Azadi Ka Amrit Mahotsav

EXECUTIVE SUMMARIES
OF SHORT TERM RESEARCH PROJECTS

Editors

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NATIONAL MEDICINAL PLANTS BOARD
MINISTRY OF AYUSH, GOVERNMENT OF INDIA

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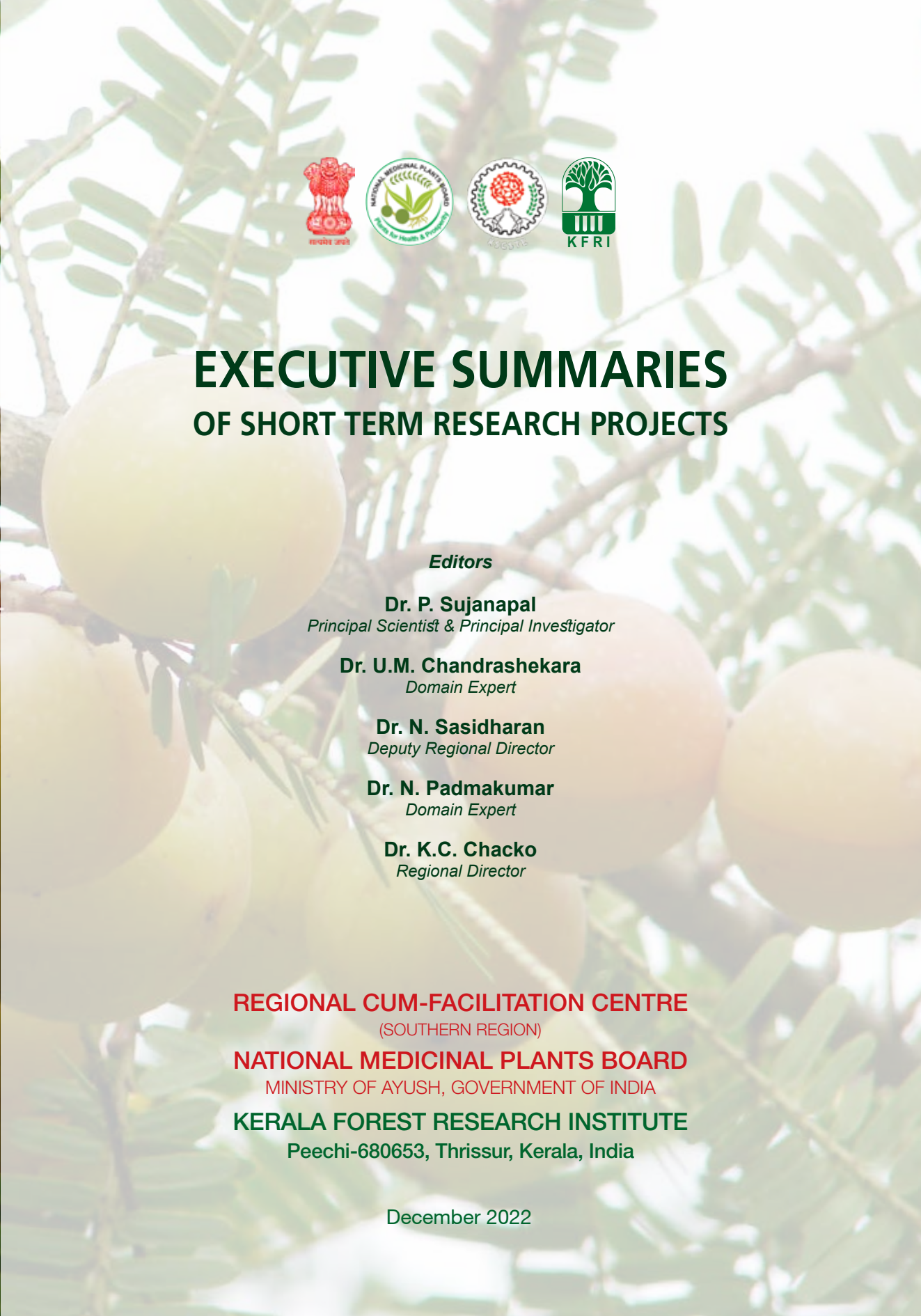

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Editors

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Disclaimer

The editors have taken utmost care to ensure that the Executive Summaries provide useful results of the projects as crisp as possible. However, the PIs and Co-PIs have the ultimate responsibility for the contents including recommendations.

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मुख्य कार्यकारी अधिकारी
Prof. (Dr.) Tanuja Manoj Nesari
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सत्यमेव जयते

भारत सरकार
Government of India
आयुष मंत्रालय
Ministry of AYUSH
राष्ट्रीय औषधीय पादप बोर्ड
National Medicinal Plants Board

PREFACE

Research plays a crucial role in the qualitative and quantitative strengthening of the medicinal plants sector in the country. The National Medicinal Plants Board (NMPB), Ministry of Ayush, Government of India has taken serious note of this requirement as evidenced by funding of a large number of research and development projects in various disciplines relevant to the demand and supply chain. In addition to such large-scale research funding directly by NMPB, it was a novel experiment by NMPB to fund short term projects through Regional Cum Facilitation Centres (RCFCs) of NMPB including the RCFC (SR). Through RCFC (SR) such seven short term projects has been implemented by Research Scientists / professional from different reputed research organization / institutions / Universities with close interaction of relevant stakeholders. The executive summaries of those seven short term projects contained in this document reveal that the investigators have sincerely executed the projects in bringing out useful information for the medicinal plants stakeholders and conduct training and workshops for the beneficiaries to disseminate the results of these projects. I congratulate the entire team of RCFC (SR) and all the investigators for efficiently implementing this commendable work.

Prof. (Dr.) Tanuja Manoj Nesari
Chief Executive Officer, NMPB

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CHAPTER 1

INTRODUCTION

The Regional cum Facilitation Centre-Southern Region (RCFC - SR) of the National Medicinal Plants Board (NMPB) facilitated implementation of seven Short Term Research Projects in the Southern Region during 2018-19. The concerned Investigators have duly completed the projects and submitted their report to RCFC - SR. The seven projects cover various disciplines; two each under agroforestry intercropping, and organic cultivation; one each on biological management, semi-processing and packaging, and ethnobotanical documentation and value addition. This publication is a collection of executive summaries of all those seven projects. In addition to the research findings, it also contains a list of nine publications that appeared in journals, three presentations in conferences and webinars, and one technical bulletin. The investigators have also taken effort to transfer useful technologies to the stakeholders, mainly the farmers of the respective localities, and there has been appreciable response by way of area expansion in cultivation. The extra effort taken by the Investigators in creating awareness on the target medicinal plants is also worth mentioning. The project-wise executive summaries are given in chapter two and the publications listed in chapter three.

Curcuma caesia

CHAPTER 2

EXECUTIVE SUMMARIES

Project 1

Biological management of pest and diseases of selected commercially important medicinal plants

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Background

Medicinal plants have been in use in the wellness sector since time immemorial. Quality of medicinal plants depends on various factors, such as, their chemical constituents; cultivation practices, harvesting and post-harvest techniques adopted; and the drug extraction procedures. Although the demand for medicinal plants - both in regional, national and international markets - is increasing exponentially, production and quality are on the decline due to pests and diseases, which in turn leads to a reduction in supply of quality raw drugs to the market and end-users.

Among insect pests, mealy bugs, aphids, cutworms and beetles; among diseases, leaf spots, leaf blight, anthracnose and root rot and root-knot nematodes are the major problems in medicinal plants. Although effective control is possible using chemical pesticides and insecticides, they are not advisable for medicinal plants cultivation as their residual effects may have adverse effects on the users. Apart from this, other issues such as pesticide resistance in pathogens, toxicity to non-target organisms and contamination of the environment add to the undesirability of using chemicals for management of pests and diseases. This calls for use of biological control, where natural enemies of pathogens are used for pests and disease management, as an alternative approach. With this background, this project was undertaken on ten commercially important medicinal plants to develop biological management techniques to control serious diseases and pests.

Material and methods

Fungal disease and insect pests of selected ten species of medicinal plants, namely, *Aloe vera*, *Alpinia calcarata*, *Andrographis paniculata*, *Asparagus racemosus*, *Kaempferia galanga*, *Piper longum*, *Plumbago indica*, *Rauvolfia serpentina*, *Sida alnifolia* and *Solanum violaceum* were surveyed in four commercial medicinal plants cultivation areas - Mattathur Labour Co-operative Society, Thrissur; Ashtangam Educational Trust Vavanoor, Palakkad; Itoozhi Illam Ayurveda Foundation Charitable Trust, Mayyil, Kannur; and Arya Vaidya Sala, Kottakkal. Infected parts of plants - leaves and stems - were collected and the symptomatology was studied. The efficacy of biological management of fungal diseases of plants using *Trichoderma harzianum, Serratia marcescens, Bacillus vietnamensis*, *Pseudomonas fluorescence* and *Bacillus thuringiensis* was assessed. Effect of two commercial biocontrol products (Econeem and Delfin) against mealy bug and brown scale beetle were assessed by following standard procedures.

