon showers. Take small pits in the beds in rows with a spacing of 25cm x 25 cm. Plant finger rhizomes flat with buds facing upwards and cover with soil or dry powdered cattle manure. The seed rate is about 2000-2500 kg per ha.

Manuring

Apply FYM / compost as basal dose @ 35 t/ha at the time of land preparation or by spreading over the beds after planting and 3t/ha each at 30DAP and 60DAP. Apply 250 kg ash / ha, half at 30 DAP and the other half at 60 DAP.

Apply FYM + *Trichoderma* + neem cake mixture @ 100 g / planting pit at the time of planting.

Vermicompost or coirpith compost may also be used at a reduced dose instead of FYM according to availability.

Apply *Azospirillum* @ 2.5 kg /ha / PGPR mix I as basal. Repeat the same dose at 60 DAP.

Mulching

Mulch the crop immediately after planting with green leaves @ 15 t/ha. Repeat mulching with green leaves twice @ 7.5 t / ha first 45-60 days and second 90-120 days after planting.

Aftercultivation

Weed the crop thrice at 60, 120 and 150 days after planting, depending upon weed intensity. Removed weeds should be recycled by way of mulching. Earth up the crop after 60 days.

Plant protection

Diseases

Rhizome rot, wilt and leaf spot diseases

Dip the seed rhizome with 5% suspension *of Pseudomonas fluorescens* P_1 for 15 minutes before planting.

Treat the seed rhizome with AMF

Apply organic manure enriched with *Trichoderma* at the time of planting.

Spray and drench the plant with *Pseudomonas fluorescens* P_1 / PGPR mix II at 45 days after planting (onset of monsoon). Repeat spraying and drenching at monthly intervals based on disease incidence and intensity.

Harvesting and curing

Time of harvest depends on the variety and it usually extends from January to March. Harvest early varieties at 7-8 months, medium varieties at 8-9 months and long duration varieties at 9-10 months after planting.

Improved method of processing

Cleaning

Harvested turmeric rhizomes are cleaned off mud and other extraneous materials adhering to them and subjected to curing within 2-3 days after harvest so as to ensure the quality of the end product.

Boiling

Fingers and mother rhizomes will have to be boiled separately. Boiling is usually done in MS pans of suitable size. Cleaned rhizomes (approximately 50 kg) are taken in a perforated trough of size 0.9 m x 0.55 m x 0.4 m made of GI or MS sheet with extended handle. The trough containing the rhizomes is then immersed in MS pan (1 m x 0.62 m x 0.48 m) containing clean water sufficient to immerse the rhizomes. The whole mass is boiled till the rhizomes become soft. The correct stage of cooking can be judged by piercing a wooden needle through the rhizome. If the rhizomes are properly cooked, the needle will pass through the rhizome without resistance. The cooked rhizomes are taken out of the pan by lifting the trough and draining the solution into the pan.

Drying

The fingers are then dried in the sun by spreading them as a thin layer on bamboo mats or drying floor. Artificial drying at a maximum temperature of 65ºC gives a bright coloured product than that of sun drying especially for sliced turmeric.

Polishing

In order to smoothen the rough and hard outer surface of the boiled dried turmeric and also to improve its colour, it is subjected to polishing. There are two types of polishing, hand polishing and machine polishing.

Hand polishing: The method of hand polishing is simple, which consists of rubbing turmeric fingers on hard surface or trampling them under feet wrapped in gunny bags. The improved method is by using hand-operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against the mesh as well as by mutual rubbing against each other as they roll inside the drum.

Machine polishing: This method consists of an octagonal or hexagonal wooden drum mounted on a central axis and rotated by power.

Colouring

Boiled, dried and half polished turmeric fingers (half polished turmeric is more suitable since colour does not stick to the rhizomes that have been polished fully to smooth finish) are

taken in bamboo basket and shaken with turmeric powder. For coating 100 kg of half polished turmeric 200 g of turmeric powder is required. When fingers are uniformly coated with turmeric powder, they are dried in the sun.

Turmeric oleoresin

This is obtained by the solvent extraction of the ground spice with organic solvents like acetone, ethylene dichloride and ethanol for 4-5 hours. It is orange red in colour. Oleoresin yield ranges from 7.9 to 10.4 per cent. One kg of oleoresin replaces 8 kg of ground spice.

VANILLA (*Vanilla planifolia*)

Vanilla is a tropical orchid requiring a warm climate with frequent rains, preferring an annual rainfall of 150-300 cm. Uncleared jungle areas are ideal for establishing vanilla plantations. In such locations, it would be necessary to retain the natural shade provided by lofty trees and to leave the soil or the rich humus layer on the top undisturbed. Vanilla is cultivated on varied type of soils from sandy loam to laterite. It requires filtered sun light. In the absence of natural shade, trees should be grown to provide shade. Dry climate and direct falling of sunlight on to the plants may cause yellowing by sun scorching.

Preparation of land and planting of standards

Clear the land of jungle growth and prepare for planting. Being a creeper, the plant requires support up to a height of about 150 cm. Low branching trees with rough bark and small leaves are preferred as support trees. Cuttings of *Plumaria alba, Erythrina lithosperma, Jatropha carcas* and *Glyricidia maculata* are suitable as live supports. They are to be planted at least six months prior to planting of vanilla for successful establishment. Cuttings of 1.5-2.0m length with 4-5 cm diameter are to be used for planting in pits of about 30cm x 30cm x 30cm at a spacing of 2.5 m between rows and 2m within row. This can accommodate about 1600- 2000 plants in one-hectare area as pure crop. The growth of live standard is to be adjusted to make them branch at a height of 150 cm to facilitate trailing of the vines and artificial hand pollination.

Planting, training and pruning

Vanilla is propagated by planting shoot cuttings *in situ*. Shoot cuttings are to be taken from healthy and vigorously growing plants. Plant rooted cuttings of 60 cm length in pits of 40 cm cube filled with dry leaves and top soil. They are planted close to the base of the support tree. The top end of the cutting is to be tied to the base of the support tree gently so that it will eventually climb on them. If shade is not sufficient from the support tree, palm fronds or other leaves can be used to provide shade to the cuttings. Longer cuttings bear earlier than shorter cuttings.

Plant the cutting with the onset of monsoon rains. Plant the cuttings at a spacing of 2.7 m between plants and 1.8 m between rows. Trail the vines on the live supports and when they attain a height of 150 cm coil on branches of support plants in loops touching the ground. Trailing or coiling is an important cultural operation, which facilitate early induction of flowering.

Manuring

Being a surface rooting plant, manuring should be confined to the surface layer of soil. Provide heavy and frequent mulching to the vines. Apply 10 kg FYM in two split doses in June-July and September-October. Cowdung slurry / biogas slurry / groundnut cake slurry @ 2 litres / plant may be applied around the base of the vine at bimonthly intervals. Vermiwash with 5 times dilution / fresh cattle urine with 10 times dilution may be applied as foliar spray at monthly intervals up to fruit set.

Aftercultivation

Vanilla cannot withstand even the slightest root disturbance. Hence remove weeds from the plant base by hand-weeding and use them as mulch. Being closely planted, no intercrops are raised in a pure plantation of vanilla. But vanilla can be planted as an intercrop in coffee, coconut, arecanut etc. The vines may be irrigated luxuriantly immediately after flower opening up to harvest of beans. Maintaining high humidity in vanilla plantation by using micro-sprinklers and foggers will help in better growth of vines.

Moisture stress is a pre-requisite for triggering of flowering in vanilla. Therefore, irrigation should be withheld from November -December up to initiation of flower buds ie. January –February.

Judicious lopping of branches of live supports during the onset of southwest and northeast monsoon periods is very important to adjust the shade level to 50 %. All pruned materials can be used as mulch.

Flowering and pollination

Flowering of vine commences usually by about the third year. The inflorescence is produced in the leaf axils during the month of January - February. There is a tendency for some of the vines to maintain only vegetative growth. A light nipping off or pruning of the terminal shoots hasten flowering. Due to the peculiar structure of the flowers, self-pollination is impossible. Hence hand pollination is adopted for fruit set. Best time for pollinating the flowers is between 6 a.m. and 1 p.m. and a success of 80-85% can be obtained. Successful fertilization is indicated by the retention of calyx and the stigma even after four days of pollination.

Plant protection

Pests

Vanilla bug (*Halyomorpha* sp.)

Collection of eggs, nymphs and adults and their destruction

Diseases

***Fusarium* wilt, *Phytophthora* rot and fungal leaf spot**

Remove and destroy all disease affected plant parts.

Dip the vines with 5% suspension of *Pseudomonas fluorescens* P_1 for 15 minutes before planting.

The organic manure used for planting and that applied at different stages of growth shall be enriched with *Trichoderma.*

After planting, drench and spray *Pseudomonas fluorescens* P_1 suspension (2%).

Pseudomonas application may be adjusted based on disease incidence and intensity.

Drenching with copper oxychloride 0.3% for phytophthora and fusarium wilt.

Harvesting and curing

The pods ripen in about 9-11 months time. Before attaining maturity, the fruit is dark green in colour and when ripe yellowing commences from the tip of the pod. Collect the pods at this time, as this is the optimum time for harvesting the pod. If allowed to remain on the vine further, the pods split. Free vanillin is not present in the beans when they are harvested. They also do not have the aroma. Vanillin is developed as a result of enzyme action on a glycoside occurring during the process of curing of beans. Harvested beans are subjected to curing which is characterized by four phases.

1. Killing or wilting beans to arrest the vegetative development in the fresh beans and initiate the enzymatic reactions responsible for the production of aroma and flavour. Killing is indicated by the development of a brown colouration of the bean.
2. Raising temperature of the killed beans (sweating) to promote the desired enzymatic reactions and to achieve rapid drying so as to prevent harmful fermentation.
3. Slow drying at ambient temperature until the beans have reached about one-third of original weight for the development of various fragrant substances.
4. Conditioning the beans by storing them in closed boxes for three months or longer to permit the full development of desired aroma and flavour.

Curing of vanilla involves immersing the beans (2-3 days after harvest) in hot water at a temperature of 63 to 65ºC for three minutes for the cessation of vegetative life. After a rapid drying on woolen blankets, when the beans are still very hot, they are kept in chests lined with blankets. Next day they are spread out in sun on blanket for three to four hours and rolled up to retain the heat. Repeat this for six to eight days during which beans lose their weight, become supple and can be twisted on finger without breaking. This is followed by slow drying in the shade for a period of two to three months.

Properly dried beans are kept in trunks where the fragrance is fully developed. Finally, they are graded according to size and bundled and placed in iron boxes lined with paraffin paper. The vanillin content of properly cured beans will be about 2.5 per cent.

Yield

The yield of vanilla varies depending on the age of vines and the method of cultivation. Normally it starts flowering from the third year, which gives yield in the fourth year. The yield stabilizes at fifth or sixth year and may decline at about 12^{th} or 13^{th} year. The plants are to be replanted at this stage. Under reasonable level of management, the average yield of a middle-aged plantation will be about 300 kg of cured beans per hectare.

NUTMEG *(Myristica fragrans)*

Nutmeg requires a hot, humid climate without pronounced dry season. The soil should be rich in organic matter and well drained. The tree prefers partial shade. Sheltered valleys are the best suited. It can be grown up to about 900 m above MSL.

Varieties

Select locally available, high yielding and high quality cultivars. Viswashree is an improved variety from IISR.

Seeds and sowing

Seeds from fully ripened tree-burst fruits are collected directly from the tree for raising seedlings. The fleshy rind and the mace are removed before sowing. Care should be taken to avoid drying of seeds, as dried seeds fail to germinate. Hence immediate sowing of seeds is recommended. Otherwise seeds should be kept in baskets filled with moistened sand till sowing. Seeds of fully mature fruits will be of black colour.

Seed beds of 100 – 120 cm width, 15 cm height and of convenient length may be prepared in cool and shady places. A mixture of garden soil and sand in the ratio 3:1 may be used for preparing nursery beds. Over this, sand is spread to a thickness of 2 -3 cm and the seeds placed 2 cm below the surface at a spacing of about 12 cm on either side. Seeds

germinate within 50 – 80 days after sowing. Young seedlings cannot withstand direct sunlight or heavy moisture. When the plumule produces two elongated opposite leaves, the seedlings are to be transferred from beds to poly bags of size 13cm x 18 cm. Field planting is done six months after germination. Seedlings attain a height of around 23 cm at this stage.

Planting

Nutmeg requires shade for optimum growth. Hence suitable banana varieties can be planted on both sides at a distance of 1m from the pit. This will provide shade in the early stages. Generally nutmeg is cultivated as an intercrop in coconut gardens. Hence the required shade for the growth of plants will be provided by the main crop like coconut. Pits of 90cm x 90cm x 90 cm are dug at a spacing of 8m x 8m with the onset of South West monsoon. The pits are filled with top soil and compost or well decomposed cattle manure and seedlings are planted.

Aftercare

Small rootlets spread very near to top soil. Hence digging should be avoided in the root zone. Therefore hand weeding is generally recommended. Certain rootlets may come above surface soil. Earthing up should be done to protect such rootlets. Dried branches are to be removed. Small branches, which grow erect from the main branches, should also be removed as they do not set fruits.

Manuring

Nutmeg requires heavy manuring. Cow dung or compost is found to be good. Apply 10 kg cattle manure or compost per seedling during the first year and increase the quantity of organic manure to 50 kg gradually till the tree attains an age of 15 years. This can be applied in two or three split doses. Application of poultry manure, vermi compost, neem cake and bone meal is also beneficial to enhance the growth and yield (Table 19).

Table 19. Additional requirement of organic manures

Organic manures	Quantity	
	1st Year	2nd Year
Bone meal	100g/plant	100g/plant
Neem cake	100g/plant	100g/plant
Poultry manure	2kg/plant	4kg/plant
Vermi compost	2kg/plant	4kg/plant

Gradually increase the dose of the manure as the plant grows. Application of biofertilizers such as *Azospirillum* and phosphobacteria / PGPR mix I @10 to 25g/plant in the root zone during the first year and 25 to 50g/plant during subsequent years is also advantageous. Seedling root dip is also beneficial to the plants. Inoculate with AMF in the nursery and field at the time of planting.

Harvesting

Peak period of harvest is from December to May. When fruits are fully ripe, the nuts split open. These are either plucked from the tree or allowed to drop. The two major products are nutmeg and mace. Dried nutmeg and mace are directly used as spice and also for the preparation of their derivatives.

The nuts meant for sowing are kept in moist places and others are dried in the sun for six to eight days till they rattle in their shell. They are stored in warm dry places prior to shelling.

Plant protection

Diseases

Pests

The hard scale *Saissetia nigra* occurs on the pencil thick branches and desaps the tissues. The infested shoots invariably develop sooty mould cover.

Spray tobacco decoction/neem- garlic suspension (2%).

Leaf spot and shot hole *(Colletotrichum gloeosporioides)*

Syptoms: Sunken spots surrounded by a yellow halo are the initial symptoms. Subsequently the central portion of the necrotic region drops off resulting in shot hole symptoms. Die back symptoms are also observed in some of the mature branches. On young seedlings drying of the leaves and subsequent defoliation are seen.

Control: The disease can be controlled by spraying 1% Bordeaux mixture 2-3 times during rainy season.

Fruit rot *(Colletotrichum gloeosporioides)*

Symptoms: Water soaked lesions are seen on the fruits, the tissues of which become discoloured and disintegrated. Premature splitting of the pericarp and rotting of mace and seed are the main symptoms of this disease. The internal tissues are found rotten. The fallen fruits become enveloped with the growth of the organism.

The above diseases can be controlled by spraying *Pseudomonas fluorescens* @ 20 g/ litre / PGPR mix II/ spraying 1% bordeux mixture.

MEDICINAL AND AROMATIC PLANTS

CHETHIKODUVELI (*Pulmbago rosea*)

This is an attractive erect rambling shrub with long tuberous roots and bright red flowers in long terminal spikes. Root tubers are the medicinally important parts. This is an esteemed remedy for leucoderma and other skin diseases. The synonyms of fire like 'agnih' 'analah' etc. are attributed to this drug to indicate caustic action of roots causing blisters on skin. The drug is used only after adequate curing and purification. Roots contain plumbagin, which is responsible for the therapeutic action of the drug.