Results

Totally, 38 fungal species belonging to 13 genera were found associated with the incubated diseased samples. The most commonly occurring dominant fungal genera were *Alternaria*, *Cladosporium*, *Colletotrichum*, *Corynespora, Curvularia, Fusarium*, *Oidium, Phoma*, *Rhizoctonia, Sclerotium, Pestalotiopsis,* and *Pythium (*Table 1*).* Insect pests commonly found were beetle (brown scale), caterpillar, mealy bug, sap sucker, grasshopper, mites, and snail; mealybugs were the major among them. Among the plants, *Sida alnifolia* was the most pest prone infested with five groups of pests - caterpillar, mealy bugs, beetles, grasshopper, and mites (Table 1). Different biocontrol agents for the biological management of fungal diseases of the ten medicinal plants are given in Table 1.

Application of commercial biopesticides namely Econeem 300 ppm and Delphin 5% resulted 100% cent per cent mortality of mealy bugs. In addition, biocontrol microbes - *Bacillus thuringiensis, Beauveria bassiana,* and *Trichoderma harzianum* at 300 µl concentration are useful in controlling brown scale beetle in *Sida alnifolia* (Table 1).

Recommendations

- *For the biological management of fungal diseases such as leaf spot, leaf blights, leaf spot, powdery mildew, wired stem and die back diseases in medicinal plants such as Aloe vera, Alpinia calcarata, Andrographis paniculata, Asparagus racemosus, Kaempferia galanga, Piper longum, Plumbago indica, Rauvolfia serpentina, Sida alnifolia, biocontrol agents, such as Trichoderma harzianum, Serratia marcescens, Bacillus vietnamensis, Pseudomonas fluorescence and Bacillus thuringiensis can be used.*

- *Commercial biopesticide products, such as Econeem 300 ppm and Delphin 5% are effective in controlling mealy bugs in medicinal plants. Biocontrol microbes, such as, Bacillus thuringiensis, Beauveria bassiana, and Trichoderma harzianum can also be used against brown scale beetles and in Sida alnifolia.*

Symptoms of diseases & insect pest damages

Species	Disease symptoms	Insect pest damage
 *Andrographis paniculata*	 Leaf spot in *A. paniculata* due to *Collectotricum gloeosporioides*	mealybug infestation recorded
 *Alpinia calcarata*	 *Alpinia calcarata* Leaf blight in caused by *Alternaria alternata*	 *Alpinia calcarata* plants showing mealy bug infestation
 *Aloe vera*	 Leaf blight of *A. vera* due to *Curvularia sp.*	No serious insect pest identified from the study sites

Symptoms of diseases & insect pest damages

Species	Disease symptoms	Insect pest damage
 *Asparagus racemosus*	 *Leaves/ phyllodes of Asparagus racemosus* showing leaf blight disease symptoms caused by *Fusarium sp.*	 Infestation of sap sucker on young shoot of *A. racemosus*
 *Kaemphferia galanga*	 Marginal leaf blight in *K. galanga* caused by *Collectotrichum gloeosporioides*	No serious insect pest identified from the study sites
 *Plumbago indica*	 *P. indica* showing leaf blight & top blight diseases symtoms caused by *Phoma sp. & Pythium myriotylum*	 Caterpillar infestation on leaves of *P. indica*

Symptoms of diseases & insect pest damages

Species	Disease symptoms	Insect pest damage
		
Piper longum	Leaf spot & blight in *P. longum* caused by *Collectotricum gloeosporioides*	Severe infestation of mealy bug in the leaves of *P. longum*
		
Rauvolfia serpentina	Severe infection of leaf spot & blight caused by *Alternaria alternata* in *Rauvolfia serpentina*	Mealy bug infestation on *Rauvolfia serpentina* in natural habitat
		
Sida alnifolia	Leaf spot disease in *Sida alnifolia* caused by *Fusarium oxysporum.*	Mealy bug infected plant of *Sida alnifolia*

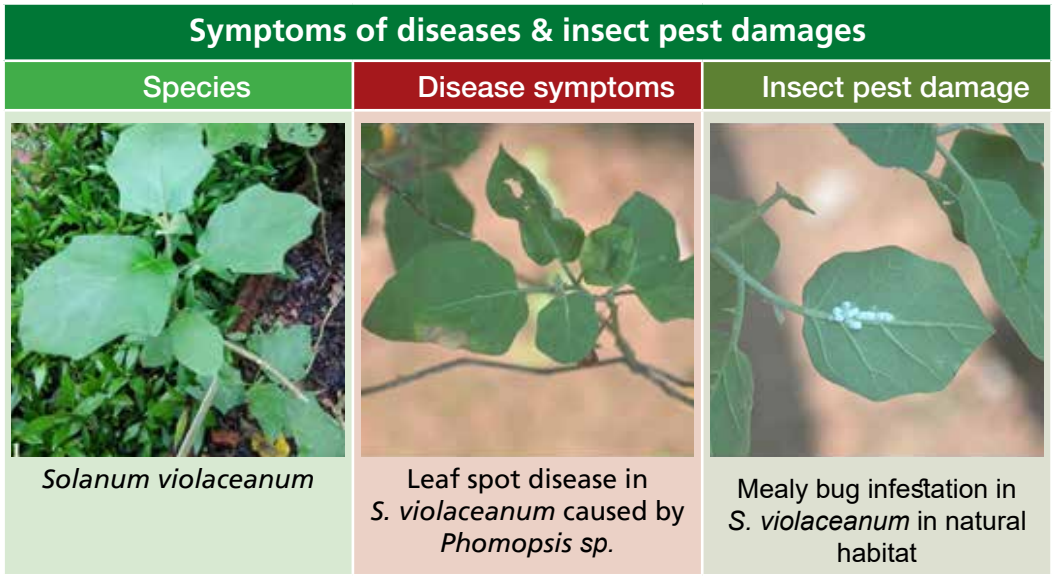

Table 1. Pathogens and insect pests of selected medicinal plants and their biological management

Sl. No.	Medicinal Plants	Symptoms	Pathogenic fungi	Biological management of disease	Insect/ other Pests	Biological management of pest
01	*Andrographis paniculata*	Leaf spot and blight	*Colletotrichum gloeosporioidies**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
02	*Alpinia calcarata*	Leaf blight	*Alternaria alternata**	Trichoderma harzianum, Bacillus vietnamensis, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
03	*Aloe vera*	Spot and blight	*Curvularia* sp.*	Trichoderma harzianum	-	-
04	*Asparagus racemosus*	Leaf spot and blight	*Fusarium oxysporum**	Trichoderma harzianum, Bacillus vietnamensis, Serratia marcescens	Mealy bug	Econeem & 300ppm Delfin @ 5% (bt)
		Powdery mildew	*Oidium* sp. *	Not available	Sap sucker	Foliar application of Isaria fumosorosae (Ifu13a) @ $1x10^{6}$ [1] Application of 5% Neem kernel extract with neem oil[2].

Sl. No.	Medicinal Plants	Symptoms	Pathogenic fungi	Biological management of disease	Insect/ other Pests	Biological management of pest
05	*Kaempferia galanga*	Leaf blight (Marginal)	*C. gloeosporioidies**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	-	No serious insect pest identified from the study sites
06	*Plumbago indica*	Leaf spot and blight	*Phoma* sp.*	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
					Cater pillar	Application of neem oil @ 3%[3] Or extract/ decoction of Cleistanthus collinus[3].
		Top blight	*Pythium myriotylum**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Sap sucker	Application of Isaria fumosorose (Ifu13a) @ $1x10^6$ or 5% Neem kernel extract with neem oil[2].
07	*Piper longum*	Leaf spot & blight	*C. gloeosporioidies**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
08	*Rauvolfia serpentina*	Leaf spot and blight	*Alternaria alternata**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
					Snails	

Sl. No.	Medicinal Plants	Symptoms	Pathogenic fungi	Biological management of disease	Insect/ other Pests	Biological management of pest
09	*Sida alnifolia*	Leaf spot and blight	*F. oxysporum**	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Beetles	Bacillus thuringensis, Beavaria bassiana, Verticillium sp. and T. harzianum
		Wire Stem	*Rhizoctonia solani**		Caterpillar	Application of neem oil @ 3%[3] or extract/ decoction of Cleistanthus collinus[4].
					Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)
					Grass hopper	Metarhizium and Beauveria bassiana[5].
					Mites	Not available
10	*Solanum violaceum*	Leaf spot and blight	*Phomopsis* sp.*	Trichoderma harzianum, Bacillus vietnamensis, Pseudomonas fluorescence, Serratia marcescens	Mealy bugs	Econeem & 300ppm Delfin @ 5% (bt)

Sources: [1]Bugti et al, 2018, [2]https://plantix.net/en/blog/pest-control-managing-sucking-pests, [3]https://www.researchgate.net, [4]Arivudainambi et al, 2010, and [5]Lomer et al, 2001.