The crop can be grown satisfactorily under open as well as in coconut gardens.

Land preparation, planting and manuring

In mid-May, trenches of 1 m width, 50 cm depth and convenient length may be made. Apply green leaves @ 20 t/ha / FYM @ 10 t/ha and bone meal 2 t/ha and fill the trench with top soil. Alternative to this, combined application of FYM @ 10 t/ha with *Azospirillum* and Phosphate Solubilising Bacteria each @ 2.5 kg/ha or PGPR mix I is also recommended. Vermicompost / coirpith compost can also be applied instead of FYM depending upon the availability in a reduced dose.

During June, beds of 15 cm height may be prepared and three nodded semi hardwood cuttings may be planted at a spacing of 5cm x 5 cm. Shade is provided immediately after planting as high humidity is required for rooting. Inoculate cuttings with AMF to ensure maximum sprouting and early growth in main field.

The crop may be top dressed with pre-composted poultry manure @ 2.5 t/ha or FYM @ 5 t/ha twice at 6 and 12 months after planting and earthed up.

Varieties

Mridhula

Clonal selection. High root yield (2.94 t/ha -dry) and low plumbagin content (0.22%). Can be used without curing in the preparation of indigenous medicines

Agni

Clonal selection. High root yield (2.65 t/ha -dry) and high plumbagin content (0.80%).Suitable for the extraction of plumbagin.

After cultivation

Keep the field free of weeds by frequent weeding up to 9 months after planting and irrigate the crop at fortnightly interval by flood irrigation during dry months.

Harvesting

Crop can be harvested in about 18 months after planting. After digging out, root tubers are cleaned by washing in water and marketed fresh or dried.

NEELA AMARI (*Indigofera tinctoria*)

Nili is a reputed drug for promotion of hair growth. Due to antitoxic property it is also a good remedy for poisons. This plant, which is the original source of natural indigo, is an erect shrub. Leaves are important in medicine and form a major ingredient of preparations like 'Nilibhringadi'. Roots are also used in ayurvedic preparations.

Nili grows well in open conditions and coconut gardens above the age of 25 years.

Land preparation

Prepare soil to fine tilth by ploughing two or three times.

Seeds and sowing

Seeds are very small and seed rate is 3-4 kg/ha. Seeds may be sown directly or transplanted from nursery to main field. Seeds require pre-treatment for good germination, as seed coat is hard. Seeds are mixed with sand and ground gently to break seed coat. An alternate method for enhancing germination is dipping the seeds in boiling water for a second. After pre-treatment seeds are broadcasted, preferably by nixing with sand 2-3 times its volume to ensure uniform coverage. Seeds germinate within a week. Transplant seedlings at 40-50 cm spacing when seedlings are 30 days old.

Season

Best time for sowing is September-October.

Manuring

Apply cattle manure @ 10 t/ha as basal dressing and incorporate into soil along with last ploughing. Topdressing may be done with pre-composted poultry manure @ 0.5 t/ha or FYM @1 t/ha incorporated with PGPR mix I (2.5 kg / ha) after each harvest.

Aftercultivation

Weeding has to be done as when required. Irrigate during summer.

Plant protection

Pests

Psyllid, *Arytaina puctipennis* sucks sap from tender shoots and leaves, causing leaf fall and wilting of plants.

Control: The pests can be controlled by spraying, tobacco decoction/ neem-garlic suspension 2%.

Harvesting

Plants start flowering 2-3 months after sowing. Harvesting is done just before flowering by cutting the plants at a height of about 30 cm from ground level. Irrigate plants after harvest. Subsequent harvests can be made at 1.5-2 months interval. Four to five cuttings

can be taken in a year depending on the growth. A crop is retained for 3-4 years for harvest of leaves after which entire plants are dug out and roots are collected.

Seed collection

A few plants per plot are left without cutting to set seeds. Ripe pods are to be harvested in the early morning to prevent loss of seeds by shattering during harvest.

CHENGAZHINIRKIZHANGU (*Kaempferia rotunda*)

Chengazhinirkizhangu is a medicinal herb with aromatic rhizome. Rhizomes are used for treatment of tumours, swellings and wounds. It helps to remove blood clots and other purulent matters in body. It is used in many *ayurvedic* formulations including 'Chyavanaprasam' for improving complexion and curing burning sensation, gastric complaints, mental disorders and insomnia.

Climate and soil

The plant is distributed in the tropics and subtropics of Asia and Africa. It grows wild in wet, humid or shaded forest ecosystems of south India. It is also cultivated as an intercrop with other commercial crops. Moist loamy soil is ideal for the crop. Laterite soil with heavy organic manure application is also well suited.

Propagation

It is propagated through rhizomes.

Varieties

At present, only local types are available for cultivation.

Season

Optimum time of planting is with receipt of pre-monsoon showers.

Land preparation

Plough the field to good tilth. Prepare raised seedbeds of 1 m breadth and of convenient length.

Seed rate

Use rhizome bits of size 10-15 g for planting. About 2500-3000 kg rhizomes are required for planting one hectare. Smoking rhizomes for 2-3 weeks is good for development of healthy sprouts. At times, rhizomes are stored in *Glycosmis pentaphylla* leaves in underground pits covered with coconut fronds.

Planting

Pits are made at 20 cm spacing on the seedbed. Whole or split rhizomes with at least one healthy sprout is planted 5 cm deep with sprout facing upwards and covering pit with FYM.

Mulching

Mulch beds thickly with green leaves or straw @ 15 t/ha immediately after planting and again after two months along with weeding and topdressing. Mulching is absolutely essential for good growth. Mulching suppresses weed growth and provides favourable soil physical, chemical and biological conditions and microclimate for better rhizome production.

Manuring

Compost or FYM @15 t/ha is to be applied in pits at the time of planting. After planting, rhizomes are lightly covered with soil. *Azotobacter* / PGPR mixI 2.5kg /ha and compost/ FYM @ 2.5 t/ha may be applied second and fourth months after planting at the time of weeding and earthing up.

Aftercultivation

Remove weeds, apply manures and earth up at two and four months after planting, followed by mulching.

Plant protection

During rainy months, rhizome rot is noticed which can be controlled by drenching 1% Bordeaux mixture.

Harvesting and yield

Crop matures in 7-8 months. Drying up of leaves is the indication of maturity. Dig out rhizomes carefully, remove leaves and clean. Rhizomes with attached tubers are usually marketed afresh. Prolonged storage may cause insect and fungus attack. Average yield is 12-15 t/ha and dry rhizome yield 27-30%.

KASTHURIMANJAL (*Curcuma aromatica*)

Curcuma aromatica is a rhizomatous herbaceous medicinal plant. Rhizome is an odoriferous ingredient of cosmetics used for cure of chronic skin diseases caused by impure blood. It is used as appetizer and tonic to women after childbirth. It is also useful against high fever and worm infestation.

Climate and soil

It is distributed in Southeast Asia. The plant grows wild in the eastern Himalayas and in moist deciduous forests of Kerala and Karnataka. It is grown as a subsistence crop in backyard, kitchen garden and interspaces of other crops in areas with good rainfall. Well-drained rich loamy soils are ideal for the crop. Higher yields of rhizomes are obtained from crop grown under shade.

Propagation

It is propagated vegetatively by rhizomes.

Varieties

At present, only local types are available for cultivation.

Land preparation

Clear the area, remove all the pebbles and stones and plough the field to good tilth. Prepare raised seedbeds of 1.2 m breadth and of convenient length. In sloppy lands the beds should be made along the contours to prevent soil erosion. .

Seed rate

A healthy disease free mother rhizome with at least one germinated sprout and weighing not less than 25g is the best planting material. It is required at the rate of 1500 kg/ha.

Planting and manuring

Take small pits at 25cm x 25 cm spacing on seedbed and plant seed rhizomes with germinating sprout facing upwards. Cover the rhizome with FYM @ 10-15 t/ha and mulch the beds with leaves or straw. Combined application of FYM @ 10 t/ha with *Azotobacter* / PGPR mix I @ 2.5 kg/ha is also recommended. At 2 and 4 months after planting, cow dung @ 5 t/ha or pre-composted poultry manure @ 2.5 t/ha may be applied after weeding and the beds may be earthed up.

Aftercultivation

Carry out gap filling if necessary within one month. Remove weeds at two and four months after planting and earth up.

Plant protection

Rhizome rot: Drench with *Pseudomonas fluoroscens* 2% solution.

Harvesting and yield

Crop matures in 7 months. Drying up of leaves is the indication of maturity. Dig out rhizomes without causing damage. Remove dry leaves and roots. Cleaned rhizomes are either marketed or dried and stored. Average yield of fresh rhizome is 28 t/ha which on drying gives 27% recovery.

Processing

Rhizome is thinly sliced and steam distilled for 3-4 hours for extracting essential oil. Oil yield is 90 litres/ha. Oil recovery is 0.33% on fresh weight basis and 1.05% on dry weight basis.

CHITTARATHA (*Alpinia calcarata*)

Alpinia calcarata (galangal) is also known as *rasna* in Sanskrit. It is a perennial herb with non-tuberous pungent rootstock. It grows to a height of 1.5 m and produces around 24 suckers per clump per year. Rhizomes are used in bronchial infections, rheumatoid arthritis and as a carminative.

Climate and soil

Alpinia comes up well in tropical climate. It grows on a wide range of climate and soil. Well-drained hilly areas and places up to 1400 m altitude are good for its cultivation. Fertile red loams to forests soils are suitable.

Propagation

It is propagated vegetatively by rhizomes.

Varieties

At present, only local types are available for cultivation.

Season

Rainfed crop is planted with onset of monsoon in May-June. Irrigated crop can be planted at any time.

Land preparation

Plough the field to good tilth. Remove all pebbles and stones. Prepare raised beds of convenient length and breadth to facilitate drainage.

Seed rate

Fresh healthy disease-free rhizome bits with at least one shoot are the planting material, which is required @ 1000-1500 kg/ha.

Planting

Take small pits on the seedbed and plant 5 cm long rhizome bits. Cover rhizome with FYM and mulch the seedbed with leaves or straw. Optimum spacing is 30cm x 20 cm under good fertility and 40cm x 30 cm under poor fertility conditions.

Manuring

Apply FYM @ 10-15 t/ha as basal in pits. Application of biofertilizer *Azospirillum* / PGPR mixI @ 2.5 kg/ha and *in situ* green manuring with cowpea is beneficial for the crop. At 2 and 4 months after planting, cow dung @ 10 t/ha or pre-composted poultry manure @ 5 t/ha may be applied after weeding and the beds may be earthed up.

Aftercultivation

Carry out gap filling, if required, within one month; remove weeds two months after planting followed by topdressing, earthing up and mulching. Thereafter no weeding is required as the crop smothers the weeds.

Plant protection

Occasionally shoot borers and leaf eating caterpillars are observed which are not serious and controlled by spraying with neem kernel suspension (5%).

Leaf blight disease can be controlled by spraying with 1% Bordeaux mixture / 2% Pseudomonas.

Harvesting and yield

Though the crop can be harvested after 18 months, optimum stage of harvest for obtaining maximum rhizome and oil yield is 36-42 months after planting. Cut and remove shoot portion and carefully dig out rhizomes and roots. Harvesting is very arduous due to strong and extensive root ramification. Separate roots, clean rhizomes and cut into 5 cm long pieces, which are dried in sun for 3-5 days to 10% moisture for marketing. Average yield of rhizomes is about 23 t/ha, which on drying gives 25% recovery.

Processing

Fresh rhizomes on steam distillation for 3-5 hours give 0.22% essential oil. Oil recovery on dry weight basis is 0.93%. Root is also a significant contributor of essential oil.

BLACK MUSLI (*Curculigo orchioides*)

Black Musli or *Nilappana*, one of the ayurvedic *dasapushpas*, is a small gåîphilous herbaceous plant with cylindrical rhizome. Rhizome is the economic part. It is a rejuvenating and aphrodisiac drug. It improves complexion and is useful in general debility, deafness, cough, asthma, piles, skin diseases, impotence, jaundice, urinary disorders, etc. It is an ingredient of ayurvedic formulations like *Vidaryadi ghrita, Vidaryadi lehya, Marma gulika, Musalyadi churna etc.*

Climate and soil

The plant is found throughout India from near sea level to 2300m altitude, particularly in rock crevices and laterite soil. It grows well in moist humus-rich soils especially in shady forest areas and rubber plantations. It is a shade loving plant and its growth, yield and quality are optimum under 25 per cent shade. It can be grown as an under storey crop or intercrop in plantations.

Propagation

The plant is propagated through rhizome. It is slow growing and less competitive.

Varieties

At present, only local varieties are available for cultivation. However, a large variability exists among natural population, which offers wide scope for improvement of the crop by selection and hybridization.

Season

Rainfed crop is planted with the onset of monsoon in May – June. Irrigated crop can be planted at any time.

Seed rate

Fresh healthy disease free rhizome with at least one shoot is the planting material, which is required @ 750 kg/ha.

Land preparation, planting and manuring

Plough the field to good tilth. Remove all pebbles and stones. Incorporate poultry manure @10t/ha or FYM 20t/ha and PGPR I @ 2.5 kg/ha. Prepare raised beds of convenient length and breadth to facilitate drainage. Fresh rhizome bits of 1.5-2 cm are planted at a spacing of 10cm x 10 cm. 25% shade is required for proper growth. Mulching is not good as it adversely affects crop establishment and yield.

After cultivation

Carry out gap filling, if any, within one month. Soil should be sufficiently moist to get maximum rhizome development. Two to three weedings are essential to control weeds. As the rhizome development is upward, regular earthing up is required for high yield.

Plant protection

Seedling rot is found during rainy season and spraying 1% Bordeaux mixture can control it. Rhizomes are found eaten by rodents and hence proper control measures are to be taken for their control.

Harvesting and yield

Plant grows actively up to 7 months, after which it could be harvested for rhizome yield. During summer months, above ground portion becomes dried up. If it is not harvested during current year, it will put forth new shoots with onset of next monsoon. Harvesting is done by digging out rhizomes. Shoot portion and roots are removed and separated rhizomes are cleaned. Fresh rhizome yield is 3-4 t/ha. Rhizomes are sliced to 1 cm size, dried in sun and marketed or stored in gunny bags. Dry rhizome yield is 1-1.5 t/ha (35-40% dryage). Higher yield is obtained if harvested during second year. Dry rhizome contains 53% starch, 12% protein, 3% fibre, 2% fat, 0.1% curculigoside and 4% ash.

HOLOSTEMMA (*Holostemma adakodien*)

Holostemma or *Adapathiyan* is a large, glabrous, laticiferous twining shrub, much branched, with shining stem and large conspicuous flowers. Root is the economic part. It is useful in ophthalmopathy, orchitis, cough, burning sensation, stomachalgia constipation, fever and *tridoshas*. It is used in preparations of *Vidaryadi ganam, Dhanwandharam thaila, Manasa mithra vatakam, Balarishta and Anuthaila.* It is also useful in eye diseases and it imparts resistance to diseases.

Climate and soil

It grows on a wide range of climate and soil. Well-drained hilly areas with an underlying hard pan are good for its cultivation. Fertile red loams to forest soils are suitable.

Propagation

The plant is propagated vegetatively by vine cuttings and rot cuttings and by seeds. Seeds are collected from the plant in November-December before being dispersed. Seeds are cleaned, dried and stored for sowing. Stored seeds after soaking in water for 4-5 hours are sown on seedbeds. When seedlings are fully germinated, they are planted in polybags, which are kept in shade and irrigated. About 1-1.5 month old seedlings are ready for transplanting.

Varieties

Jeeva

Clonal selection. Purple cordate plant type with long internodes, high yield of thick, sweet roots 1.50t/ha dry root with high soluble sugar content (8.33%)

Season

Rainfed crop is planted with the onset of monsoon in May – June. Irrigated crop can be planted any time.

Land preparation

Plough the field to good tilth. Remove all pebbles and stones.

Planting

Pits of $30cm^3$ size are taken at 1-1.2m distance and filled with 10kg dried cow dung and top soil and formed into a mound. Seedlings are transplanted on mounds.

Manuring

Two months after planting, topdressing may be done with cow dung @ 5 kg/plant or pre-composted poultry manure @ 2 kg/plant.

After cultivation

Carry out gap filling, if any, within one month; remove weeds two months after planting followed by top dressing, earthing up and mulching. Thereafter no weeding is required as the crop smothers the weeds. Since the crop is twining in nature, *pandal* or stakes are to be provided to aid trailing. Regular irrigation is to be given till flowering.

Plant protection

Common pests are aphids and leaf eating caterpillars and can be controlled by spraying tobacco decoction.

Leaf spot and leaf blight diseases can be controlled by spraying 1% Bordeaux mixture.

Harvesting and yield

Flowering and fruiting occurs in November-December. Harvesting can be done at 18 months after planting by digging the soil to collect tubers. Tubers are cut into pieces of 10 cm length and dried in sun before sale. Yield of fresh tubers is about 1-1.5 t/ha which on drying gives 500-600 kg.

LONG PEPPER (*Piper longum*)

Long pepper is a slender aromatic climber whose spike is widely used in ayurvedic and unani systems of medicine particularly for diseases of respiratory tract and in abdominal complaints.

Soil and climate

Long pepper is successfully cultivated in well drained forest soils rich in organic matter. Laterite soils with high organic matter content and moisture holding capacity are also suitable for cultivation. It is a tropical plant adapted to high rainfall areas with high humidity. An elevation of 100-1000 m is ideal. It needs partial shade to the tune of 20-30% for best growth. The natural habitat of the plant is on the borders of streams.

Seeds and sowing

Long pepper is propagated by suckers or rooted vine cuttings collected from female plants.15-20 cm long 3-5 nodded rooted vine cuttings establish very well in polybags. Inoculate cuttings with fluorescent *Pseudomonas*, phosphorus solubilizing bacteria and AMF to improve seedling quality index and early growth in the main field. The best time for raising nursery is March-April. Normal irrigation is given on alternate days. The rooted cuttings will be ready for transplanting in 2 months time. With the onset of monsoon in June the field is ploughed well and brought to good tilth. 15-20 cm raised beds of convenient length and breadth are taken. On these beds, pits are dug at 60cm x 60 cm spacing and well decomposed organic manure at 100 g/pit is applied and mixed with the soil. Rooted vine cuttings from polybags are transplanted to these pits.

Varieties

Viswam

For open and shaded conditions

Manuring

The crop needs heavy manuring @10 t FYM / vermicompost @ 6.25 t/ha every year**.** Top dressing with FYM @ 5 t/ha is recommended. Application of wood ash 2 t/ha enhances crop growth and spike production. Apply PGPR mix I @ 2.5 kg/ha in order to supplement N, P, K nutrition.

Irrigation

The crop needs irrigation once a week. Sprinkler irrigation is ideal. With irrigation the crop continues to produce spikes and off-season produce will be available. However, unirrigated crop after the onset of monsoon grows vigorously and shows much hardiness than the irrigated crop.

After cultivation

Gap filling can be done one month after planting. *P. longum* can also be cultivated as an intercrop in plantations of coconut, subabul and eucalyptus. Weeding has to be resorted to whenever necessary. However, care is to be taken not to break the roots of thippali, as any damage result in damping off.

Plant protection

Mealy bugs and root grubs, attack the plant particularly during summer. Infested plants show yellowing and stunted growth. Adults and nymphs of *Helopeltis theivora* severely feeds on the foliage which can be controlled by 0.25% neem kernel suspension. Rotting of leaves and vines during monsoon season caused by *Colletotrichum gloeosporioides* Necrotic lesions and blights on leaves during summer caused by *Colletotrichum* and *Cercospora spp.* can be controlled by spraying 1% Bordeaux mixture repeatedly / application of *Aspergillus terreus* @ 2 g / kg of potting mixture along with neemcake @ 2 g / kg of potting mixture is effective.

Harvesting and processing

Vines start flowering six months after planting and flowers are produced almost throughout the year. Spikes mature in 2 months time. Optimum stage of harvest is when spikes are blackish green. Pungency is highest at this stage. Spikes are hand picked when they become mature and dried. Yield of dry spike is 400 kg /ha during first year, increases to 1000kg during third year and thereafter it decreases. Therefore, after 3 years the whole plant is harvested. Stem is cut at ground level and roots are dug up. Average yield is 500 kg dry roots/ha.

The harvested spikes are dried in sun for 4-5 days until they are perfectly dry. The green to dry spike ratio is 10:1.5 by weight. The dried spikes have to be stored in moisture proof containers. Stem and roots are cleaned, cut into pieces of 2.5-5 cm length, dried in shade and marketed.

KACHOLAM (*Kaempferia galanga*)

Aromatic essential oil of roots of Kacholam is widely used in perfumery, as a condiment, and as a folk medicine. Asians employ rhizomes and leaves as a perfume in cosmetics, hair washes and powders. It is used to protect clothing against insects. Also used in chewing with betel nut.

Kacholam is a plant adapted for tropical climate. Fertile loamy soil having good drainage is ideal for the crop. Laterite soil with heavy organic manure application is also well suited.

Preparation of land

Prepare the land to a good tilth during March by ploughing or digging. On receipt of pre-monsoon showers in April, prepare beds of 1 m width, 25 cm height and of convenient length with spacing of 40 cm between beds.

Seed materials

Whole or split rhizome with at least one healthy sprout is the planting material in kacholam. Select well developed healthy and disease free rhizomes. Rhizomes can be stored in cool dry place or pits dug under shade, plastered with mud or cowdung. Two weeks before planting, smoking the rhizomes by spreading it on *Glycosmis pentaphylla* (panel) leaves is practised in certain localities.

Varieties

Kasthuri

High yield and high volatile oil with yield potential of more than 2 tonnes dry rhizomes per ha and have good aroma and flavour.

Rajani

High yield and high oleoresin with yield potential of more than 2 tonnes dry rhizomes per ha and have good aroma and flavour.

Season and method of planting

Planting is done during the month of May with receipt of four or five pre-monsoon showers. Take small pits in the beds in rows with a spacing of 20cm x 15cm and at a depth of 4-5 cm and plant rhizomes with at least one viable healthy bud facing upwards. Adopt seed rate of 700-800 kg/ha. Immediately after planting mulch the beds thickly with green leaves @ 15 t/ha. Inoculate seed material with *Azospirillum* + PSB + AMF for enhancing rhizome production and oil yield.

Manuring

After planting, rhizome is lightly covered with soil and FYM or compost at the rate of 20 t/ha is applied in pits. *Azotobacter* / PGPR mixI along with 2.5kg/ha and compost/FYM @ 2.5 t/ha may be applied second and fourth months after planting at the time of weeding and earthing up. Apply PGPR mix I @ 2.5kg/ha along with organic manure.

Plant protection

Pests

Major insect pests damaging the crop are shoot borer and the general management measures for organic cultivation may be adopted to control insect pests.

Diseases : Rhizome rot and leaf spot.

1. Select sites having proper drainage
2. Select seed rhizomes from disease free areas
3. When incidence of rhizome rot is noticed in the field, dig out the affected plants and drench the beds with 1% Bordeaux mixture
4. Inoculation with native arbuscular mycorrhiza, *Trichoderma* and *Pseudomonas fluorescens* at the time of planting.
5. Spray 1% Bordeaux mixture for controlling leaf spot

Harvesting and curing

The crop can be harvested seven months after planting. Drying of leaves is the indication of crop maturity for harvest. Harvest the crop carefully without cutting rhizomes, remove dried leaves and roots, wash rhizomes in water and dry. With sharp knife, chop rhizomes into circular pieces of uniform size except end portion, which has to be cut separately. Spread cut rhizomes uniformly on clean floor and allow drying for four days. On fourth day, heap the rhizomes and keep it overnight. On the next day it is again spread and dried. Clean the dried produce, bag and store in cool dry place or market it. In case of prolonged storage rhizomes may be dried in sun occasionally to prevent insect and fungus attack.

ASOKA *(Saraca asoca)*

Asoka or *Asokam* is a medium sized handsome evergreen tree growing up to 9m in height with numerous spreading and drooping glabrous branches. It is a sacred tree of Hindus and Buddhists and possesses varied medicinal properties. Bark is useful in dyspepsia, fever, burning sensation, visceromegaly, colic, ulcers, menorrhagia, metropathy, leucorrhoea and pimples. Flowers are considered to be uterine tonic and are used in vitiated conditions of *pitta*, syphilis, cervical adinitis, hyperdipsia, burning sensation, haemorrhoids, dysentery, scabies in children and inflammation. Well-known Ayurvedic preparations are *Ashokarishta* and *Ashokaghrita*. *Ashokarishta* is prescribed in leucorrhoea, haematuria, menorrhagia and other diseases of genitourinary system of females.

Climate and soil

Asoka grows well in areas with well-distributed rainfall and in slightly shady areas. The tree is grown throughout India except in northwestern part of the country upto an elevation of about 750 m. It grows on a wide range of soils.

Propagation

The plant is seed propagated. Seeds are formed usually during February-April. Seeds are collected when they ripen and fall down. They are sown after soaking in water for 12 hours on prepared beds. Seeds germinate within 20 days. Seeds are then planted in polybags. 2-month-old seedlings from the polybags are used for transplanting.

Varieties

At present, only local varieties are available for cultivation.

Season

The crop is planted with onset of monsoon in May – June.

Planting

Square shaped pits of 60cm depth are taken at 3m spacing and filled with topsoil, sand and dried cow dung @ 20 kg/pit. 2 months old seedlings are then transplanted.

After cultivation

The base of the trees is to be cleared of weeds and FYM @ 2 kg/tree/ year may be applied twice; first in May- June and again in October-November. The dose is to be increased gradually to 10 kg from 5th year onwards. The plant responded well to organic manuring and also to biofertilisers like *Azospirillum* and Phosphobacter at 1.0 kg/ha.

Plant protection

No serious pests or diseases are generally noted in this crop.

Harvesting and yield

Asoka can be cut after 20 years for collection of bark, the medicinally useful part. It is cut at a height of 15cm from soil level. If irrigation and fertilizers are given, the stump will produce new shoots and it can be harvested again after 5 years. Alternatively, the bark can be collected without cutting down the tree. Bark is peeled off first, vertically from one side of the main trunk. The excised area is renewed with fresh bark in 1-2 years. Then, bark on the other side can be peeled off. The process can be continued over years.

STRYCHNINE TREE *(Strychnos nux-vomica)*

Strychnos or *Kanjiram* is a large deciduous tree with a fairly straight and cylindrical bole having dark grey or yellowish grey bark and minute tubercles. *Strychnos* is highly toxic to man and animals producing stiffness of muscles and convulsions, ultimately leading to death. In small doses it can serve as efficacious cure for paralysis and other nervous disorders. The seeds are used as a remedy in intermittent fever, dyspepsia, chronic dysentery, paralytic and neuralgic affections. It is also useful in impotence, neuralgia of face and heart disease. Leaves are applied as poultice in the treatment of chronic wounds and ulcers and the leaf decoction is useful in paralytic complaints. Root and root bark is used in fever and dysentery.

Climate and soil

The plant is distributed throughout India in deciduous forests up to 1200m. It is also found in Sri Lanka and Malaysia. It prefers tropical and subtropical climate. It is grown in different soil types such as laterite, sandy and alluvial.

Propagation

It is propagated through seeds. Viability of seeds decreases on storage. Fresh and dry seeds of *Strychnos nux-vomica* has poor germination. Germination can be substantially increased by treating the seeds with hot water (50^{o} C) for a period of six to twelve hours prior to sowing.

Season

Seedlings can be planted in main field with the onset of South-West monsoon in May-June.

Planting

Seeds are sown in poly bags. The saplings are later transplanted to the main field in pits of about 60 cm^3 size taken at a spacing of 3m x 3m, filled with top soil and 20 kg organic manure.

Manuring and after cultivation

Basins of the trees are cleared of weeds and after application of manures covered with soil. FYM @ 2kg per tree is to be applied during early stages and the dose is gradually increased to 20 kg from 5^{th} year onwards.

Plant protection

No serious pests or diseases are generally noted in this crop.

Harvesting and yield

Flowering is during March-April and fruiting during May-December. Fruits take about 8-9 months to mature. Mature fruits are to be harvested from time to time. Mature pods are collected and seeds are extracted, washed, dried and stored for later use. The yield is 50-75 kg dry seed per tree per year.

EUCALYPTUS (*Eucalyptus citriodora*)

Eucalyptus thrives both in the tropics and subtropics. High humidity and plenty of rainfall are conducive to its luxuriant growth. It can be grown in varied types of soils. The essential oil is used in preparation of cosmetics, hair oil and soap and forms a raw material for menthol manufacture.

Preparation of land

Clear the land of jungle growth. Take pits of size 45cm x 45cm x 45 cm at a spacing

2m x 2 m at least one month prior to planting and allow to weather. 20 kg FYM is applied in each pit, mixed with top soil and fill pits with soil completely so as to prevent water stagnation.

Planting

Seeds can be sown directly or seedlings raised in nursery and 4-5 months old seedlings are transplanted with commencement of southwest monsoon. After planting, press the soil around the seedling and form mound.

Manuring

When organically grown, nutrient requirement should be met by application of *Azotobacter* 2.5 kg/ha and compost or FYM @ 10 tonnes/ha each year with the onset of monsoon.

Aftercultivation

During first year, cultivate the rows in both directions to prevent weed growth. Hand weeding is done around the seedlings. Fire belts are to be provided all around.

Intercropping

Eucalyptus can be grown along with coffee, lemongrass and palmarosa. In the first four years, intercropping with pineapple, yam and vegetables can be done.

Harvest and curing

Pruning of side branches may be started from second year onwards. Lopping at a height of 2 m is done during third or fourth year and thereafter lopping is resorted to at half-yearly intervals leaving only one branch. For extracting oil, steam distillation is resorted to. Optimum time for distillation is two hours and average recovery of oil is 1.5-1.8% of the net weight of leaves. Wilting of cut leaves under shade for 24 hours before distillation will increase oil recovery percentage.

Pests and diseases

Important pests of Eucalyptus are termites, leaf cutting ants, snout beetles and wood borers. Pests can be controlled by spraying tobacco decoction/ neem-garlic suspension. Major diseases are seedling blight, stem end rot and leaf spots and can be controlled by spraying 1% Bordeaux mixture.

LEMONGRASS (*Cymbopogon flexuosus*)

Lemongrass prefers warm climate with a well-distributed rainfall and well-drained soil. Usually it is grown on poor, gravelly soils. Lemongrass is a perennial grass mainly cultivated on hill slopes as a rainfed crop. The crop provides maximum yield from the second to fourth year of planting and economic yield up to the sixth year. Thereafter, the yield declines considerably. The leaves yield aromatic oil, containing 70-85% citral. This oil is used in soaps, cosmetics and disinfectants and is a raw material for manufacturing ionones and vitamin A.

Varieties

OD-19

High yielding, high oil

Seeds and sowing

The crop is propagated mostly through seeds. It can also be propagated vegetatively through planting of slips.

Seeds can be sown directly in the field or seedlings are raised in a nursery and then transplanted. Transplanted crop is found superior to direct-sown crop in respect of grass yield, oil content and citral content in oil. Seeds are sown in well prepared nursery beds during April-May with the onset of pre-monsoon rains and covered with thin layer of soil. The seed rate is 3 to 4 kg/ha. Seeds collected in the season should be sown latest by August of the same year. Seedlings will be ready for transplanting in 45-60 days (6-7 leaf stage).

Land preparation

Land is prepared by digging. Raised beds of 75-80 cm width and of convenient length are formed with a spacing of 30-35 cm between beds. On sloppy terrain, the beds are formed along the contours. At the early southwest monsoon (June-July), two seedlings or slips per hill are transplanted on beds at a spacing of 30-40 cm in 4-5 rows. Before planting, top leafy portion of seedling is cut off leaving the plant stalk about 15-20 cm length.

Manuring

Basal application of compost made of spent lemongrass (refuse obtained after distillation) @ 2.5 t /ha and wood-ash @ 2t /ha is beneficial. Weeding, manuring with 10 t/ha FYM and earthing up may be done twice a year ie. with the onset of premonsoon showers and in July-August after second harvest.