Project 2

Performance of medicinal plants as intercrops in Melia dubia based agroforestry under organic production system

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Background

Intercropping using medicinal plants is an agroforestry system that makes best use of the land and other resources for greater income by farmers. Through the present project an attempt was made to assess the possibilities of cultivation of medicinal crops in the interspaces of *Melia dubia* plantation. The specific objectives of the project were to (i) to study the performance of medicinal plants as intercrops in *Melia dubia* plantation under organic production system, and (ii) to work out the economics of cultivation of *Trachyspermum ammi (A*jwain) crop as influenced by organic management practices under *Melia dubia*-based agroforestry system.

Materials and Methods

Two experiments were laid out in the farmer's field of the University of Agricultural Sciences, Raichur during 2019-20. In the first experiment on intercropping, eight medicinal plants {*Adhatoda vasica* (Vasaka, Aadusoge), Andrographis *paniculata* (Kalmegh, Nilabevu), *Coriandrum sativum (Dhania,* Coriander), *Cymbopogon citratus (*Lemongrass), *Ocimum basilicum (Basil*), *Ocimum tenuiflorum (*Tulsi), *Trachyspermum ammi (*Ajwain), and *Withania somnifera (*Ashwagandha)} were planted as intercrop in one and half year-old *Melia dubia* plantation planted at 2m x 1m spacing. The good quality seeds/seedlings were procured from Indian Institute of Horticultural Research (IIHR), Bangalore, and University of Agricultural and Horticultural Sciences (UAHS) Bagalkot, and planting was done in August 2019 following a package of practices recommended by IIHR and UAHS. Observations on

growth and yield were recorded. The second experiment was designed to assess the effect of organic manure treatments on growth and yield of Ajwain in *Melia dubia*-based agroforestry system. The experiment was conducted during 2019-20 in Ulkal village close to College of Agriculture, Bheemarayanagudi, UAS, Raichur. Experiment, comprising eight treatments, was laid out in randomized block design with three replications. Ajwain was cultivated as an intercrop in one and half year-old *Melia dubia* plantation, by sowning at a spacing of 45 cm x 10 cm. Organic manures *viz*., FYM, vermicompost and sheep manure were applied as per treatments fifteen days before sowing of crop. Quantity of nutrients was calculated as per the recommended dose of nitrogen (RDN) *i.e*., 100: 50: 50 kg N, P_2O_5 and K_2O per ha. Panchagavya was prepared (for spraying at flower initiation) by using 7 kg fresh cow dung and 1 kg cow ghee mixed thoroughly and stored for 2 days. These ingredients were mixed thoroughly daily thrice. After 2 days, 3 liters of cow urine and 10 liters of water were added to this solution and were fermented for 15 days, stirring twice daily. Then, 2 liters of milk, 2 liters of curd, 250 g of jaggery, 2 liters of tender coconut water and 12 ripened bananas were added and the mixture was allowed to ferment for 15 days with intermittent stirring 2 to 3 times daily. The solution was filtered and used as a spray at the rate of 3 per cent at initiation of flowers. Growth parameters were recorded at physiological maturity stage. The crop was harvested and separated, and grain and stalk yield was determined. The observations recorded in these studies were analyzed statistically for a test of significance following the Fisher's method of analysis of variance (ANOVA).

Results and discussion

Eight medicinal plants (Ajwain (*Trachyspermum ammi*), Ashwagandha (*Withania somnifera*), Basil (*Ocimum basilicum*), Coriander (*Coriandrum sativum*), Kalmegh (*Andrographis paniculata*), Lemongrass (*Cymbopogon citratus*), Tulsi (*Ocimum tenuiflorum*) and Vasaka (*Adhatoda vasica*) planted as intercrops with *Melia dubia* recorded varying performance in terms of average yield (0.36 t ha^{-1} to 6.23 t ha^{-1}), net return (Rs. 7,410 to Rs.1,61,400, and B:C ratio (1.26 to 7.33). (Table 1). Among eight species, *Cymbopogon citratus* (crop yield: 6.23 t ha^{-1}, Net return of income: Rs.1,61,400 ha^{-1}, B:C ratio: 7.33), *Ocimum basilicum* (crop yield: 3.53 t ha^{-1}, Net return of income: Rs. 1,51,100 ha^{-1}, B:C ratio: 6.93), and *Adhatoda vasica* (crop yield: 3.83 t ha^{-1}, Net return of income: Rs. 1,17,886 ha^{-1}, B:C ratio: 6.61), and *Ocimum tenuifolium* (crop yield: 2.81 t ha^{-1}, Net return of income: Rs. 1,15,200 ha^{-1}, B:C ratio 5.52) found promising as intercrop in *Melia dubia* plantation.

Table 1. Average yield and economics of medicinal plants cultivated as intercrop with *Melia dubia*

Medicinal plant intercropped with *Melia dubia*	Average yield of medicinal plant (t ha^{-1})	Net return of income from medicinal plant (Rs. ha^{-1})	B: C ratio of medicinal plant
Adhatoda vasica (Vasaka, Aadusoge)	3.83	1,17,886	6.61
Andrographis paniculata (Kalmegh, Nilabevu)	0.86	7,410	1.26
Coriandrum sativum (*Dhania,* Coriander)	0.76	37,185	4.01
Cymbopogon citratus (Lemongrass)	6.23	1,61,400	7.33
Ocimum basilicum (Basil)	3.53	1,51,100	6.93
Ocimum tenuiflorum (Tulsi)	2.81	1,15,200	5.52
Trachyspermum ammi (Ajwain)	0.53	46,660	3.07
Withania somnifera (Ashwagandha)	0.36	61,250	3.23

Economic analysis of *Trachyspermum ammi* (Ajwain) cultivation under organic nutrient management practices in *Melia dubia*-based agroforestry system is presented in Table 2. Significantly higher net return was realized in the sole Ajwain crop under *Melia dubia*, due to higher seed yield. Application of vermicompost equivalent to 75 % RDN with foliar spray of Panchagavya @ 3% gave better returns, followed by application of FYM equivalent to 75 % RDN with foliar spray of Panchagavya @ 3%, and application of sheep manure equivalent to 75 % RDN with foliar spray of Panchagavya @ 3%. Absence of lower organic manure application resulted in lower return.

Table 2: Economic analysis of *Ajwain* cultivation under organic nutrient management practices in *Melia dubia* based agroforestry system

Treatments (All treatments are under *Melia dubia* intercropping, except the last one)	Net returns (Rs. ha^{-1})	B: C ratio
No organic manure	33,253	3.29
FYM equivalent to 100 % RDN*	44,937	2.82
Vermicompost equivalent to 100 % RDN	50,277	2.45
Sheep manure equivalent to 100 % RDN	46,680	2.35

FYM equivalent to 75 % RDN + Foliar spray of Panchagavya @ 3 %	55,167	3.21
Vermicompost equivalent to 75 % RDN + Foliar spray of Panchagavya @ 3 %	60,593	2.73
Sheep manure equivalent to 75% RDN + Foliar spray of Panchagavya @ 3 %	50,757	2.45
Ajwain sole crop (No tree component)	78,790	3.27

*RDN: Recommended dose of nitrogen (100 kg ha^{-1})

Recommendations:

Intercultivation of medicinal plants in early years of *Melia dubia* plantation is a profitable system for *Cymbopogon citratus, Ocimum basilicum, Adhatoda vasica, Ocimum tenuifolium, Withania somnifera, Trachyspermum ammi, and Coriandrum sativum.* Organic nutrients such as Farm Yard Manure, Vermicompost, Sheep manure, and foliar spray of Panchagavya either singly or in combination may be used, based on soil/foliar anaysis to improve productivity and net return.

General view of experiment

Melia dubia + *Coriandrum sativum*

Melia dubia + Withania somnifera

Melia dubia + Ocimum tenuiflorum

Melia dubia + *Adhatoda vasica*

Melia dubia + *Ocimum basilicum*

Melia dubia + *Trachyspermum ammi* (Ajwain)

Ajwain + *Melia dubia* agroforestry system

Project 3

Improving the semi processing and packaging methods to enhance the quality and market value of selected medicinal plants in Peechi-Vazhani Wildlife Sanctuary and Silent Valley National Park, Kerala

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Background

Tribal communities, settled in protected areas of Kerala, generate part of their livelihoods through collection of medicinal plant produce and selling them to traders and herbal industries without semi-processing and value addition. Most of them do not have sufficient infrastructure, skills, and financial support to undertake any intervention related to value addition resulting in only low income for collectors. Hence, there is an urgent need to develop and standardize the semi-processing and value addition technology for commercially medicinal plant species. This project was an attempt to address these challenges and prospects in developing value addition/semi-processing, packaging methods, marketing and good collection practices for important medicinal plants. The specific objectives of the projects were (i) explore the opportunities for conducting field level semi-processing and value addition exercises for prioritized medicinal plants and (ii) develop and standardise semi-processing and packaging methods for prioritised medicinal plants, considering the industry requirements to improve the quality of herbal collections.

Materials and Methods

The selected study areas were Peechi-Vazhani Wildlife Sanctuary having twelve Eco Development Committees (EDCs) in Thrissur District, and Silent Valley National Park in Palakkad district with seven EDC's. Out of 7 EDCs in

Silent Valley Wildlife division, five (Anavai EDC, Bhavani Range; Kakkinikkad EDC, Bhavani Range; Uppukulam EDC, Silent Valley Range; Watchers EDC, Silent Valley Range; Karuvara EDC, Bhavani Range) were selected for this study. Out of 12 EDCs in Peechi-Vazhani Wildlife division, four (Olakara EDC, Peechi Range; Kakkinikkad EDC, Peechi Range; Maniyankinar EDC, Peechi Range; Chimmony EDC, Chimmony Range) were selected for this study.

Medicinal Plant species selected for field level semi processing and value addition included *Acacia concinna (*Cheenikai), *Asparagus recemosus (*Sathavari), *Baliospermum montanum (*Nagadhanthi*), Canarium strictum (*Kunthirikkum), *Desmodium gangeticum (*Orila), *Garcinia gummi-gutta (*Kudumpuli), *Hemidesmus indicus (*Naruneendi*), Nilgirianthus ciliata (*Karimkurinji), *Piper longum (*Thippali), *Psuedarthria viscida (*Moovila), *Rauvolfia serpentina* (Amalpori/Sarpagandhi*), Sida acuta, Sida cordifolia* and *Sida rhombifolia* (Kurunthotti).

Various semi-processing and packaging methods that are applicable to the above-mentioned medicinal plants were explored from literature and by visiting the existing processing units across Kerala. The different semi-processing and post-harvest management practices were examined for various parameters including suitability for the species selected, applicability, affordability, skill requirements, power efficiency, maintenance of tools and equipment, service support, industry requirements, local adaptability, etc. The developed semi-processing and post-harvest management practices were taken to community members for their feedback on the application and implementation at EDC level. Based on the community perceptions, the proposed semi-processing methods were refined to improve the quality and standards of raw drugs of above-mentioned species.

Results/ Guidelines

The season and method of harvesting medicinal plants are very important as the plants contain numerous active constituents, chemical compounds responsible for the therapeutic activity, which are affected by environmental factors such as temperature, humidity, light and manner of handling during harvest. Techniques and time to harvest varies with the species and plant parts. Thus, the good collection practices that must be followed for producing quality plant materials

The methods of primary processing of NTFPs are dependent on the plant parts. Temperature and relative humidity are the main factors affecting the quality of fresh herb during storage. As far as possible, the minimum standard operating procedures must be followed for semi-processing methods at EDC level. The harvested crop can be collected on clean cement floor or good

tarpaulin sheet. The material is washed using clean water to remove soil particles sticking on to them especially with rhizomes and roots. In some caes (eg.few fruits/ seeds), washing is not recommended because of the likelihood of decomposition and mould infestation. Value addition practices developed for the selected medicinal plants are given below:

Species	Processing	Packing
Acacia concinna	Grind the dried pods into fine powder (shikakai powder)	Shikakai powder may be packed using plastic or tin containers for buyers from industry. Shikakai powder may also be packed in air-tight small plastic pouches and marketed in small quantities through eco-shops.
Asparagus racemosus	Boil tubers and dry	Dried tubers may be stored in gunny bags & cardboard boxes and marketed.
Baliospermum montanum	Dry the roots. If specially demanded by industry, cut the roots into small pieces, dry and grind into powder.	Completely dried roots/root powders may be stored in gunny bags, metal containers and plastic bags.
Canarium strictum	Dry the resin and grind into fine powder.	Pack the fine powder of resin in air-tight plastic or tin containers.
Desmodium gangeticum	Dry the whole plant and make them into small pieces.	Store the dried plant materials in gunny bags.
Garcinia gummi-gutta	Extract the seed oil/ghee by crushing the seed kernels.	Pack the seed oil in plastic or tin containers.
Hemidesmus indicus	Dry the roots. If demanded by industry, cut the roots into small pieces, dry and grind into powder.	Dried roots/root powders may bee stored in gunny bags, metal containers and plastic bags.
Nilgirianthus ciliata	Dry the roots. If demanded by industry, cut the roots into small pieces, dry and grind into powder.	Completely dried roots/root powders may be stored in gunny bags, metal containers and plastic bags.

Piper longum	Dry the whole fruit with stalk and grind into fine powder.	The fine powder may be packed using plastic or tin containers for buyers from industry. The powder may also be packed in air-tight small plastic pouches and marketed in small quantities through eco-shops.
Pseudarthria viscida	Dry the whole plant.	Store the dried plant materials in gunny bags.
Rauvolfia serpentina	Dry the roots. If demanded by industry, cut the roots into small pieces, dry and grind into powder.	Completely dried roots/root powders may be stored in gunny bags, metal containers and plastic bags.
Sida acuta, Sida cordifolia, Sida rhombifolia	Dry the roots. If demanded by industry, industry, cut the roots into small pieces, dry and grind into powder.	Completely dried roots/root powders may be stored in gunny bags, metal containers and plastic bags.

Recommendation

The semi-processing and packaging methods for the twelve medicinal plants, developed through interaction meetings with local community members and plant collectors of Peechi- Vazhani Wildlife Sanctuary and Silent Valley Wildlife Division and thereafter improved using feedback from herbal industries and officers of Kerala Forest Department.is a step ahead in quality upgradation and value addition of medicinal plants collected from forests by the forest-dependant communities. The target agencies may adopt the standardised methods given in this report to improve the quality standards of raw drugs of these twelve species as well as the livelihood of the forest-dependant communities..

Project 4

Ethnomedical documentation and value addition of different parts of Ashoka [(*Saraca asoca* (Roxb.) de Wilde)] through standard operative procedure

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Background

The medicinal tree Ashoka (*(Saraca asoca* (Roxb.) de Wilde) has multiple uses in the Indian Systems of Medicine and in folklore practices. All parts namely root, stem bark, leaves, flowers, and seeds of Ashoka are abundantly used in several classical drug preparations. The bark has an astringent and bitter taste. Potency is cool, after digestion turns to pungent; it pacifies the pitta and kapha. The stem bark is used to treat various diseases such as, menorrhagia, leucorrhea, bleeding hemorrhoids, dysfunctional uterine bleeding, dyspepsia, fever, burning sensation, ulcers, pimples, intestinal worms, snakebite, etc. In addition, different parts of Ashoka has several ethno-medicinal uses that are not well-documented. Their dosage forms, method of preparation and mode of use with complete therapeutic modalities are also not mentioned. This project had the following objectives: (i) to document the ethno-medical and folk-lore uses of different parts of Ashoka and (ii) to adopt Standard Operative Procedure (SOP) for the value addition of different parts of Ashoka.

Materials and Methods

The complete documentation on the ethno-medico-botanical utility of different parts of Ashoka with dosage forms, method of preparation, etc., in the Moodbidri Forest Range of Karnataka, was carried out. The preliminary physico-chemical, phyto-chemical study, ash analysis of different parts of Ashoka were carried out before subjecting topharmaceutical preparations. Some of the preparations were standardized through analytical studies. The preparations made with different parts of Ashoka were subjected to standardization tests, such as tests for particle size, bulk density, refractive index, Brix value, Iodine value, saponification value, viscosity, specific gravity, rancidity test and spreadability.