Plant protection

Serious pests or diseases do not generally infest the crop.

Harvesting

Harvesting is done by cutting the grass 10 cm above ground level. During first year of planting, three cuttings are obtained and subsequently five to six cuttings per year are taken subject to weather conditions. Harvesting season begins in May and continues till end of January. The first harvest is taken about 90 days after planting and subsequent harvests at intervals of 40-50 days. Optimum interval between harvests to obtain maximum quantity of oil is 40-45 days for local types of lemon grass. For OD-19, optimum interval was found to be 60-65 days when grown in hill-tops and 45-55 days in valleys and lower areas.

Seed collection

Crop for seed production is left without cutting to get maximum seeds. Crop flowers during November-December and seeds are collected during January-February. Whole panicle is cut and dried for one or two days and then threshed and sieved to collect the seeds.

Distillation

Lemongrass is distilled in copper stills of about 100 kg capacities by steam distillation, or water and steam distillation process. Time required for one distillation is about two hours including time required for charging and discharging, provided firewood is well dried and of good quality. For one distillation, about 40 kg of firewood is required. A light yellow, lemon-scented volatile oil is obtained. Providing a perforated disc just above the water level in the copper still will be helpful to produce oil of better quality. This method is known as water and steam method. When crop area is large enough, steam method is found to be more economical. Coal is used as fuel.

Cut grass is chopped into smaller pieces before feeding to the distillation unit. It can be stored up to 3 days under shade without any adverse effect on yield or quality of oil.

Storage of oil

Lemongrass oil can be stored up to 3 years without affecting the quality of oil, if kept in aluminum containers sealed air-tight using wax. The containers are to be kept in darkness.

Yield

Grass yield during first year will be about 10 t/ha, which gives about 28 kg of oil. From second year onwards, grass yield will be about 25 t/ha giving about 75 kg of oil. Average recovery of oil is 0.30-0.35% with 70% citral for local types of lemongrass while OD-19 variety gives 0.40-0.45% oil recovery and 75-85% citral content.

PALMAROSA (*Cymbopogon martinii* var. *motia*)

Palmarosa (rosha grass) is adapted to marginal areas and poor soils; can be grown under dense canopies of trees and used for soil conservation. Flowering tops and foliage contain sweet smelling oil emitting a rose like odour and is widely used in soaps, cosmetics and perfumery industries. Oil is also used as a raw material for producing geraniol, which is extensively used in perfumery industry.

Propagation

The crop can be propagated by seeds and slips. Seedlings establish quicker and are better than slips from clones. So seedlings are preferred as planting materials under Kerala conditions. Prepare seedbed in well-ploughed soil after 15th April. Seeds @ 4-5 kg/ha is sown in seed beds and covered with a thin layer of soil. Give frequent watering till the onset of southwest monsoon. Seeds collected in January-February must be sown at the earliest.

Planting

Prepare the main field for planting; form beds and plant the seedling, two on a hill, at a spacing of 30cm x 20 cm. Apply organic manures like compost made of spent grass @ 6 t/ha and wood ash 2.5 t/ha at the time of formation of beds. Weeding, manuring with FYM @ 4 t/ha and earthing up may be done twice a year ie. with the onset of premonsoon showers and in July- August.

Harvesting

By about 3.5 to 4 months, plants attain a height of 150-200 cm and they start producing inflorescence. Grass is cut one week after flowering. Generally two cuttings are made during first year of planting. From second year onwards, 3 to 4 cuttings are possible.

Distillation

As in the case of lemongrass, extraction of palmarosa oil is done either by hydro distillation or steam distillation. It takes two hours to complete one distillation. Average recovery of oil from Amaravathy variety is 0.40 to 0.45%. Allowing the cut grass to wilt in shade for 24 hours during monsoon seasons and 48 hours during the post-monsoon will increase the oil recovery.

Plant protection

Pink globular root aphids occur on roots and cause withering of the crop in patches due to de-sapping. Dig out and burn affected patches and irrigate with water charged with fish oil soap or emulsion spray oil to control the aphids.

VETIVER (*Vetiveria zizanioides*)

Vetiver is a perennial grass, commonly known as 'khus' plant and mainly cultivated on hill slopes as a rainfed crop. Essential oil is extracted from the roots and known as 'khuskhus oil'.

It prefers a warm climate and grows in areas up to 600 m elevation. Even though vetiver grows almost in all soils, a rich and fairly well drained sandy loam is the best. An annual rainfall of about 100 to 200 cm, temperature ranging from 25 to 40ºC and moderate humidity are ideal for its growth.

Its root contains fragrant oil, which is a perfume by itself. The dry aromatic roots are made into curtains, mats, fans, etc. to emit scented cool aroma when moistened. The oil is used as a valuable fixative for blending perfumes and cosmetics.

Varieties

Two types of vetiver namely, South Indian and North Indian (khus) are generally under cultivation. South Indian types produce higher root and oil yield, but North Indian types have superior oil quality. Among South Indian types, Nilambur type (ODV-3) on an average produces 5 t/ha of root, yielding 20-30 kg oil/ha.

Planting

Crop is propagated through slips. June-July is the optimum period for planting. Two to three ploughings are given so that soil is well loosened and ridges or beds of convenient length are made. Slips are planted in two rows on 1 m wide beds.

Manuring

Usually 5 t/ha of FYM or compost is applied at the time of bed preparation. Normally, vetiver crop is not manured on fertile soils. On poor soils, application of 4 t/ha FYM as topdressing during second year is found beneficial for increasing root and oil yield.

Harvesting and distillation

Optimum period of harvest of roots to get maximum oil yield is 18 months. Harvesting is done with digging forks. Roots are washed gently to remove the earth and are chopped into bits of 4-5 cm length. Oil is extracted by hydro-distillation. Roots must be distilled for 40-50 hours.

Vetiver as a soil binder

Vetiver has a deep, dense and strong fibrous root system. Perennial and sterile characteristics of the crop with its hardiness and unpalatability to livestock make it an excellent soilconserving crop. It may be planted as a contour hedge on sloppy lands or can be used to protect banks of major irrigation canals.

ORNAMENTAL PLANTS

ANTHURIUM (*Anthurium spp.*)

Anthurium is one of the important economic flowers of export potential. There are more than 500 species and several varieties. Few of them are commercially important.

Anthurium andreanum, A. veitchii and *A. scherzerianum* are the economically viable species. Many of them are partially epiphytic in growth habit. Plants prefer to grow under shade. The tolerable level of light in the tropical region during summer is 20-30 per cent. Excess light causes yellowing and scorching of leaves. Very low light intensity causes excessive vegetative growth and low flowering. It is preferable to grow anthurium in the open, under artificial shade structures for better growth and yield. Plant prefers to grow under a relative humidity of not less than 60 per cent and a temperature of not more than 30^0 C.

Propagation

Anthurium is multiplied by seed and vegetatively by stem cuttings or by separation of basal sprouts. Propagation by seed is not recommended as a commercial propagation method as it results in high variability. Plants can be multiplied in large number by micro-propagation techniques from the tender leaf bits.

Varieties

Varieties suitable for cut flower production under Kerala conditions are Tropical, Can Can, Flame, Casino, Caesar, Acropolis, Lima White, Akapana, Senator, Cheers, Salasaga, Chichas, Pistache and Midori. Varieties suitable as pot plants are Condor, Excellent, Diablada and Bonina.

Seed propagation

Seeds are produced by hand pollination. Selfing or crossing can be made. Seeds become mature within a period of 4-6 months after pollination. Mature seeds will have a pulpy coating. The pulp is carefully removed without injuring the soft seed. Seeds are sown immediately after extraction. Sowing is done on a medium of clean fine sand or on a moist cotton pad. Sprouted seeds on cotton pad are shifted to sand medium for further growth. Seedlings are highly variable and will take two years for flowering. Seed propagation is not recommended for commercial production, but only for the production of hybrid varieties.

Vegetative propagation

Plants are propagated vegetatively by cutting the thick main stem into 3-4 cm long discs. If the stem is very thick, the discs can be cut vertically. Each bit should have minimum two lateral buds. Cut-pieces are treated with fungal formulations of *Verticillium locanii* and planted on a medium of clean river sand. Cuttings will take 1-2 months for sprouting. Suckers from flowering plants can also be separated as and when available and planted in the medium.

Seedlings and sprouted cuttings of 5-10 cm height are transferred to the main field or pots. Planting in pots is preferred in the plains. Cultivation in beds is good at higher altitudes (about 1000 m above MSL). A loose medium above the ground is suitable for anthurium. Old and chopped coconut husk (3 cm size) mixed with brick pieces and charcoal are filled in narrow trenches 10 cm below and above ground level. Pots can also be filled with the same mixture. An ideal pot should be 30 cm diameter at top with 3 large holes at the bottom on sides. One seedling can be planted in a pot. On ground, the spacing is 45 to 60 cm depending upon the variety. Fresh cowdung or neem cake mixed with 10-15 times of water, kept for 4-5 days, can be sprayed on the plants after filtering. Cow's urine can be sprayed or drenched after mixing with 25 times of water.

Cultivation practices

1. Growing medium

Coarse sand : Neopeat (3:1)

Fresh cow dung/ neem cake/ neem cake: groundnut cake(1:1) mixed with 10-15 times of water, kept for 3-4 days, supernatant liquid filtered and sprayed on the plants once in a week.

2. Growing medium

FYM - 200 g/pot

Vermi compost - 100 g/ pot

Biofertilizers - Azospirillum, VAM and Phosphobacteria each @ 2g /plant /2 months.

Trichoderma - 20 g/ pot

Application of Panchagavya 3% or Vermiwash 3% at 15 days interval as sprays on the plant

3. Growing medium

Sand : Leaf compost (1:1)

Application of organic manure mixture with the following composition @ 40 g per plant once in two months

Leaf compost - 500 g

Coir pith compost - 1.2 kg

Bonemeal - 1.5 kg

Neem cake - 500 g

Poultry manure - 300 g.

Plant Protection

Two major diseases are bacterial blight and anthracnose. Blackening of the stem and decay of leaf axils and drying of leaves and flowers are the symptoms of bacterial blight. Tiny circular black spots appear on leaf and spadix in case of anthracnose.

Management of bacterial blight

Sanitation, isolation of affected plants

Cut and burn affected parts, sterilize the instruments used for cutting by flaming before using on another plant

Spraying *Pseudomonas* (2%) on the plants / PGPR mix II (2%)

Application of crude extract of neem cake/ *Tagetes erecta* (2:1), Neem cake extract 2%, Neem oil 1% or coconut oil 1%

Root dip and foliar spray with *Bacillus* sp.(0.07%)

Application of turmeric powder: sodium bicarbonate (10:1) @ 1.5% at weekly intervals.

Application of fresh cowdung as sprays (5%)

Management of anthracnose

Preventive spraying with broth culture of *Pseudomonas fluorescens* 0.5% / PGPR mix II 2%

Spray *Phyllanthus niruri* extract (30%) or neem oil (1%) at fortnightly intervals

Pruning of older leaves and flowers, removal or suckers at young stage, cleaning of crown before rains are other operations to be carried out in order to have better growth and flowering.

Harvesting

The flowers are harvested with its long stem when $1/4^{th}$ to $3/4^{th}$ flowers on the spadix are open, indicated by the change of colour. Colour varies with the varieties.

ORCHIDS

Orchids are noted for their bewitchingly beautiful, long-lasting flowers, widely differing in shape, size and colour. They belong to the family Orchidaceae, reported to comprise over 600 genera, 30000 species and a lakh man-made hybrids. They have varying habitats but epiphytic orchids dominate the trade. They are also classed as monopodials (stems having a vertical growth, non-branching, with aerial roots) and sympodials (stems having a horizontal growth, producing pseudobulbs in clusters, no aerial roots).

The ideal location for orchid growing is in the open conditions, under appropriate level of shade nets. In Kerala it is also grown under the shade of coconut trees above 10 years old.

Most attractive orchids belong to the group of epiphytes, which require free moving air at all times. The orchid plants produce aerial roots, which absorb water and nutrients from the atmosphere. Both terrestrial and epiphytes grow under varying levels of shade. Plants grown under deep shade will have good vegetative growth and poor flowering. Hence shade and light regulations are very important operations for better flowering. This requirement varies with the species and varieties. Some species grow in open sunlight. A humid and warm atmosphere is congenial for the growth of most of the tropical orchids. Better results are obtained when the atmospheric humidity is 50% to 80%. Orchids require proper temperature for good growth and flowering. Accordingly there are tropical, subtropical and temperate orchids.

Genera / varieties

The popular genera of orchids suitable for growing in Kerala are *Arachnis, Aranthera, Vanda, Phalaenopsis* (monopodials); Aranda, Mokara (inter-generic monopodials); *Dendrobium, Cattleya, Oncidium* (sympodials).

Dendrobium is the most popular genus of Kerala. Some of the important varieties belonging to this genus are given below, grouped according to colour.

Purple and white: Sonia 17, Sonia 28, Sonia Bom Jo, Earsakul

Purple: Renappa, New Wanee, Sabine Red, Jurie Red, Velvet Soft

White: Emma White, Fairy White, Kasem White, Snow White, Lemon Glow

Pink: Sakura Pink, New Pink, Deep Blush, Master Delight, Pink Cascade

Yellow: Sherifa Fatimah, Kasem Gold, Tongchai Gold.

Propagation and planting

The conventional method of propagation is by vegetative means. Monopodial orchids are propagated by stem cuttings. Terminal cuttings with one or two healthy aerial roots are ideal as planting material. Basal cuttings of 30 cm length with a few roots and leaves are also good. Sympodial orchids are propagated by separation of pseudobulbs. A plant with minimum two or three pseudobulbs with the basal root is ideal for planting. Some of the sympodial varieties produce sprouts at the top of pseudobulb called as keikes. Keikes when fully grown can be separated and planted. Besides, backbulbs or spent canes (shoots that have ceased to produce flowers) before they shrivel can be severed from the mother plant and placed horizontally over the medium to stimulate sprouting of new shoots.

Seed propagation is possible only under aseptic conditions. Seedlings produced by embryo culture will take 2-5 years for flowering, depending on the genus.

Meristem culture is very effective in large scale propagation of orchids.

Terminal cuttings of monopodial orchids are planted loosely on old coconut husks at a spacing of 30 cm between plants and 45 cm between rows in long beds. There can be two or three rows in a bed. Basal cuttings will sprout within a period of two months.

Partial shade up to 50% is required for sprouting. Basal cuttings are planted close to each other in nursery beds for sprouting. After sprouting they are planted at the recommended spacing. Monopodial orchids can be grown on ground above soil level. A thick bed of 15-20 cm height is loosely arranged. Well-dried coconut husks are better than fresh husks. Sympodial orchids are grown on benches above ground level or suspended from above. Slotted wooden baskets filled with small pieces of dried coconut husk or partially burnt charcoal is good for plant growth. Planting is done above the medium with a support for proper anchorage.

Planting can also be done in pots or other containers. Mud pots of 10-20 cm diameter with several large holes on the side and bottom, filled with tile bits, chopped coconut husk or charcoal are used for planting. Both monopodial and sympodial orchids are to be supported properly since the planting is done above the medium. A clear solution of fresh cowdung can be used for irrigation for a few days. Dipping in fresh cowdung solution before planting also gives good results.

Manuring

Monopodial orchids grown on ground can be given cowdung slurry once in a month. One kg fresh cowdung mixed in 5 litres of water is sufficient for one square metre. Two or three applications can be given in a year. Sympodial orchids are sprayed with the supernatant liquid of cowdung slurry.

Adopt any of the following practices for orchids grown in pots

1. Fresh cow dung/ neem cake/ neem cake: groundnut cake (1:1) mixed with 10-15 times of water, kept for 3-4 days, supernatant liquid filtered and sprayed on the plants once in a week.
2. Fresh cow dung – 500 g and cow urine - 500 ml mixed with 10 litre of water, allow to settle, filter, dilute 3 times with water and spray on the plants once in two weeks
3. Panchagavya, 3% as sprays on the plant at 15 days interval
4. Panchagavya 3% + Vermiwash 3% as sprays on the plant at 15 days interval
5. Spray Pseudomonas/ PGPR mix II at monthly intervals.

Plant Protection

Snails and slugs

Sprinkle salt over wetted gunny bags placed in shady places near the orchard.

Thrips

Spray fungal formulations of *Hirsutella thompsonii* (10g of the formulation/litre) / *Verticillium locanii,/ Metarhizium anisopliae/, Beauveria bassiana* (10^{10}conidia/litre)

Harvesting

The spikes are harvested when all the buds of the spike except two or three are open.

JASMINE (*Jasminum spp.)*

Jasmine is an important flower crop that could be grown on a commercial scale in Kerala. *Jasminum sambac* is the most ideal species for cultivation in Kerala. The flowers are used for preparing garlands. The jasmine oil has great export potential in addition to its use for medicinal purpose.

Jasmine can be planted on a wide range of soils. Well-drained sandy loams and red loams are ideal for its cultivation. In clayey soils, there is increased vegetative growth and reduced flowering. They give good yield in low rainfall conditions.

Important cultivars

There are trailing, climbing, and erect growing species and cultivars. Three important species and their varieties are given below:

1. *Jasminum sambac*: Gundumalli, Motia, Virupakshi, Sujimalli, Madanabanam, Ramabanam.
2. *Jasminum grandiflorum*: Co-1 Pitchi, Co-2 Pitchi, Thimmapuram, Lucknow.
3. *Jasminum auriculatum*: Co-1 Mulla, Co-2 Mulla, Long Point, Long Round, Short Point, Short Round.

Propagation

Layering and cutting are the main propagation methods. Better rooting of cuttings can be obtained by planting in coarse sand. Simple and compound layering methods are followed during June-July to October-November. Layers will be ready for planting within 90-120 days.

Planting

After ploughing the land, pits of about 40cm x 40cm x 40cm size are taken and filled with top soil and 15 kg well-rotten FYM.

Planting distance depends on the species and also on soil and environmental conditions.

Species	Planting distance
J. sambac	1.2m x 1.2 m
J. auriculatum	1.8m x 1.8 m
J. grandiflorum	2.0m x 1.5 m

Planting is usually done during June-August.

Manuring

Neem cake - 100 g
FYM - 100 g
Groundnut cake - 100 g

Soil application at monthly interval per plant from 2nd month after planting.

or

Neem cake - 100 g
Poultry manure - 100 g
Groundnut cake - 100 g

Soil application at monthly interval per plant from 2nd month after planting.

Pruning

Pruning is essential and is done at a height of 45cm from the ground level during mid December-January.

Weed-control

Manual weeding is effective but expensive. Mulching reduces weed population.

Irrigation

Constant and adequate water supply during peak flowering season (March-October) is essential for high yield of flowers. After flowering is over, the water supply can be cut off. During summer, irrigate twice in a week.

Plant protection

Apply neem based insecticides (2ml/litre) for the control of pests like bud and shoot borer, blossom midge

Drench the soil with 1% Bordeaux mixture to reduce fusarium wilt

Spray panchagavya, 3% at 15 days interval

Yield

Yield of flowers and jasmine oil vary according to the species and management practices.

Species	Flower yield (t/ha)	Oil yield (kg/ha)
J. sambac	5	15.44
J. auriculatum	5	28.00
J. grandiflorum	6	29.00

TUBEROSE (*Polianthes tuberosa)*

Tuberose occupies a very special position among the ornamental bulbous plants because of its prettiness, elegance and fragrance. It has good economic potential for loose/cut flower trade and essential oil industry.

Porous, well-drained sandy loam soils are the best suited for tuberose cultivation.

Cultivars

There are four groups of cultivars as given below:

1. *Single* : Flower is pure white and has only a single row of corolla segments. Cultivars are Sringar, Culcutta Single, Mexican Single and Suvarna Rekha.
2. *Double*: Flowers are white, tinged with pinkish red. Petals are in several whorls. Cultivars are Suvasini, Culcutta Double and Pearl.
3. *Semi-double*: Similar to double but with only 2 to 3 rows of corolla segments.
4. *Variegated*: This has variegated leaves with yellow margins.

Propagation

Propagation is by bulbs. Boat shaped bulbs of size 2 to 3 cm are preferred for planting. About 1.25 to 1.50 lakh bulbs (800 to 900 kg) are required for planting one hectare.

Cultural practices

Land is prepared well by ploughing two or three times. FYM at 30 t/ha is mixed well with soil. Best time for planting is May-July. The bulbs preferably those of size 2-5 cm or above are to be planted at a depth of 7-10 cm, with a spacing of 20cm x 25 cm. A heavy

irrigation once in 5-10 days is necessary depending upon the weather conditions. The peak flowering is between June and October.

Manuring

Application of poultry manure @ 30 t/ha / FYM @ 60 t/ha at the time of planting. The same quantity is applied for the ratoon crops also.

Ratoon crop

After the harvest of the main crop, the flower stalks are headed back and the plot is manured and irrigated. Three or four ratoon crops can be taken from single planting. If the bulbs are not uprooted and replanted after three or four ratoons, the spikes tend to become smaller and unattractive.

Plant protection

Spray panchagavya, 3% at 15 days interval to reduce the incidence of pests and diseases.

Harvest and yield

Tuberose is harvested by cutting the spikes from the base for table decoration or the individual flower is picked from the spike for making garlands and other floral ornaments. The average yield of flower is as follows.

Plant crop : 5-10 t/ha

First ratoon : 9-12 t/ha

Second ratoon : 4-6 t/ha

MARIGOLD (*Tagetes erecta*)

Marigold is a popular annual flower that could be grown on a commercial scale. It has gained popularity on account of its easy cultivation and wide adaptability. Free flowering habit, short duration to produce marketable flowers, wide spectrum of colour, shape, size and good keeping quality make marigold an acceptable commercial crop.

A wide range of soils with good drainage is suitable for cultivation of marigold. Sandy loam soil with pH 5.6 to 6.5 is ideal for its cultivation.

Cultivars

There are two species of marigold, namely, African marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*). Inter-specific hybrids between these two species also have been evolved, which are known as Red and Gold hybrids. Varieties under this group are Nugget, Show Boat and Red Seven Star.

African marigold varieties

Apricot, Primrose, Sun Giant, Guinea Gold, Fiesta, Golden Yellow, Hawai, Crown of Gold, Honey Comb, Cupid, Pusa Narangi Gaintha and Pusa Basanti Gaintha.

French marigold varieties

Rusty Red, Naughty, Marietta, Flame, Star of India and Hormony.

Propagation

Seeds are used for raising the crop.

Cultural practices

Seedlings are prepared by sowing the seeds in the nursery beds as follows:

Prepare nursery beds of 6 m length, 1.2 m width and 10-20 cm height. Apply 30 kg FYM and mix well in the soil. Sow the seeds in rows 7.5 cm apart. Cover the seeds with fine FYM and irrigate. The seedlings will be ready for transplanting within one month.

For the main-field, the land should be ploughed well and FYM @ 30 t/ha should be incorporated to the soil. Pinching is done to increase the total yield. It consists of removing terminal portion of the plant 30-45 days after transplanting.

Irrigate once in 4-6 days depending upon soil moisture and weather conditions. Weeds have to be removed at monthly intervals.

Harvest and yield

Marigold flowers will be ready for harvest in about 2½ months time from the date of transplanting. The plant continues to bear flowers for another 2-2 ½ months from the date of first harvest. The flowers are harvested when they have attained full size. Harvest the flowers in the evening along with a portion of stalk. Yield of French marigold will be

8-12 t/ha and that of African marigold 11-18 t/ha.

General recommendations for control of pests and diseases in flower crops

Any of the fungal formulations of *Hirsutella thompsonii* (10g of the formulation/ litre), *Verticillium locanii*, *Metarhizium anisopliae*, *Beauveria bassiana* (10^{10}conidia/ litre) is effective in reducing population of thrips in flower crops.

Spraying 3% Dasagavya is effective in controlling pests and diseases.

Ecofriendly management of water hyacinth (*Eichhornia crassipes*) in water bodies

Water hyacinth in water bodies can be managed by spraying 5% Cashew Nut Shell liquid (CNSL) emulsion followed by spraying 40%Wetable Powder formulation (WP) of *Fusarium pallidoroseum* (5%). Spraying may be repeated with WP 5% alone, after 2 weeks if any new sprouts develop.

* A minimum of 30 minutes may be given between the applications of CNSL and *Fusarium pallidoroseum*

** In moving water bodies fencing with rope and coconut leaf is recommended

FARMING ON HOUSE TERRACE

Farming on house terrace is strictly organic farming. Since available land for cultivation is shrinking drastically especially in urban areas, it is high time that alternative measures like farming on house terrace are to be explored. Farming on house terrace including vegetable cultivation, poultry rearing, azolla cultivation and vermi- composting facilitate better time and space utilization, disposal of household organic garbage, proper harvesting of sunlight, reduced incidence of pests and diseases, reduction of family expenditure, nutritional security due to physical and economic access to vegetables and eggs and above all the better availability of fresh, hygienic, safe and eco-friendly vegetables and eggs to the urban families.

Vegetable cultivation in plastic sacs

(a) Plastic sacs are better than earthen flower pots. Among plastic sacs, fertilizer sacs are better.

(b) Seventy five percent of the volume of the plastic sac is to be filled with potting mixture which is prepared by mixing thoroughly soil, sand and powdered cow dung in the ratio 2:1:1 incorporated with PGPR mix I.

(c) The top edge of the sac is to be folded to have a thick border facilitating irrigation and intercultural operations.

(d) The sacs are to be arranged in line on the terrace ensuring wall underneath. The sacs are to be placed on bricks placed in a triangular format.

(e) Photo insensitive crops and bushy varieties are preferred to photo sensitive crops and trailing varieties.

(f) Sowing or transplanting at the rate of two per hill and two hills per sac is advantageous.

(g) Transplantation shock to seedlings can be reduced by providing shade by unfolding the edge of the sac and putting a handful of azolla at the base of the seedling.

(h) Organic manures enriched with PGPR mix I are to be applied in sacs at weekly interval.

(i) Adequate quantity of water has to be used for irrigation, both in the morning and evening so that excess water will not drip out and plants will not wither.

(j) Daily observation and mechanical methods are to be followed for pest control. If situation warrants for the application of pesticides, organic pesticides are to be used.

(k) Crop rotation including a pulse crop has to be followed in each sac.

(l) After each crop, it is better to change the position of bricks and sacs a little so that easy cleaning of the terrace is facilitated and permanent wetting of any portion of the terrace is avoided.

Poultry rearing under deep litter system

(a) Deep litter system has to be followed for rearing poultry on terrace. Approximately 2 ½ sq. feet area has to be provided for each layer in the netted cage.

(b) It is better to avoid the cock and rear the layers alone.

(c) The floor of the cage should be without any gap and saw dust has to be used as a good absorbent litter in the cage. The floor should be a raised one leaving space between the terrace and the floor.

(d) The cage has to be kept in a shaded corner of the terrace. On the roof of the cage, thick cardboard has to be fitted to reduce the temperature inside the cage. Over the cardboard, polythene sheet has to be spread and fitted so that splashes of rain water will not damage the cardboard.

(e) A plastic sheet has to be spread above the cage and tied tightly to poles at distance to provide shade and air column and to protect the cage from rains.

(f) A handful of lime has to be dusted over the litter at weekly interval and raked to avoid caking and to act as a disinfectant.

(g) Periodic vaccination has to be done to the layers.

(h) Plenty of hygienic water and a variety of feed are to be provided in the cage. Low cost and locally available vessels are to be used for feeding which are to be hung in the cage to avoid toppling by the layers. A round plastic plate has to be kept under the water vessel to avoid wetting of the litter.

(i) Fresh broken shells are to be kept in separate container as feed for providing calcium to the layers. Powdered dry fish has to be fed to supply protein to the layers.

(j) Garlic and onion are to be fed for three consecutive days at monthly interval to avoid infestation by worms and to maintain the general health of the layers. Turmeric powder can be occasionally mixed with feed to act as an antiseptic.

(k) Crop residues, fallen leaves, weeds and leaves of chekurmanis, drumstick, papaya etc. have to be fed to the layers. Fresh azolla can be washed and fed so that the birds will lay ‘organic eggs’.

(l) Eggs are to be taken out of the cage as early as possible.

(m) The litter with the excreta of layers can be occasionally removed from the cage, heaped in a convenient place for a few weeks and then applied as organic manure to vegetable crops.

RESOURCES FOR ORGANIC FARMING

GREEN MANURE CROPS

Sunn hemp *(Crotalaria juncea)*

It is a vigorous growing green manure crop, which can be incorporated at 10 weeks after sowing. It does not withstand water logging. The seed rate is 25-35 kg/ha. The green matter yield is 15-20t/ha. Quantity of nitrogen fixed by the crop is 75-80 kg/ha.

Daincha *(Sesbania aculeata and S. rostrata)*

Sesbania aculeata

It is a quick growing succulent green manure crop, which can be incorporated at about 8 to 10 weeks after sowing. This crop adapts to varying conditions of soil and climate. It can be grown even under adverse conditions of drought, waterlogging, salinity etc. Recommended seed rate is 20 to 25 kg per ha. The green matter yield is 10-20 tonnes per ha. Quantity of nitrogen fixed is 75 to 80 kg per ha.

Sesbania rostrata

It is a green manure crop, which has nodules both on the stem and root. It thrives well under waterlogged condition. The normal seed rate is 30 to 40 kg per ha. A green matter yield of 15 to 20 t/ha equivalent to 150-180 kg N/ha is obtained within a period of 8 to 10 weeks.

Wild indigo or kolingi (*Tephrosia purpurea*)

It is a slow growing green manure crop. It is not grazed by cattle and is suitable for light soils. It resists drought but does not withstand water stagnation. The seeds have a waxy, impermeable hard seed coat and do not quickly germinate. To hasten germination, the seeds are to be abraded with sand or steeped in hot water at 55^0C for two to three minutes. The seed rate is 20-25 kg/ha and the green matter yield varies from 8 to 10 t/ ha. When kolingi is sown in an area for two or three seasons continuously, scattered seeds will give rise to volunteer plants and there is no need for further sowing.

Indigo/ Bengal indigo (*Indigofera tinctoria*)

Indigo resembles kolingi, but has a more leafy habit. It shows resistance to drought. Better yield is obtained when two irrigations are given and when grown in clayey soil. Seed rate is 20kg/ha. Green matter production is 8-10t/ha.

GREEN LEAF MANURE CROPS

GLIRICIDIA (*Gliricidia maculata*)

It is a shrub, which takes up a tree habit under favorable conditions of soil and climate. For green leaf purposes, the shrub should be kept low by pruning or lopping at a height of 2-3m. The shrub can be pruned two or three times a year and it withstands repeated lopping. Within two years after planting, the plants are ready for lopping. Each plant gives five to ten kg of green leaves annually.

Subabul *(Leucaena leucocephala)*

This species, a native of Central America, occurs as a branched shrub. It is a promising forage tree crop, the leaves of which contain about 3-4% of N. Leucaena fixes about 500-600 kg N/ ha per year.

Cassia *(Cassia auriculata)*

Propagated by seeds. During flowering, tree is topped (stem and branches cut) and loppings used for green leaf manuring.

AZOLLA CULTIVATION

Azolla, a floating fern which harboures the nitrogen-fixing blue-green algae can be cultivated in shallow cement tanks or pits lined with polythene sheets. Pits or tanks of convenient length and breadth and 15 cm depth are made. Soil has to be spread with uniform thickness at the bottom of the tank at the rate of 7 kg per m^2. Fresh cow dung at the rate of 2.5 kg per m^2 has to be made into a slurry and poured uniformly on the soil in the tank. Rajphos or Mussoriphos at the rate of 15 gm per m^2 has to be given along with cow dung slurry. Water has to be added to the tank to a depth of 8 cm. Healthy azolla at the rate of 250 to 500 gm per m^2 has to be spread uniformly in the tank. Azolla starts multiplying after a period of one week.

Azolla cultivation can also be done in partially shaded place on terrace

(a) Approximately 50 percent shade is required for the healthy growth of azolla in tanks on terrace.