Results

a. Documentation of folklore medicinal preparation of Ashoka

In the present study, following folklore medicinal preparations of Ashoka prevailing in Moodbidri Forest Range were documented.

No.	Parts of Ashoka tree	Uses
1.	Dried root	For curing paralysis and visceral numbness
2.	Root powder	Root powder mixed with water is applied to the face for treating blackish discoloration of the face used to treat skin complications, such as, eczema, psoriasis, acne, dermatitis, herpes etc. used as herbal remedy for mental problems
3.	Root decoction	For consuming after delivery to enhance and clear lochia discharge (in females after delivery).
4.	Stem decoction	For treating eczema and anemia
5.	Stem bark decoction	Administered orally for treating dysfunctional uterine bleeding, fever, anemia etc. Consuming twice a day for the treatment of diabetes, uterine debility, and hysteria. Regular usage improves intellect. administered for treating uterine affections, biliousness, dyspepsia, dysentery, colic, piles, ulcers, pimples, fracture of the bones etc.
6.	Leaf decoction	Given internally for blood purification, killing intestinal worms, and treating abdominal pain
7.	Tender leaves	Tender leaves roasted with ghee and grinded with coconut and then mixed with buttermilk and salt is called as Tambuli. It is consumed with rice as food as well as to treat Gastritis. The paste of tender leaves with rose water/ water/milk is applied to the face for treating acne.
8.	Leaves	Juice of leaves and cumin seeds is given internally to cure abdominal pain Paste of leaves and coconut oil is useful to cure dandruff and hair fall

9.	Flowers	Flowers cleaned with water are ground with grated coconut, pepper, and little water and salt. To this mixture, buttermilk is added and served as Tambuli with rice. This Tambuli is also useful in treatment of dysentery, scabies in children and other skin diseases. The paste of fresh flowers is used as face pack in acne vulgaris A dried flower mixed with honey is used to treat itching in scrotum, joint pain, chest pain, neck pain, sleeplessness, and breathing problems. The paste of flower powder and coconut oil is applied over skin for scabies and eczema The dried flower powder mixed with milk or honey is given for controlling diabetes
10.	Seed	Consumption of small quantities (2-3 g.) of seed powder is useful to treat fever, asthma, and urinary disorders, such as, urinary calculi, burning micturition.

b. Value addition of different parts of Ashoka based on ethno-botanical survey

Based on the information gathered from ethno-botanical survey and documentation, twelve products, such as, Ashoka root ointment, Ashoka stem syrup, Ashoka stem powder soap, Ashoka bark Kashaya, Ashoka bark syrup, Ashoka bark granules, Ashoka tender leaf Tambuli, Ashoka leaf ointment, Ashoka flower powder Tambuli, Ashoka flower syrup and Ashoka seed powder (Figure 1) were prepared. The method of preparation, storage and packing of the products are provided below.

1. Ashoka root ointment

Ashoka root is cleaned well to remove physical impurities and dried properly. The dried roots are powdered coarsely with the help of a pulverizer. One part of the coarse powder of the root is boiled with 8 parts of water and reduced to half and filtered to get the Kashaya. Then, 80 g of fine powder of the root is taken and mixed with a little amount of water and made into paste. This paste is boiled with 500 ml of oil and 2 liters of Kashaya till the signs of the end point of Taila Paka are observed. Then it is filtered and 500 ml of prepared Ashoka root oil is taken in a dry, clean vessel and heated over low flame and temperature noted. When temperature reaches 60ºC, 100 g small pieces of Beeswax were slowly added and stirred carefully until it dissolves completely. After complete dissolution of Beeswax, the contents were filtered through a

clean cloth to separate insoluble particles possibly present in Beeswax. 30 g of the prepared ointment is filled in each ointment tubes immediately, before it gets solidify and labelled.

2. Ashoka stem syrup

Ashoka stem is cleaned to remove physical impurities and dried properly. The dried stem is powdered coarsely with the help of pulveriser. One part of the coarse powder of the stem is boiled with 8 parts of water and reduced to half and filtered to get Kashaya. To 4 liters of prepared Kashaya add 4 kg sugar and boil till the signs of end point of syrup are observed. Then add 0.5% of the mixture of methyl paraben and propyl paraben to the syrup as preservative. The syrup is measured and filled in 200 ml bottles and stored properly.

3. Ashoka stem oil

Ashoka stem is cleaned to remove physical impurities and dried properly. The dried stem is powdered coarsely with the help of pulveriser. One part of the coarse powder of the stem is boiled with 8 parts of water and reduced to half and filtered to get Kashaya. 150 gm of fine powder of the stem is mixed with little amount of water and made into a paste. This paste is boiled with 1,000 ml of oil and 2 liters of Kashaya till the signs of end point of Taila Paka is observed. Then it is filtered.

4. Ashoka stem soap

Dissolved 200 gm of sodium hydroxide in 750 ml of water, stirred well for 10 minutes and kept overnight. Next morning, the earlier prepared 1 litre of Ashoka stem oil is added slowly to the Sodium hydroxide solution and stirred continuously for 15 minutes. Later added 50 gm of melted beeswax gently and stirred well. The solidified soap is poured to the tray and dried under sunshine for 4 hours and cut into pieces of required shapes and sizes.

5. Ashoka bark Kashaya

Bark is cleaned to remove physical impurities and dried properly. The dried bark is powdered coarsely with the help of pulveriser. One part of the coarse powder of the bark is boiled with 8 parts of water and reduced to one fourth and filtered. 20 gm of methyl paraben and propyl paraben are added as preservative.

6. Ashoka bark Syrup

Stem bark is cleaned to remove physical impurities and is dried properly. The dried stem is powdered coarsely with the help of pulveriser. One part of the coarse powder of the stem is boiled with 8 parts of water and reduced to half and filtered to get Kashaya. To 4 litres of prepared Kashaya added 4 kg of sugar

and boiled till the signs of end point of syrup is observed. A mixture of 0.5 % methyl paraben and propyl paraben is added to the syrup as preservative. The Syrup is measured and filled in 200 ml bottles and stored properly.

7. Ashoka bark granules

Ashoka stem bark is cleaned to remove physical impurities and dried properly. The dried stem is powdered coarsely with the help of pulveriser. One part of the coarse powder of the stem is boiled with 8 parts of water and reduced to half and filtered to get Kashaya. To 4 litres of prepared kashaya added 4 kg of sugar and boiled till the sign of end point of syrup is observed. Added 100 gm of fine powder of Ashoka bark and stirred well, till to form granules.

8. Ashoka tender leaf Tambuli

Two kg of properly cleaned Ashoka tender leaves are grinded with coconut, mixed with buttermilk and salt. This Tambuli (A traditional food preparation) is eaten during lunch by mixing it with rice.

9. Ashoka leaf Ointment

Ashoka leaves are cleaned to remove physical impurities and dried properly. The dried leaves are powdered coarsely with the help of pulveriser. One part of the coarse powder of the leaf is boiled with 8 parts of water and reduced to half and filtered to get Kasahaya. 80 gm of fine powder of the leaf is taken and mixed with little amount of water and made into paste. This paste is boiled with 500 ml of oil and 2 litre Kashaya till the sign of end point of Taila Paka is observed. Then it is filtered. 500 ml of prepared Ashoka leaf oil is taken in a dry, clean vessel and heated over low flame and note the temperature. When temperature reaches 60°C, 100 gm small pieces of beeswax are slowly added to the vessel containing the Taila and stirred carefully until it dissolves completely. After complete dissolution of beeswax, the contents are filtered through a clean cloth to separate insoluble particles possibly present in beeswax. Filled 30 gm of the prepared ointment in ointment tubes immediately, before it gets solidifies and labelled.

10. Ashoka flower powder Tambuli

Two kg of Ashoka flowers is cleaned to remove physical impurities and dried properly under shade. The dried flowers are powdered with the help of pulveriser and sieved. This powder is grinded with coconut; thereafter buttermilk and salt are added. It is eaten during lunch by mixing with rice.

11. Ashoka flower syrup

Ashoka flowers are cleaned to remove physical impurities and dried properly under sun light. The dried flowers are powdered coarsely with the help of

pulveriser. One part of the coarse powder of the flower is boiled with 8 parts of water and reduced to half and filtered to get a kashaya. Take 4 litres of prepared kashaya and add 4 kg sugar and boiled till the signs of end point of syrup is observed. Add 0.5% of the mixture of methyl paraben and propyl paraben to the syrup as preservative. Measure 200 ml of the syrup and fill in each bottle and store properly.

12. Ashoka seed powder

Properly clean 2 kg of Ashoka seeds to remove physical impurities. These are cut into small pieces and dry properly under shade. The dried seeds are powdered with the help of pulveriser and sieved.