(b) Polythene sheet of thickness of minimum 150 gauge is conducive for making azolla tanks.

(c) Once started multiplying, 250 to 450 gm of azolla can be harvested daily from one sq. metre area.

(d) The harvested azolla can be used as organic manure for vegetable crops and as feed for poultry.

(e) Removal of a little quantity of water from the azolla tank and addition of fresh water, addition of cow dung slurry and phosphorus at the rate of 0.5 kg and 10 gm respectively per sq. metre area of tank are to be done at weekly interval.

(f) Removal of one fifth of soil and addition of same quantity of fresh soil to the tank has to be done at monthly interval.

(g) The whole tank has to be replaced with new tank once in six months.

(h) The production cost of azolla comes to about 50 paise per kg.

(i) Mosquito will not grow in tanks where azolla is grown.

***In situ* azolla nursery**

For large scale field application, azolla nursery can be raised in the field itself. Field should be ploughed thoroughly and leveled uniformly. The field is divided into one cent plots (20 x 2 m^2) by taking bunds and channels. Water is maintained at 10 cm level. Fresh cow dung slurry prepared by mixing 8 kg of cow dung in 20 litres of water is sprinkled over the plot. Fresh Azolla inoculum is spread @ 8 kg per plot. Rock phosphate may be applied @ 100 g in three split doses at 4 days interval. 15 days after inoculation, Azolla is harvested and applied to the main field.

SOIL SOLARIZATION

Solarization is a method of hydrothermal disinfection. This is done by covering moist soil with transparent polythene sheet and exposing it to direct sunlight during the hottest period of the year.

Method of solarization

a. Nursery bed

The nursery bed for raising seedlings is to be levelled and pebbles present on the surface removed before solarization. Incorporate the required quantity of organic manure in the soil and irrigate @ 5 litres per m^2. Cover the beds with 100-150 gauge transparent polythene sheets. Seal the edges of the sheet with soil to keep it in position in order to maintain the temperature and moisture inside the polythene mulch. Adequate care is also to be taken to see that the sheet is in close contact with the surface of soil to prevent the formation of air pockets between the soil and polythene sheet. Keep the sheet in this way for 20-30 days. Protect it from stray animals and birds. After the period of solarization, remove the sheet and the bed is ready for sowing and transplanting.

b. Potting mixture

The required type of potting mixture is to be prepared as per the recommended practice. Spread this mixture on a levelled ground to a height of 15-20cm. Moisten with water using a rose-can and cover the soil with polythene sheet and solarize for

20-30 days as described above. After solarization, the sol can be used for sowing/ planting. This method is found to be very effective to raise disease free pepper cuttings.

c. Main field

Solarization can also be effectively used for the control of soft rot of ginger and similar soil-born diseases in the field. The land used for planting ginger is initially prepared to a fine tilth and pebbles removed. Prepare raised beds as per the recommended practice. Apply organic manure before solarization. Irrigate the bed once (5litre/m^2) and cover with polythene sheet. Leave the bed without any disturbance for 20-30 days. After this period, remove the sheet and plant rhizome bits. All the other agronomic practices are to be followed as per the package of practices recommendations. Bio pesticides can be incorporated in soil after removing the polythene sheet.

Hints for solarization

1. Solarization is to be done in open field without any shade.
2. Transparent thin polythene sheet (100 to 150 guage) is to be used, as it is both cheaper and more effective in heating due to better radiation transmittance than thicker sheets.
3. Summer months are more suitable for solarization.
4. Soil should be kept moist during solarization to increase the thermal sensitivity of resting structures of soil-born plant pathogens and weeds, and to improve heat conduction.
5. Solarization period may be extended to one month or more to ensure pathogen control at deeper layers.
6. Summer showers will not affect solarization. However, excessive seepage of water into the bed during solarization should be avoided.
7. Potting mixture should never be heaped and solarized, as this will drastically reduce the efficiency of the technique.
8. Soil should be in good tilth allowing close contact between the plastic sheet and the soil to prevent the formation of air pockets, which reduces heat conduction.

Benefits of solarization

1. Control of fungal pathogens: Several soil born pathogens can be controlled by solarization. This includes fungi like *Pythium, Phytophthora, Fusarium, Rhizoctonia* etc.
2. Control of nematodes: Population reduction of nematodes like *Meloidogyne, Heterodera, Xiphinema,* etc. has been achieved by solarization.

3. Control of weeds: A number of commonly occurring weeds particularly annuals can be effectively controlled by solarization. These include, among monocots, *Cynodon dactylon, Cyperus rotundus and Digitaria ciliaris* and among dicots, *Crotalaria muconata, Indigofera hersuita* and *Noxia* sp.
4. Plant growth response: Increased growth response is observed in plants cultivated in solarized soil. This is mainly evident as increase in plant height, number of leaves, better root formation, increased root nodulation in legumes and yield.

COMPOSTING

Composting is largely a biological process in which microorganisms of aerobic (which require air or oxygen for development) and anaerobic (which functions in absence of air or free oxygen) decompose organic matter and lower the carbon-nitrogen ratio of the substrate. Compost is prepared from vegetable and animal residues collected in the farm or towns or villages.

Method of composting

The available residues in the farm are collected and stored till they form sufficient mass for compost making. A trench of suitable size say 4-6m long 2-3m broad and 1-1.5m deep is dug, the accumulated residues is well mixed, and a layer of 30cm in thickness, is spread all along the length of the trench. This layer is well moistened by sprinkling cow dung slurry and water over it. A second layer (30cm thick) of the mixed residues is then spread. The process is repeated till the heap rises to a height of 45cm to 60cm above ground level. The top is then covered with a thin layer of soil. After three months of decomposition, the mass is taken out of the trench and formed into a conical heap above the ground, moistened with water, if necessary, and covered with soil. After one or two months, the manure will be ready for application to field.

Vermicompost

Vermitechnology is a process by which all types of biodegradable wastes such as farm wastes, kitchen wastes, market wastes, bio wastes of agro-based industries, livestock wastes etc. are converted to nutrient rich vermicompost by using earthworms as biological agents. Vermicompost contains major and minor nutrients in plant available forms, enzymes, vitamins and plant growth hormones.

Species suitable: *Eudrillus eugineae* has been identified as the best species of earthworm for vermitechnology under Kerala conditions.

Vermicomposting of farm waste

Pits/tanks of size 2.5m length, 1 m breadth and 0.5 m depth are taken in thatched sheds with sides left open (well-rings can also be used). The bottom and sides of the pit are made hard by compacting with a wooden mallet. At the bottom of the pit, a layer of coconut husk is spread with the concave side upward to ensure drainage of excess

water and for proper aeration The husk is moistened and above this, bio waste mixed with cow dung in the ratio of 8:1 is spread up to a height of 30 cm above the ground level and water is sprinkled daily. After the partial decomposition of wastes for 10 to 14 days, the worms are introduced @ 500 to 1000 numbers per pit. The pit is covered with coconut fronds. Moisture is maintained at 40 to 50 per cent. When the compost is ready, it is removed from the pit along with the worms and heaped in shade with ample light. The worms will move to bottom of the heap. After one or two days the compost from the top of the heap is removed. Put back the undecomposed residues and worms to the pit for further composting as described above. The vermicompost produced has an average nutrient status of 1.5% N, O.4% P_2O_5 and 1.8% K_2O with pH ranging from 7.0 to 8.0 .The nutrient level will vary with the type of material used for composting.

Precautions

1. The compositing area should be provided with sufficient shade to protect from direct sunlight.
2. Adequate moisture level should be maintained by sprinkling water whenever necessary.
3. Take preventive measures to ward off predatory birds, ants or rats.

Normal time taken for vermicomposting is 60-75 days. When the compost is ready, watering should be stopped to facilitate separation of worms from the compost. The compost is taken out from the pit and heaped in sunlight. The worms settled at the bottom of the heap are separated and used for further composting. It is better to apply the fresh compost directly to the crop or can be dried under shade and sieved for storage.

Vermicomposting of Biowaste on plain surface

Partially decomposed organic wastes are piled at a height of 2m x 1m x 0.5 m on areas at cool and elevated places. Release the earth worms at the middle of the heap. Water is sprayed everyday to keep the biowastes in moist condition. Protect the earth worms from excessive heat and rain. Organic wastes get converted into vermicompost within 75 – 90 days depending upon the nature of biowastes, number of worms, weather conditions etc. When the compost is ready separate the worms and release them in another heap of partially decomposed organic waste for further composting.

Vermicompost from coconut leaves

Weathered coconut leaves can be converted into good quality vermicompost in a period of three months with the help of earthworm, *Eudrillus sp*. On an average, 6-8 tonnes of leaves will be available from a well-managed coconut garden, which will yield 4-5 tonnes of vermicompost with about 1.2, 0.1 and 0.5% N, $P_2O_5$and K_2O respectively.

Vermicomposting of household wastes

Select a wooden box of 45cm x 30cm x 45 cm or an earthen/plastic container with broad base and drainage holes. Keep a wire net with small holes at the bottom of the

box. Add a layer of soil of 3cm depth and a layer of coconut fibre of 5cm depth above it for draining of excess moisture. About 250 worms are introduced into the vermicomposting unit along with a handful of cow dung. Spread daily vegetable wastes in layers. Cover the top of the box with a piece of jute sac to provide dim light inside the box. When the box is full, keep the box without disturbance for a week. When the compost is ready, keep the box outside for 2-3 hours so that the worms come down to the lower fibre layer. Remove compost from the top, dry and sieve. The vermicompost produced has an average nutrient status of 1.8% N, 1.9% P_2O_5 and 1.6% K_2O, but composition will vary with the substrate used.

Mass multiplication of worms

Earthworms can be multiplied in 1:1 mixture of cow dung and biowaste taken in a cement tank or wooden box or plastic basin with proper drainage facilities. The nucleus culture of earthworms is to be introduced into the above mixture @ 50 numbers per 10 kg of organic wastes and covered with wet gunny bag. The unit should be kept in shade. Sufficient moisture level should be maintained by occasional sprinkling of water. Within 2 months, the earthworms multiply several times, which can be further used for large scale vermicomposting.

Vermicomposting *insitu*

Vermicomposting can be done in the field itself in coconut basins; banana pits etc containing biowastes-cowdung mixture (8:1). The worms are introduced into this biowastes. Sprinkle water as and when required. The waste gets transformed into vermicompost by the action of worms.

Enriched vermicompost

Enriched vermicompost with high manurial value for organic farming can be prepared by adding natural materials (e.g. Rock phosphate), Organic additives (oil cakes, bone meal etc) and beneficial microorganisms to the biowastes during vermicomposting. The manurial value of the enriched vermicompost varies depending upon the proportion of additives used for enriching.

Seed coating with vermicompost

For treating 5 to 10 kg seeds (cowpea seeds) 500 g Vermicompost is required. Moisten the seed and mix vermicompost with the seed by using minimum quantity of water or kanjivellam of the previous day.

Preparation of vermiwash

Method 1

The system consists of a plastic basin having a capacity of 20 litres, a plastic perforated wastepaper basket and a PVC pipe of 5cm diameter and 30cm length. The wastepaper basket is covered with nylon net and placed at the centre of the basin upside down. A hole is made at the bottom of the waste paper basket so that a PVC

pipe of 5cm diameter can be placed into the basin through the hole in such a way that one end of it touches the basin. The PVC pipe is perforated so that the leachate from the basin seeps through the wastepaper basket and collects in the PVC pipe, which can be siphoned out by a kerosene pump. In the basin outside the wastepaper basket, a layer of brick pieces are placed and a layer of coconut fibre of 2-3 cm placed above it. After moistening this, 2 kg worms (about 2000) are introduced into it and 4 kg kitchen waste is spread over it. After one week, the kitchen waste turns into a black well decomposed compost. Two litres of water is sprinkled over the compost containing worms. After 24 hours, the leachate collected in the PVC pipe is removed by siphoning. The collected leachate is called vermin wash, which is actually an extract of compost containing worms. This is used for soil application and foliar spray (with 5 to 10 times dilution) in different crops. Vermiwash is honey-brown in colour with a pH of 8.5 and N, P_2O_5 and K_2O content 200, 70 and 1000 ppm respectively.

Method 2

For the collection of vermiwash a cement tank with side tap is constructed and a layer (5 cm thickness) of small brick pieces or gravel is placed at the bottom of the tank. Above it a layer of coconut fibre of 3-4cm thickness is placed. A definite quantity of bio waste (4kg) is added to the system along with 2kg of earthworms. After two weeks, the entire mass of bio waste will turn to brownish black compost. Then sprinkle two litres of water to the tank containing freshly formed vermicompost and earthworms. Vermiwash is collected through the side tap after 24 hours. Again biowaste is added to the system and the process is repeated.

Method 3

This is a simple and economical technique to collect vermiwash. The system consists of an earthen pot of 10kg capacity, which is filled with pieces of stone up to a height of 10cm from the bottom. Above this, a plastic net is placed and spread out. Then a thick layer of coir fibre along with humus containing 1500-2000 worms of *Eudrillus euginae* or Ei*senia foetidae* is laid down. The hole situated at the bottom of the pot is fixed with a water tap through which vermiwash is collected. Every day, the kitchen waste is put into the container. Allow the composting process to continue for one week or more till brownish black mass of compost is obtained. Occasionally, two or three tablespoons of fresh cow dung slurry is poured on the humus as feed for the worms. After the formation of compost, soak the entire mass with two litres of water. After 24 hours, about 1.5 litre of vermiwash can be collected. This process can be continued for one or two weeks till the brown colour of wash disappears. The less enriched compost that remains in the post can be collected and used as manure. Later, the pot can be emptied and set up again to continue the process.

The potential of vermiwash as a biocide either simply or when mixed with botanical pesticides can be very well exploited for kitchen garden.

Recommendation for crops

When vermicompost is applied as organic manure instead of FYM, the quantity can be reduced to about half the recommended dose of FYM.

Coirpith composting

Coirpith, one of the agricultural wastes is produced and heaped in large quantities as waste material from the coir industry. Approximately 2.5 lakh tonnes of coirpith accumulate in Kerala as waste. Coirpith has wide C: N ratio and its lignin rich nature does not permit natural composting process as in other agricultural wastes. *Pleurotus spp*. has the capacity to degrade part of the cellulose and lignin present in coirpith by production of enzymes viz., celluloses and lactases. The C: N ratio of coirpith is reduced from 112:1 to 24:1 as a result of composting. The lignin content also reduces from 30% to 4%.

Method of composting

Materials required: Corpith 1 tonne, poultry manure 10kg, mushroom (*Pleurotus*) spawn 1.5Kg.

Select a shaded place of 5mx3 m dimension and level it after removing weeds. First spread 100kg coirpith uniformly. Spread 300g (one bottle or cover) of Pleurotus spawn on this and cover this with a second layer of 100kg coirpith. On the surface of the second layer, spread 2kg poultry manure uniformly. Repeat this sandwiching process of one layer of coirpith with spawn followed by another layer of coirpith with poultry manure upto 1m height. Sprinkle water if necessary to keep the heap moist. Allow the heap to decompose for two months.

This coirpith compost contains macronutrients as well as micronutrients. It has the unique property of absorbing and retaining moisture to about 500-600 percent. It improves the water infiltration rate and hydraulic conductivity of soil.

BIOCONTROL AGENTS

1. Arbuscular Mycorrhizal Fungi (AMF)

Inoculation with AMF at the time of planting in the nursery or main field improves the growth and tolerance of crop against root pathogens, particularly *Phytophthora, Pythium, Rhizoctonia* and root nematodes of black pepper, cardamom, ginger, turmeric, cowpea, rice and transplanted vegetables.

Trichoderma

Biocontrol of soil born plant pathogens involves mass introduction of antagonistic microorganisms in the soil**.** *Trichoderma* spp. is a group of broad-spectrum antagonists subjected to detailed studies for their potential as biocontrol agents. They are effective

against the quick wilt of pepper *(T. viride* T6, *T. longibrachiatum* T2), rhizome rot of cardamom (*T. longibrachiatum* T2, *T. virens* T9) and ginger (*T. viride* T10). A non-axenic system, viz. neemcake-cow dung mixture is used as food base for *Trichoderma* spp.

Dry neem cake and cowdung are to be powdered and mixed to get a coarse texture and then moistened by sprinkling water. Add the commercial preparation of *Trichoderma* spp. (available in polythene packets) @ 1-2 kg per 100 kg of neemcake - cow dung mixture. After thoroughly mixing, cover it with a perforated polythene sheet or ordinary newspaper and keep it in shade for 4-5 days for multiplication. Again mix well and keep for three more days for further multiplication. This preparation is ready for incorporation in the soil. Cow dung alone can also be used as the food base; but, since neem cake is found to be a better substrate, the incorporation of neem cake to cow dung at the ratio of 1:10 (w/w) is better than using cow dung alone. If cow dung alone is used, mixing has to be done at 5 days interval and it will be ready for use only on the 15th day. This *Trichoderma* incorporated neemcake-cow dung mixture can be used in the potting mixture in nursery beds and in the field; i.e. wherever cow dung is used as a manure.

2. Fluorescent pseudomonas

Fluorescent pseudomonas are a group of bacteria very effective against disease incited by species of *Phytophthora, Pythium, Rhizoctonia, Fusarium, Colletotrichum, Ralstonia and Xanthomonas* in various crop plants in the nursery as well as in the main field.

Two isolates of *Pseudomonas fluorescens* (P1 and P14) have been developed by the Kerala Agricultural University for the disease management and growth promotion of crop plants. This is found highly effective for the management of foot rot and fungal pollu of black pepper, sheath blight and bacterial leaf blight of paddy, bacterial leaf spot and Phytophthora infestation in betel vine, bacterial wilt of solanaceous vegetables, bacterial leaf blight of anthurium and *Colletotrichum* and *Phytophthora* infestation in vanilla and rhizome rot of ginger. The organism significantly improves the growth and biomass production of crop plants.

3. PGPR mix II

It is a consortium of highly compatible rhizobacteria having broad spectrum of inhibitory property with different mechnanisms. Bacteria promote plant growth and have better ability to multiply and persist in varying soil conditions. Effective against all fungal and bacterial plant pathogens of crop plants. Application method and schedule are similar to that of *P. fluorescens*. If not compatible, apply *Trichoderma* as enriched organic manure and *Pseudomonas* separately as spray and drench.

Method of application

The talc-based formulation at 1-2% level may be used for soil drenching and spraying. Seedlings / cuttings are treated with *Pseudomonas* culture by dipping the

root/tip of cuttings in slurry of *Pseudomonas* (250g in 750ml for 20 minutes). For seed treatment in paddy use 10g talc-based *Pseudomonas* culture for 1 kg of seed; suspend *Pseudomonas* in water used for sprouting. This helps in the control of fungal and bacterial diseases.

For transplanted crop, dip the roots at the time of transplanting, and one spray may be given at 30th day after transplanting. For black pepper, drenching the nursery plants immediately after planting followed by one or two sprays depending on the extent of disease. For managing foot rot of pepper in the main field, drench the base of the vine and spray the plant with *Pseudomonas fluorescens* @ 20g/litre at the onset of monsoon. A second spray may be given, if necessary during the mid-monsoon period.

For all the crops, the time of application and the frequency of application may vary depending on the incidence and intensity of the infection. A combined application of *Trichoderma* and *Pseudomonas fluorescens* may be resorted to, only if both are compatible, at the time of planting in the nursery and/or main field for the control of diseases of pepper, cardamom and ginger. The application may be repeated based on the intensity of disease incidence.

BIOFERTILIZERS

The use of the biofertilizers is quite important while practising the concepts of integrated plant nutrient management and organic farming. Some of the commonly used biofertilizers in Kerala are as follows.

1. Rhizobium (*Bradyrhizobium* and *Azorhizobium*)

It induces better root nodulation and stem nodulation (*Azorhizobium*) in inoculated plants and thereby brings down the requirement of nitrogen fertilizer for the cultivation of pulses, oil seeds and legume green manures. Commercially it is available as carrier based inoculum. Method of application is seed treatment.

2. *Azotobacter*

Suitable only for upland crops like vegetables, tapioca, plantation and orchard crops. It is available as carrier-based inoculum. If fixes N about 15-20kg/ha under ideal upland conditions and thereby reduces the requirement of nitrogen fertilizers by 10-20 per cent. Methods of application are seed treatment, seedling dip and direct soil application in organic manure.

3. *Azospirillum*

It is suitable for both upland and wetland conditions and is available as carrier-based inoculum. It fixes N about 20-25 kg per ha under ideal conditions thereby effecting

a reduction of 25 per cent in the quantity of N fertilizers required. Treatment with *Azospirillum* also induces better root formation in inoculated plants. Hence this biofertilizer is also recommended for root induction in polybag raised seedlings of plantation and orchard crops and also for vegetables. The isolates of *Azospirillum brasilense* strains AZR 15 and AZR 37 from Kuttanad soils are highly effective for rice, Vegetables and nursery plants. The strains AZ 1 and AZ 2 are effective in vegetable and nursery plants. In sequential rice-rice cropping system, inorganic nitrogen fertilizer can be substituted upto 20%-50% through seedling dip or field application of Azospirillum 2.5kg/ha.

Method of application

Seed treatment: For treating 5-10 kg seeds, 500g culture is required. Moisten the seeds by sprinkling water or rice-gruel water. Take 500g culture in a plastic tray/basin, add moistened seeds, mix well and dry in shade for 30 minutes. This may be sown immediately.

Seedling root dip (for transplanted crops): Slurry of the culture is prepared by mixing 500g culture with 750 ml of water and the roots are dipped in the slurry for 15-20 minutes before transplanting.

Soil application: Mix the culture with FYM or compost in the ratio 1:25 and apply directly in the soil.

Inoculation for paddy: Mix 2 kg of culture in 60 litters of water and soak the seeds required for 1 ha (60 kg) for 24 hours before sowing. At the time of transplanting, dip the roots of seedlings for 15-20 minutes in the culture slurry prepared by mixing 2 kg inoculum with 40 litres of water. This slurry can be used for treating seedlings required for 1 ha. Another 2 kg culture may be applied to the field along with FYM or compost.

4. Blue green algae (BGA)

Mainly recommended for wetland rice cultivation. However, the use of this biofertilizer is not feasible in acidic soils with pH below 6.0. It is available as carrier-based inoculum and it fixes N about 25-30 kg/ha under ideal conditions.

Methods of application

Direct broadcasting in the rice fields @ 10 kg/ha one week after transplanting the seedlings.

5. Azolla

It is suitable for wetland rice cultivation. The required quantity of azolla will have to be raised in the farmers field itself. Fixes N about 25 to 30kg/ha.

Method of application: Apply fresh azolla @ 10 t/ha before transplanting the rice seedlings at the time of ploughing.

6. Phosphate solubilising bacteria and fungi

Recommended mainly for upland crops raised in neutral and slightly alkaline soils. Available as carrier-based inoculum. Enables the efficient utilization of cheaper sources of phosphatic fertilizers such as rock phosphate by crop plants in neutral and alkaline soils.

Method of application : Seed treatment and direct application in organic manure.

7. Vesicular/Arbuscular Mycorrhiza (VAM/AMF)

Vesicular arbuscular mycorrhiza is mostly recommended for upland especially for raising container and tissue culture plantlets and transplanted crops. It mainly improves the uptake of available P by inoculated plants. There is also an enhanced absorption of water and other nutrients such as N and K and certain micronutrients. Mycorrhiza inoculation can improve the survival and establishment of tissue culture plantlets under field conditions. Also induces better resistance against certain soil born plant pathogens. It is commercially available as granular inoculum consisting of infected roots and soil with mycorrhizal spores. It is given as soil application.

AMF fungus *Glomus microcarpum* var. *microcarpum* is suitable for tropical tuber crops. The inoculation can be done by placing inoculum (3-5 g/sett) beneath the sett before planting. The rate of spore load in the inoculum should be to the tune of 50 to 400 spores per 100 g soil medium. Method of application is the rooted infected cutting technique.

8. PGPR mix I

It is a compatible consortium of N, P and K biofertilizers and helps to save 25% N, P and K fertilizers. Methods of application and dose are same as that of Azospirillium.

Application techniques of biofertilizers

1. Seed treatment

Five hundred grams of commercially available inoculum will be required for treatment of seeds for one hectare area. For this, thick slurry of the carrier –based inoculum is initially prepared by mixing 500g of the inoculum in 1.25 liters of water. The stickiness of the bioferilizer on seed surface can be significantly improved by using 10% jagerry solution or 5% sugar solution supplemented with 40% boiled and cooled gum Arabic solution or rice – gruel water. The required quantity of seed material is then gently mixed with this slurry without damaging the seed coat. The treated seeds are spread evenly over a gunny bag dried in shade and sown immediately in moist soil. Under no circumstances, the treated seeds are exposed to direct sunlight for a longer period of time since the UV rays of solar radiation will reduce significantly the population of inoculated bacteria on seed surface.

2. Seedling treatment.

This method of application is mainly recommended for transplanted crops. In this procedure, the roots of seedlings to be transplanted are dipped in loose water slurry of the biofertilizer (500 g in 2.5 liters of water) for 20 minutes, prior to transplanting.

3. Soil application

Soil application is generally recommended for all types of biofertilizers except *Rhizobium, Bradyrhizobium* and *Azorhizobuim.* The methods is to apply the biofertilizer after mixing with dried FYM. Compost or vermicompost @ 1:25. For crop of six-months duration, the recommended dose is 1-2 kg/ha. This can be increased to 2-4 kg/ha for crops more than six months duration. For perennial crops, 10 to 25 g of the biofertilizer is to be applied in the root zone during the first year and 25 to 50 g during subsequent years. This can be done at the time of sowing, transplanting or during intercultivation.

Factors influencing the efficiency of biofertilizers in Kerala.

1. Use adequate quantiity of organic manure (as per the recommendation for each crop) along with biofertilizer application. This is essential to ensure better survival, growth and activity of the introduced microbial inoculum in acidic soils.

2. Liming is essential if the soil pH is below 6.0. In moderately acidic soils, the application of lime@ 250 kg/ha is recommended along with biofertilizer treatment.

3. Irrigation is essential during summer months after biofertilizer application to ensure the survival of the introduced microbial inoculum in the soil.

4. Since N biofertilizers can supplement only a part of the nitrogen requirement of the inoculated plant, low dose of nitrogen and full doses of phosphorus and potassium as per the recommendation may be applied. This is essential to ensure better plant growth and yield. Similarly, in the case of P biofertilizers, the full doses of nitrogen and potassium should be applied as organic manure.

5. Use only biofertilizers, which are manufactured as per the quality parameters prescribed by the Bureau of Indian Standards. In the case of bacterial biofertilizers, the prescribed standard is that in the final product, the population of the desired bacterium should not be less than ten million per gram of the carrier material and there should not be any contamination with other microorganisms when examined at 1:100000 dilution. Further, it should have a shelf life of at least six months.

6. The commercially available biofertilizer should always be used before the expiry date marked on the culture packet.

7. Topdressing with rockphosphate 25kg/ha 10 days after inoculation of BGA will enhance its growth under field conditions.

8. Since the occurrence of green algae in rice field can affect the normal growth and proliferation of BGA, the population of green algae should be controlled initially by applying copper sulphate @ 4kg/ha.

9. In moderately acidic soils of pH around 6.5, root nodulation by *Rhizobium* and *Bradyrhizobium* can be improved by pelleting with finely powdered calcium carbonate. (See recommendation under cowpea).

10. Application of P_2O_5 @ 1 kg/ha as rock phosphate is recommended once in 4 days in P_2O_5 deficient soils to ensure good growth of azolla. The development of a reddish purple colour in azolla is a typical symptom of P_2O_5 deficiency.

11. Since a floating population of azolla can release its bound nutrients only during decay in the soil, it is essential to incorporate azolla in the soil prior to the transplanting of rice seedlings.

BOTANICAL PESTICIDES

1. Leaf / Plant Extract

Preparation of 5% extract

Macerate 50g of leaf / plant in a mixie. Soak the macerated product in 1 litre of water for 24-48 hours. Strain the solution and spray.

2. Neem Seed Kernel Extract (NSKE)

Preparation of 5% NSKE

Grind neem kernel to coarse powder. Take 50 g of the powder in a cloth bag and dip it in ½ litre of water for 24 hours. Squeeze the cloth bag repeatedly till the out flow turns light brown. Dissolve 5 g of ordinary bar soap in 0.5 litre of water. Add the soap solution to the kernel extract, stir well and spray.

3. Tobacco decoction

Steep 500g of tobacco waste in 4.5 litre of water for 24 hours. Dissolve 120g of ordinary bar soap separately in 0.5 litre of water. Add the soap solution to the tobacco extract and stir vigorously. Add 5 litres of water to this stock solution and spray.

4. Neem oil + garlic 2% emulsion

Preparation of 10 litres

Ingredients: 200ml neem oil, 200g garlic and 50g ordinary bar soap.

Preparation : Slice the bar soap and dissolve in 500ml luke warm water. Grind the garlic pearls, mix it with 300 ml water and strain to prepare garlic extract. Pour the 500ml soap

solution into 200ml neem oil slowly and stir vigorously to get a good emulsion. Mix the garlic extract in the neem oil + soap emulsion. Dilute this 1 litre stock solution by adding 9 litres of water to get 10 litres of 2% neem oil + garlic emulsion.

Preparation of 5% Cashew Nut Shell Liquid (CNSL) emulsion

To prepare 10 litres of 5% CNSL emulsion, 500ml of CNSL and 50g bar soap are required. Slice the bar soap and dissolve in 500 ml of water. Pour 500 ml of CNSL slowly and stir vigorously to get a good emulsion. Dilute this one litre solution by adding 9 litres of water to get 10 litres of 5% CNSL emulsion

BOTANICAL PREPARATIONS FOR PEST CONTROL

1. Neem / *Azadirachta Indica*

Preparation	Dose	Pest
Neem leaf	250 g/plant	Nematodes of bhindi, brinjal
Leaf Extract	2 – 5%	Leaf feeders of amaranthus like *Spodoptera litura* & leaf webber, aphids of vegetables
Neem Twig	Plant neem twigs in coconut gardens after receipt of monsoon rains during April-May for controlling root grubs.	
NSKE	3-5%	Aphid of brinjal, Shoot & Fruit borer of okra, brinjal *Helicover pa armigera* of tomato and cowpea, Pod fly of cowpea, American Serpentine Leaf miner of vegetables (ASLM) (Cucurbits, brinjal, cowpea), Ornamentals (Marigold)
Neem oil	2.5-10%	Pea Aphid, ASLM, Epilachna Beetle, Mites of vegetables
Neem oil	4%	GLH, BPH of rice
Neem Cake	250 Kg/ha	Shoot & fruit borer of bhindi, brinjal
Neem Cake Extract	10%	Root knot nematode of vegetables
2. Custard apple – *Annona squamosa*		
Leaf Extract + Cow's urine	10% + 10%	Leaf feeders
Seed Extract	2-5%	Lepidopteran pests like Epilachna beetle of Brinjal & Bitter gourd Pea Aphid, Stem Borer, Bugs

3. Tobacco – *Nicotiana tabacum*		
Tobacco decoction	Soft bodied insects of all kinds (aphids, jassids, mealy bugs, hoppers)	
4. Clerodendron – *Clerodendron infortunatum*		
Plant extract	4-8%	Tobacco caterpillar, Epilachna beetle of brinjal, cucurbits, Leaf roller of okra
Fresh plant or shade dried powdered plant mixed with cow dung	1:10	Rhinoceros beetle of coconut
5 Vilaitulsi – *Hyptis suaveolens*		
Plant Extract	10%	Aphid and soft bodied pests of vegetables
6. King of bitters – *Andrographis paniculata*		
Plant Extract	10%	Jassids of cucurbits, Leaf caterpillars
7. Yellow Oleander – *Thevetia neriifolia*		
Leaf Extract	4-10%	Leaf Webber of Amaranthus, Aphids of Brinjal and Cowpea, Leaf roller of Bhindi, Epilachna Beetle of brinjal
Seed Extract	2%	Leaf feeders like Epilachna beetle of brinjal & bitter gourd
8. *Chromolaena (Eupatorium) odorata*		
Leaf	15 t/ha two Mulching @ 3 t/ha at 30 days planting. after	Nematodes of Vegetables weeks before planting. Sweet potato Weevil
9. Tulsi – *Ocimum spp*		
Plant	Handful of crushed ocimum + 10 g jaggery + 0.5 g carbofuran (Fruit Trap)	Fruit fly of cucurbits, mango
10. Chinese chaste tree – *Vitex negundo*		
Leaf Extract	5-10%	Fruit & Shoot borer of okra, Leaf caterpillars of cucurbits, *H. armigera* of chick pea.
Dried, Powdered leaf	1:100	Stored product pests
11. Lantana – *Lantana camara*		
Plant Extract + Cow's urine	10% + 10%	Soft bodied pests

Mixtures

1. Tobacco decoction +*T. neriifolia* leaf extract (4%)

   Tobacco decoction + *C. infortunatum* (4%)

   Effective against pests of amaranthus, okra, brinjal, bitter gourd and cow pea.