Recommendation

The face pack of the Ashoka (*S. asoca*) root powder is beneficial to treat blackish discoloration of the face. The Ashoka root and leaf ointments can be used to treat acne and blackish discoloration of the face. The Ashoka stem syrup can be used to treat ailments like eczema and acne, while the Ashoka bark syrup is useful for treating dysfunctional uterine bleeding and anaemia. For treating skin diseases, the Ashoka stem powder soap is useful. While the Ashoka bark Kashaya (decoction) is useful for treating gynecological disorders, the bark granules are useful for general debility/weakness and anaemia. While the tender leaf Tambuli and flower syrup help in treating gastritis, the flower Tambuli (A traditional food preparation) can be consumed for gastritis and menorrhagia. Ashoka seed powder can be used to treat ailments like urinary calculi and burning micturition.

The present study also focused on phytochemical and pharmaceutical analyses. Further, clinical study on a large scale will be beneficial to conclude its utility in various disorders; thereby we can develop various medicinal, cosmoceutical products of Ashoka for the marketing.

ASHOKA- DIFFERENT PART PRODUCTS

Ashoka root ointment

Ashoka leaf Ointment

Ashoka stem soap

Ashoka bark granules

Ashoka bark Kashaya

Ashoka bark Syrup

Ashoka flower syrup

Ashoka stem syrup

Ashoka flower powder

Ashoka seed powder

Figure 1. Products prepared in Alva's Ayurveda Medical College using different parts of Ashoka tree based on ethnobotanical information

Project 5

Standardisation of organic cultivation and biocontrol of pests and diseases of Coleus in Telangana

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Background

Coleus forskohlii (hereafter, *Coleus*) is an important medicinal plant mainly used for treating many human diseases. The productivity of coleus in Telangana has been hampered by its susceptibility to root rot, wilt disease and leaf eating pests. The farmers are hesitant to apply different chemicals to control these pests and diseases since they lead to high cost of cultivation and severe economic loss. Moreover, organically grown medicinal plants are in good demand both in local and regional markets. However, due to lack of systematic information on organic cultivation of *Coleus*, growers are reluctant to adopt such practices. With this background, the present project was undertaken to a) standardise the organic package of practices of Coleus, b) study the influence of organic compounds on establishment, and growth and yield of Coleus, c) impart knowledge on organic cultivation of Coleus to the farmers.

Materials and methods

The study was conducted in Agricultural College, Aswaropet, Telangana. Cuttings of Coleus were procured from the reliable source and raised in 15 x 6 cm polyethylene bags containing 200g of potting mixture consisting of soil, sand, and vermi-compost. To the potting mixture neem cake, beejamrut and panchamrut were added respectively. *Trichoderma viridae*, *Glomus faciculatum, Pseudomonas fluroscens* inoculums (10 g per cutting) were placed adjacent to the cut ends of stem cuttings in the poly bags. Planted cuttings were placed under 60% shade net for 50 days for rooting. Then the plants were then kept for 5-7 days in open conditions to harden before transplanting to the main field. Five plants were randomly selected from 55

days old nursery cuttings for observations related yield parameters i.e., shoot dry weight and root dry weight.

The rooted 55 days old cuttings raised in nursery were transplanted planted on ridges at a spacing of 60 x 45 cm (row spacing was 60 cm and 45 cm between plants). Transplanting was done into planting holes with a depth of 10-12 cm and a diameter of 8-10 cm by placing intact ball of earth without polythene covers. Harvesting was done 140 days after transplanting and plants were manually uprooted with care not to damage the tubers. Dry root and shoot weights are recorded from each replicated plot. The experimental data pertaining to all the characters studied were subjected to statistical analysis of variance technique

Results

Dry shoot and root weights were significantly higher in plants treated with panchamrut followed by neem cake (Table 1).

Table 1. Effect of organic and bioinoculants on shoot and root (dry) weight of *Coleus forskohlii* at the nursery stage (55 days old cuttings) before transplanting

Treatment	Dry shoot weight (g/plant)	Dry root weight (g/plant)
Panchamrut	1.20	1.092
Neem cake	1.19	0.078
Glomus faciculatum	1.05	0.069
Pseudomonas fluroscens	0.98	0.063
Beejamrut	0.87	0.051
Trichoderma viridae	0.81	0.044
Control (soil, sand, and vermi-compost)	0.77	0.013

Plants treated with *Azotobacter, G. faciculatum, T. viridae* along with Jeevamrut showed significant increase in dry shoot and root yield followed with neem cake, vermicompost and Farm yard manure. The uninoculated control treatment and RDF recorded the minimum yield parameters for *Coleus forskohlii* (Table.2)

Table 2. Effect of organic and bioinoculants on shoot and root yield of *Coleus forskohlii* in field conditions.

Treatment*	Dry shoot yield (t ha^{-1})	Dry root yield (t ha^{-1})
Jeevamrut +Azotobacter + TV	2.64	0.42
Neem cake +Azotobacter +GF+ TV	2.58	0.41
Jeevamrut +Azotobacter +GF	2.45	0.39
Neem cake +Azotobacter +GF	2.31	0.38
Vermicompost+ Azotobacter +GF+TV	2.01	0.32
FYM+ Azotobacter+ GF + TV	2.00	0.31
Vermicompost + Azotobacter + GF	1.99	030
Recommended dose of fertilisers	1.98	0.18
FYM+ Azotobacter + GF	1.98	0.29
Control	1.35	0.12

*GF= *Glomus faciculatum*, TV= *Trichoderma viridae*, FYM= Farm yard manure

Recommendation

Recommended organic package of practices for *C. forskohlii* in Telangana is (i) application of a basal dose of 100 kg solid Jeevamrut + 250 kg of FYM with 5 kg Azotobacter + *Glomus faciculatum* and *Trichoderma viridae*. followed by (ii) top dressing of 200 lit. Jeevamrut for every 15 days up to 120 days after planting.

Training conducted to the farmers on organic cultivation of *Coleus forskohlii* in Telangana State

Project 6

Development of multi-tier cropping model for medicinal plants under coconut plantation in Telangana

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Background

Several farmers of Telangana State have switched over to coconut from their traditional crops for greater income. Coconut is intercropped mainly with cacao and banana. Apart from the perennial crop cacao and one time crop banana, the coconut plantation can be intercropped with various medicinal plants, particularly short duration seasonal crops, which can bring a change in the cropping system for better utilisation of resources and additional income to the farmers. The present project was undertaken in a 16 years old coconut plantation (spacing of 8.0 m × 8.0 m) in the Agricultural College farm at Aswaropet Mandal, Bhadradri Kottagudem Dist., Telangana State to assess the yield of various medicinal plants under coconut plantation and to impart training to the farmers about the multitier cropping system.

Materials and methods

Nine medicinal crops *viz*., Kalmegh (*Andrographis paniculata,)* Tulsi (*Ocimum tenuiflorum),* Cassia (*Senna angustifolia)*, Solanum (*Solanum nigrum)*, Coleus (*Coleus forskohlii)*, Ashwagandha (*Withania somnifera)*, Bhumi amla (*Phyllanthus amarus),* Peppermint (*Mentha* x *piperita*), and Tribulus (*Tribulus terrestris)* were selected to grow as intercrop in the coconut plantation. Different combinations were tried to find the best cropping pattern in terms of yield and economic returns. All the treatments or the cropping models were planned in the inter rows of coconut. All the medicinal plants as sole and multi-tier crops were transplanted at recommended spacing. All the treatments had replicated thrice. All the inter-cultural operations and plant protection measures were taken care of as and when required. Vegetative growth parameters such as plant height, plant spread, leaf area index, and yield

parameters *such as* herbage and root yield of medicinal plants intercropped with coconut were collected and subjected to analysis of variance. The data of yield of medicinal plants are given in Table 1..

Results and discussion

All the medicinal crops selected for the project work performed well under coconut plantation with significantly high crop yield equivalent ratio for *Senna angustifolia* (Table 1).

Table 1. Herbage or root dry yield of medicinal plants as intercrops under coconut plantation. In the case of *Coleus forskohlii*, the value is for root dry weight.

Medicinal plants intercropped with coconut	Herbage or root dry weight (Kg ha^{-1})	Crop yield equivalent ratio*
Ocimum tenuiflorum	654	320
Senna angustifolia	733	24,000
Andrographis paniculata	627	1,280
Coleus forskohlii	598	2,000
Solanum nigrum	438	4,800
Withania somnifera	387	1,120
Tribulus terrestris	423	60
Mentha x piperita	357	240
Phyllanthus amarus	333	768

Crop yield equivalent ratio for the cropping model (Coconut + Tulasi+ Colues + *Tribulus terrestris* Cropping model -1) is 282.75, and it provides the par results when coconut grow as sole crop.