2. Neem oil (20ml) + garlic 20g + 5g soap/ litre of water – Coconut eriophyid Mite.

3. *A. panniculata* extract (10%) + cow's urine (10%) + 10g bird chilli/ litre – caterpillar pest.

4. Neem oil (20ml) + ponamia Oil (10ml) – garlic (20g) + 5g soap/ litre given as 3 sprays – panicle initiation, berry formation & berry maturation controls pollu beetle of pepper.

5. Keeping castor cake soaked in water @ 1 Kg/5 litre of water in small mud pots in coconut garden attracts rhinoceros beetles which can be collected and killed.

Commercial neem based pesticides.

Neem Azal T/S 1%	2 ml/litre4 ml/litre	Pests of eriophyid mite vegetables Coconut
Nimbecidine	2 ml/litre	Pests of vegetables
Econeem	2 ml/ litre	Pests of vegetables
Econeem plus	200-450 ml/ha worms (Cotton), Thrips,	Diamond back moth, Boll Mealy bugs
Econeem plus	10 ml + 10 ml	water (root injection) Coconut Eriophyid Mite
Neem gold	0.6%	Pollu beetle

PREPARATION OF PERMITTED FUNGICIDES FOR ORGANIC FARMING

Bordeaux mixture (1%)

Dissolve 1 kg of powdered copper sulphate crystals in 50 litres of water. In another 50 litres of water, prepare milk of lime with 1 kg of quick lime. Pour the copper sulphate solution into the milk of lime slowly stirring the mixture all the while. Test the mixture before use for the presence of free copper, which is harmful to the plants, by dipping a polished knife in it. If the blade shows a reddish colour due to the deposits of copper, add more lime till the blade is not stained on dipping. Always use wooden, earthen or copper vessels for the prepation of Bordeaux mixture. Use the fungicide in the same day of preparation.

In order to confer sticking qualities to Bordeaux mixture, rosin washing soda mixture , may be added. The addition of the sticker is particularly recommended for sprayings conducted during rainy season. For preparing the mixture, 10 litres of water out of 100 litres required for preparing Bordeaux mixture may be kept apart. Boil 10 litres of water , preferably in an earthen pot and add 500 g of good quality washing soda (sodium carbonate). Boil again until the solution becomes slightly dark in coloue. Add one kg of powdered rosin (arpoos) in the boiling washing soda solution. Reduce the flame for avoiding frothing, foaming and spilling over. Boil the solution for 5-10 mintes till the black bubbles appear. Cool the solution until the temperature reaches below 45 degree Celsius. The cooled mixture (10 litres) is then added slowly to the prepared Bordeaux mixture (90 litres) under vigorous stirring.

Bordeaux paste

Dissolve 100 g of copper sulphate and 100 g of quick lime each in 500 ml of water separately. Mix together to make one litre of the paste.

PREPARATION OF *'Panchagavya' and 'Dasagavya'*

1. *'Panchagavya'*

Cow dung -7 kg and cow ghee-1 kg are mixed in a clean container thoroughly both in morning and evening hours and kept aside for 3 days. After 3 days, cow Urine -10 litres and water - 10 litres are added. The mixture is kept for 15 days with regular mixing both in morning and evening hours. After 15 days, add cow milk – 3 litres, cow curd - 2 litres, tender coconut water - 3 litres, jaggery - 3 kg and well ripened poovan banana - 12 nos. Panchagavya can be prepared in a wide mouthed mud pot or concrete tank or plastic can.

Precautions

a) Keep the container open under shade

b) Stir the contents twice a day both in morning and evening

c) The Panchagavya stock solution will be ready after 30 days

d) Do not mix buffalo products

It is stored in shade covered with a wire mesh or plastic mosquito net to prevent houseflies from laying eggs and the formation of maggots in the solution

2. *'Dasagavya'*

Dasagavya is Panchagavya + plant extracts

Plants used :

Azadirachta indica
Calotropis sp
Tephrosia purpurea
Vitex negundo
Datura metel
Jatropha curcas
Adathoda vasica
Pongamia pinnata

The plant extracts are prepared by separately soaking the foliage in cow urine in 1:1 ratio for ten days. The filtered extracts of all the plants are then added @ 1 litre each to 5 litres of the *Panchagavya* solution. The mixture is kept for 25 days and stirred well, meanwhile, to ensure thorough mixing of *Panchagavya* and the plant extracts.

ORGANIC CERIFICATION

Organic certification means having the farm and the farmer's methods inspected by an organic certifying group to ensure that they comply with the guidelines on organic farming. Organic certification improves the image of organic agriculture and provides transparency in certification. For gaining consumer's confidence, valid organic certification is an essential pre-requisite for marketing especially in the export market. Generally organic certification involves many standards inspection and certification.

Certification is a procedure by which a third party gives a written assurance that a product, causes or service is in conformity with certain standards. Organic standards are defined as minimum production practices including storage, transportation, processing, handling, packing and labelling requirements which must me followed for certifying the products as organic.

It is to be recognized that animals are a part of organic farming system since they contribute to nutrient cycles, soil fertility and higher yields. Draught purpose is achieved and the by products are utilized well. Forage crops improve crop rotation and allow for diversification in farming. There are many organic standards on national as well as international levels. Generally standards vary with the country and to sell the products in a particular country, the standards of the importing country are to be followed. Certification is the key to the national organic program. In US since 21st October 2002 it is a federal offence to label any food product as organic unless it has been certified. Certification process focuses on the methods and materials used in production. There are two main requirements:

1) The methods and materials used in production must meet organic standards.
2) There must be clear and ongoing documentation of these methods and materials.

The concept of organic certification is that a third party- an organic certifying agent- evaluates producers, processors and handlers to determine whether confirm to an established

set of operating guideline called organic standards. Those confirm are certified by the agent and allowed to use a logo, product statement or certificate to document their product as certified organic. In other words, the certifier vouches for the producer and assures buyers of the organic product's integrity.

CERTIFICATION IN INDIA

The Ministry of Commerce launched NPOP (National Programme for Organic Production) in March 2000, designed to establish national standards for organic products, which could then be sold under the logo "India organic". For the proper implementation of NPOP, NAPP (National Accreditation Policy and Programme) has been formulated with Accreditation Regulations announced in May 2001. These make it mandatory that all certification bodies whether international or foreign operating in the country must be accredited by an Accreditation Agency. There are six accreditation agencies in India: -

1) Agricultural Processed Food Products Export Development Authority (APEDA)
2) Coffee board
3) Spices board
4) Coconut Development Board
5) Tea Board
6) Directorate of Cashew and Cocoa Development

APEDA has recognized the following Inspection Certification bodies, all of these are able to certify based on the NPOP:

1) BVQ1 (India) Pvt. Ltd (Mumbai)
2) E cocrt SA (Aurangabad)
3) IMO control private limited (Bangalore)
4) Indian organic certification agency (Indocert,Aluva)
5) International Resources for farmer trade members
6) Lacon quality certification Pvt. Ltd (Theepany, Kerala)
7) National organic certification Association Pvt. Ltd (Pune)
8) One Cert Asia Agri Certification Pvt. Ltd (Jaipur)
9) SGS India pvt. Ltd (Gurgaon)
10) Skal International (Bangalore)
11) Uttaranchal State Organic Certification Agency (Uttaranchal)

Many of the Indian farmers are small scale, poor farmers who may not be able to afford the cost of certification. Private certification bodies are creating International control systems and participatory guarantee system as alternative means of certification to reduce the cost of certification.

APPENDIX -I

Average nutrient content of common manures

Material	Nutrient content %		
	N	$P_2 O_5$	$K_2 O$
FYM	1.0	0.5	1.0
Compost	0.5	0.4	0.8
Groundnut cake	7.0	1.5	1.5
Castor cake	4.3	2.0	1.3
Neem cake	5.0	1.0	1.5
Gingelly cake	6.2	2.0	1.2
Coconut cake	3.0	1.9	1.8
Bone meal	3.5	21.0	-
Fish meal	4.1	3.9	0.3 - 1.5
Poultry manure	1.2 – 1.5	1.4 – 1.8	0.8 – 0.9
Sheep manure	0.8 - 1.6	0.3 - 0.4	0.3 - 0.4
Vermicompost	1.2 - 1.8	0.4 - 0.8	1.0 - 1.8
Vermiwash (ppm)	200 - 500	70 - 400	400 - 1000
Coirpith compost	1.06	0.06	1.2

Note: - Composition of organic manures vary widely

APPENDIX – II

Products for use in fertilizing and soil conditioning

1. On - farm resources permitted

a. FYM, poultry manure, slurry, urine
b. Crop residues and green manures
c. Straw and other mulches

2. Off - farm resources of restricted use

a. Blood meal, meat meal, bone meal and feather meal without preservatives
b. Compost made from any carbon based residues
c. FYM, slurry, urine
d. Fish and fish products with out preservatives

3. Biodegradable byproducts from food and textile industries without synthetic additives

1. Sea weed and sea weed products
2. Sewage sludge and urban compost
3. Vermicast, animal charcoal, compost and spent mushroom and vermiculate substances, compost from organic household waste substance
4. By-product from oil palm, coconut and cocoa.
5. By products of industries, processing ingredients from organic aquaculture

Permitted off farm Products

1. Peat without synthetic additives (prohibited for soil conditions permitted for manuring)
2. Saw dust and wood shaving from untreated wood
3. Compost from plant residues

Minerals permitted

1. Calcified sea weed
2. Calcium chloride
3. Lime stone
4. Gypsum
5. Chalk and phosphate chalk
6. Magnesium sulphate
7. Sodium chloride
8. Clay (Bentonite, Perlite, Zeolite)

Minerals restricted

1. Calcium and magnesium rock
2. Mineral potassium with low chlorine content
3. Natural phosphate (Rock phosphate)
4. Pulverized rock
5. Trace elements
6. Wood ash from untreated wood
7. Potassium sulphate
8. Basic slag

Materials prohibited

1. Human excreta
2. Chilian nitrate and all synthetic nitrogenous fertilizers
3. Synthetic hormones

Other products permitted

1. Bacterial preparation (Bio fertilizers)
2. Bio dynamic preparations
3. Plant preparation and botanical extracts
4. Vermiculite
5. Peat

APPENDIX - III

Products for pest and disease control

Permitted products

1. Chromatic traps
2. Clay (eg. Bentonite, perlite, Vermiculite and zeolite)
3. Gelatin
4. Mechanical traps
5. Light trap
6. Sticky traps
7. Plant based extracts (eg. Neem, garlic, pongamia etc)
8. Pheromones (Traps and dispenses only)
9. Homeopathitic and Ayurvedic preparations
10. Herbal and biodynamic preparations
11. Plant based repellents
12. Soft soap (Potassium soap)
13. Casein
14. Sodium bicarbonate
15. Derris root
16. Extract from mushroom (Shitake fungus)
17. Extract from Chlorella

Restricted products

1. Chloride of lime/soda
2. Copper salt
3. Diatomceous earth
4. Light mineral oil, propolis, lecithin, silicates
5. Permangnate of potash
6. Pyrethrum cinerifolium
7. Quassia amara
8. Quick lime
9. Parasite predators of insect pest
10. Lime sulphur, sulphur
11. Tobaco tea
12. Viral fungal and bacterial preparations
13. Sea weeds and seaweed meals
14. Sea weed extract
15. Sea salt and salty water
16. Fermented products from aspergillus
17. Natural acids (vinegar)

Biocontrol agents permitted for pest and diseases control

1. Viral preparations
2. Fungal preparations
3. Bacterial preparations
4. Parasites, predators and sterile insects

Prohibited materials

Mineral powders (stone meal, silicate)

Ethyl alcohol

APPENDIX-IV

Biopesticides available in the market

Generic names and **formulations**	**Trade name**
Bacillus thuringiensis	Dipel-8L Kurstaki Halt Biobit Biolep Delfin (Serotype 3a x b)
Trichoderma viride	Ecoderma
*Trichoderma harzianum*0.5WS	NIPROT
NPV of *Helicoverpa Armigera* of 0.43 AS	HELICIDE
NPV of *Spodoptera litura* 1 AS	SPODOCIDE
Pseudomonas fluorescens 1.75	Biocure B
Verticillium lecani 1.15	Biocatch
Beauveria basian 1.15	Biopower

APPENDIX-V

List of organic products approved by the Technical Evaluation Committee held on 06.09.2007

1. Neem cake

	N	P	K	Ingredients with % of composition
Neem Cake	5.7	0.9	2.62	Neem cake – 100%
Green Star Neem Cake	1.32	0.35	2.02	Neem fruits – 100%
PMCS Neem de-oiled cake	0.3	0.2	1.9	Neem seed
Neem cake PoP Neem	1.9	0.3	21.1	Neem fruits
"Arya Vep" Neem Cake	1.36	0.4	1.4	Neem fruits
Neem cake	1.8	0.3	2.0	Dried Neem fruits
Neem cake (Garuda Neem)	1.2	0.4	1.9	Neem fruit
Tropical Neem cake	1.86	0.3	1.97	Crushed Neem fruit
SAMIRDHA Neem cake	1.2	0.65	1.2	Neem cake 100%

Jeevan Neem cake	1.4	0.3	2.4	Neem cake 100%
Neem cake	0.5	0.6	1.6	Deoiled Neem cake 100%
Neem Plus Semi oiled Neem cake	1.6	0.4	2.1	Neem
Neem cake	1.3	0.2	1.6	Crushed Neem 100%
SURYA Neem cake	1.7	0.4	1.9	Neem fruit 100%
FARMER'S Neem crushed cake	1.54	0.32	2.06	Crushed Neem Seed 100%
MAC NEEM GOLD Neem cake	2.0	1.2	1.8	Neem fruit 100%
Sasya Super Neem Cake	1.2	0.3	1.6	Neem seed 100%
Neem cake	1.4	0.3	1.5	Neem seed 100%
Neem cake	3.4	0.89	1.3	Crushed de-oiled neem seed 100%
Neem cake	4.8	0.98	1.2	Neem cake 100%
Mythri Neem cake	2.0	0.62	1.9	Neem seed 100%
VEP-X Oiled Neem Cake	1.78	0.26	1.31	Neem fruit 100%
Kirlos Neem Cake	0.89	0.25	1.3	Neem 100%
Plantrich Neem Cake	2.59	0.24	1.16	Crushed Neem cake 100%
Kaveri crushed neem oil cake	1.33	0.78	1.66	Crushed neem fruit 100%
Farmers brand neem cake	1.6	0.5	1.9	100% Neem seed cake
Neem cake	1.4	0.4	1.7	100% seed expeller
ABTECH Neem Cake	1.2	0.1	1.8	Crushed Neem 100%
Haritha Neem Cake	1.89	4.48	1.17	Neem seed
Deer Neem Cake	1.7	1.5	1.5	Neem Cake 100%
Haritha Neem Cake	1.5	0.32	0.6	Crushed Neem Seed 100%
Malcos – Super Neem cake	0.78	0.38	1.05	Crushed Neem fruit 100%
Malcos – Neem cake	0.71	0.16	1.05	Neem cake 100%
Neem cake	1.46	0.4	1.51	Neem cake 100%
Neem cake	2.43	0.17	2.31	Neem cake 100%

Neem cake	0.77	0.75	2.03	100% Neem cake