Among the three cropping models, namely (i) Coconut + *Ocimum tenuiflorum* + *Coleus forskohlii* + *Tribulus terrestris*, (ii) Coconut + *Senna angustifolia*+ *Solanum nigrum* + Mentha x piperita, and (iii) Coconut + *Andrographis paniculata* + *Withania somnifera* + *Phyllanthus amarus* tested the Coconut + *Ocimum tenuiflorum* + *Coleus forskohlii* + *Tribulus terrestris*, (Cropping model -1) recorded the highest crop yield equivalent ratio (Table 2). Thus, multi-species cropping model with Coconut, *Ocimum tenuiflorum*, *Coleus forskohlii*, and *Tribulus terrestris* as crop components is recommended to the farmers of Telangana.

Table 2. Crop yield equivalent ratio of coconut and medicinal plants based three cropping models in Telangana

Cropping model	Crop yield equivalent ratio
Coconut + *Ocimum tenuiflorum* + Coleus *forskohlii* + *Tribulus terrestris*	282.75
Coconut + *Senna angustifolia*+ *Solanum nigrum* + *Mentha* x *piperita*	54.42
Coconut + *Andrographis paniculata* + *Withania somnifera* + *Phyllanthus amarus*	82.52

Recommendation

In Telangana State, farmers generally grow coconut as sole crop. As recorded from this study, several medicinal plants which have commercial value in the State can be cultivated as intercrop with coconut to enhance the economic value of the plantation. The mixed species cropping model like Coconut + *Ocimum tenuiflorum* + Coleus *forskohlii* + *Tribulus terrestris* may be promoted among farmers.

Coconut plantation in Agricultural College Farm at Aswaropet, Telangana selected for cultivating medicinal plants as intercrop

Medicinal plants planted in coconut plantation of Agricultural College Farm at Aswaropet, Telangana

Coleus *forskohlii*

Andrographis paniculata

Ocimum tenuifolium *Withania somnifera*

Harvested produce of some medicinal plants intercropped in coconut plantation

Training conducted to the farmers on intercropping of medicinal plants in coconut plantations

Project 7

Standardization of organic production technique and processing of black turmeric (*Curcuma caesia* Roxb.)

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Background

Curcuma caesia Roxb, commonly (Black turmeric or Kali Haldi) native to North-East and Central region of India, is cultivated outside its natural habit also for several medicinal uses. The rhizome is bluish-black in colour with pungent smell and bitter taste. It contains essential oil and is rich in starch. It is used for medicinal preparations. Supply of *C. caesia* is far below its demand, and the price has reached even Rs.1200/- kg in the year 2021 and therefore there is a great demand for planting stock (rhizomes). For increasing the crop yield through organic cultivation; as well as good processing technology need to be standardized and the farmers must be trained to adopt the newly developed agro techniques for their economic benefit. The specific objectives of this project were to (a) standardize the rapid multiplication technology using various growing media for quality planting material production of Black turmeric, (b) study the effect of organic manures, bio-stimulants and mulches on growth and yield of Black turmeric, and (c) standardize the processing technology of Black turmeric.

Materials and Methods

Following five experiments, each laid out in a randomized block design with three to five replicates, were carried out in Western Block of Horticultural College and Research Institute, TNAU, Periyakulam under coconut ecosystem.

Experiment 1: Standardization of planting material and growing media for black turmeric

Experiment 2: Standardization of organic manure on yield of Black turmeric

Experiment 3: Standardization of mulching on growth and yield of black turmeric

Experiment 4: Effect of bio-stimulants on growth and yield of black turmeric

Experiment 5: Standardization of processing technique of black turmeric

The results of each experiment were subjected to suitable statistical analysis.

Results

(i) Standardization of planting material and growing media

The effect of various treatments on sprouting percentage, shoot length, root length and vigour index showed significantly high values when grown in the growing media of Cocopeat + Vermicompost + *Pseudomonas* (Table 1). *Thus, amo*ng the various growing media, Cocopeat + Vermicompost + *Pseudomonas fluorescens* combination is a suitable growing media for rapid multiplication of black turmeric through single rhizome bud technology.

Table 1. Effect of growing media on growth parameters of black turmeric rhizome sprouts

Treatment	Sprouting %	Shoot length (cm)	Root length (cm)	Vigour Index
Cocopeat	74.90	12.42	8.98	930.13
Vermicompost	76.65	14.68	7.00	1,125.12
Cocopeat + Vermicompost	78.07	15.50	9.47	1,209.71
Cocopeat + *Pseudomonas fluorescens*	84.56	16.66	10.72	1,408.44
Vermicompost + *Pseudomonas fluorescens*	83.01	16.08	11.16	1,335.05
Cocopeat + Vermicompost + *Pseudomonas fluorescens*	95.99	25.63	12.80	2,459.94
Standard Potting mixture	56.66	9.27	5.72	525.37

ii) Standardization of organic manure on yield

Organic manure treatment (T_3) containing 50% N (25% N as FYM + 25% N as Vermicompost) + 50% K (25% K as Potassium Schoenite + 25% K as Potassium humate) recorded significantly high yield per plant and per plot followed by the organic manure treatment (T_6) containing 50% N (25% N as FYM + 25% N as *Azospirillum*) + 50% K (25% K as Potassium Schoenite + 25% K as Potassium humate) (Table 2).

Table 2. Effect of Organic manures on growth and yield parameters of Black turmeric

Treatment		Fresh rhizome yield (g plant^{-1})	Estimated fresh rhizome yield (t ha^{-1})
T_1	100% N (50% N as FYM + 50% N as Vermicompost) + 100% K (50% K as Potassium Schoenite + 50% K as Potassium humate)	242.67	17.96
T_2	75% N (37.5% N as FYM + 37.5% N as Vermicompost) + 75% K (37.5% K as Potassium Schoenite + 37.5% K as Potassium humate)	254.33	18.82
T_3	50% N (25% N as FYM + 25% N as Vermicompost) + 50% K (25% K as Potassium Schoenite + 25% K as Potassium humate)	297.67	22.03
T_4	100% N (50% N as FYM + 50% N as *Azospirillum*) + 100% K (50% K as Potassium Schoenite + 50% K as Potassium humate)	235.00	17.39
T_5	75% N (37.5% N as FYM + 37.5% N as *Azospirillum*) + 75% K (37.5% K as Potassium Schoenite + 37.5% K as Potassium humate)	229.33	16.97
T_6	50% N (25% N as FYM + 25% N as *Azospirillum*) + 50% K (25% K as Potassium Schoenite + 25% K as Potassium humate)	268.33	19.86
T_7	Control	183.00	13.54

(III) Standardization of mulching on yield

In the mulching trial (Table 3) the rhizome yield varied significantly from 12.73 to 22.03 t ha^{-1}. The plants mulched with dry grass(T_4) recorded the highest fresh rhizome yield per plant (297.67 g) and fresh rhizome yield per hectare (22.03 t).

Table 3. Effect of Mulching on growth and yield parameters of Black turmeric

Treatment	Fresh rhizome yield (g plant^{-1})	Estimated fresh rhizome yield (t ha^{-1})
T1: Silver colour plastic mulch	249.67	18.48
T2: Coir pith as mulch	224.00	16.58
T3: Paddy straw as mulch	262.33	19.41
T4: Dry grass as mulch	297.67	22.03
T5: Control (without mulching)	172.00	12.73

(iv) Effect of bio-stimulants on yield

In the bio-stimulants trial, the rhizome yield varied significantly from 12.7 to 21.8 t ha^{-1} (Table 4). The plant sprayed with Panchagavya @ 3 per cent (T_2) recorded the highest fresh rhizome yield per plant (295.0 g) and estimated fresh rhizome yield per hectare (21.83 t).

Table 4. Effect of Bio-stimulants on yield parameters of Black turmeric

Treatment	Fresh rhizome yield (g plant^{-1})	Estimated fresh rhizome yield (t ha^{-1})
T1: Humic acid 0.2 per cent	247.00	18.28
T2: Panchagavya spray 3 per cent	295.00	21.83
T3: Vermiwash 3 per cent	229.00	16.95
T4: 3% Neem cake Extract	267.00	19.76
T5: Control (water spray)	173.33	12.83

(v) Standardization of processing technique

Experiment 5: Standardization of processing technique of black turmeric

After harvesting of black turmeric, rhizomes were taken for standardizing the processing technique (Table 5). The final weight was recorded after curing and drying. The dry recovery (%) after curing and drying ranged from 17.3 to 42.97% with highest value for treatment T_7 (Dipping in boiling water for 10 minutes and drying). The time taken for drying varied from 147 hrs. to 175 hrs. between the treatments.

Table 5. Effect of different methods of Black turmeric processing. In all the eight treatments, the initial weight of the sample taken for the experiment was 200 g.

Treatment	Dry recovery (%)	Time taken for drying (hrs.)
T_1: Traditional boiling of rhizome for 40 minutes and drying	31.05	170
T_2: Traditional boiling of rhizome for 60 minutes and drying	32.23	175
T_3: Traditional boiling of rhizome for 90 minutes and drying	28.82	170
T_4: Improved boiling for 10 minutes and drying (using TNAU model)	29.74	165
T_5: Improved boiling for 20 minutes and drying (using TNAU model)	30.13	160
T_6: Improved boiling for 30 minutes and drying (using TNAU model)	33.53	160
T_7: Dipping in boiling water for 10 minutes and drying	42.97	155
T_8: Raw rhizome sliced and drying (3 mm thick slices)	17.30	147

Recommendation

Based on the present study, following procedure for cultivation and processing of Black turmeric is recommended

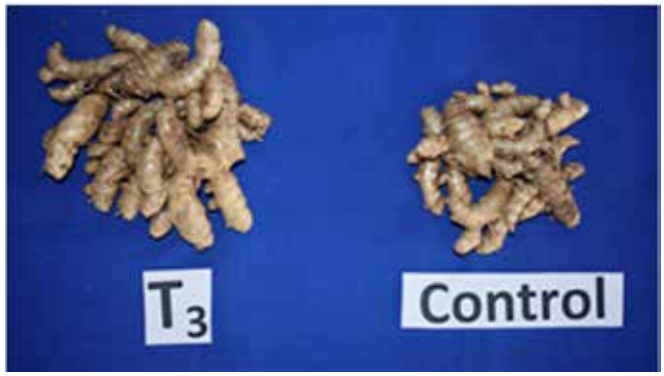
- Grow the single bud rhizome sprouts of Black turmeric in the growing media consisting of Cocopeat + Vermicompost + Pseudomonas fluorescens to obtain quality planting materials.
- Follow the organic production technique involving application of 50% N (25% N as FYM + 25% N as Vermicompost) + 50% K (25% K as Potassium Schoenite + 25% K as Potassium humate) along with spraying of Panchagavya at 3 percent and mulching with dry grass for obtaining better yield of Black turmeric.
- Dip the harvested rhizomes of Black turmeric in boiling water for 10 minutes and dry for 6 to 7 days to record a considerably high dry recovery percentage.

Black turmeric rhizomes

Black turmeric sprouts for transplantation

Experimental plot at Horticultural College and Research Institute, TNAU, Periyakulam

Influence of organic manure on rhizome size at harvest stage



CHAPTER 3

PUBLICATIONS BY THE PROJECT INVESTIGATORS

The seven journal papers, two conference/webinar presentations and one technical bulletin that come out of the seven projects are listed below.

Publications in research journals

1. **Chitra R.** Janaki D. and Jansirani P. 2020. Analysis of bioactive components of acetone rhizome extract of Black turmeric (*Curcuma caesia* Roxb.) through Gas Chromatography Mass Spectrometry (GC-MS). *Current Advances in Agricultural Sciences*, 12: 44-48
2. **Chitra R.** Janaki D. and Jansirani P. 2020. Effect of Different Types of Mulches on Growth and Yield of Black Turmeric (*Curcuma caesia*). *International Journal of Current Microbiology and Applied Science*, 9: 2817-2824.
3. **Chitra R.** Janaki D. and Jansirani P. 2020. Influence of bio-stimulants on growth and rhizome yield of black turmeric (*Curcuma caesia*). *International Journal of Chemical Studies*. 8: 2304-2307.
4. **Chitra R.** Janaki D. and Jansirani P. 2022. Conservation Strategy for Endangered Medicinal Plant – Black turmeric (*Curcuma caesia*). *Indian Forester* ,148: 41-44.
5. Jimtha John, C., Bibishna, A.V., and **Mallikarjuna Swamy G.E.** 2021. Antimycotic effects of a prodigiosin producing Serraatia marcescens rhizobacteria. *Rhizosphere*, 18 :100336.
6. **Kulkarni S.** 2021. Influence of organics on productivity and economics of Ajwain (*Trachyspermum ammi*) cultivation under *Melia dubia* based agroforestry system. International Journal of Phytomedicines and Related Industries. *Medicinal Plants,* 13: 638-643.
7. **Soumya Saraswathi M.** and Subrahmanya Padyana, 2021. Pharmaceutical and Analytical Study on Different Parts of Ashoka [*Saraca asoca* (Roxb.) de Wilde]. *International Journal of Research in Ayurveda Pharmacy,* 12: 27-34.
8. **Soumya Saraswathi M.** and Subrahmanya Padyana, 2021. Physico-Chemical and Phyto chemical Study on Different Parts of Ashoka [*Saraca asoca* (Roxb.) de Wilde]. *World Journal of Pharmaceutical Research* 10: 1009-1018.

9. **Soumya Saraswathi M.** and Subrahmanya Padyana, 2021. Ethno-Medico-Botanical Utility of Different Parts of the Plant Ashoka. *International Ayurvedic Medical Journal*, February-March: 2775-2779.

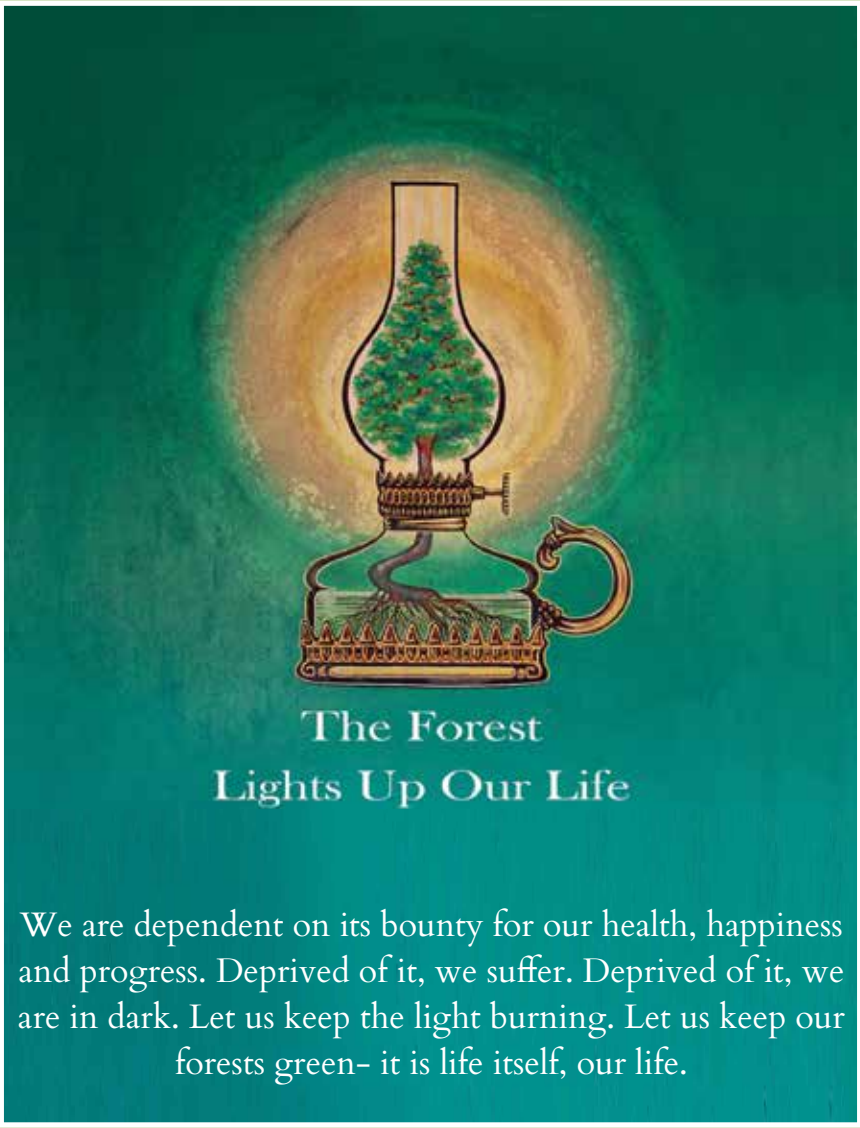
Presentations in conferences and webinars

1. **Chitra R**. 2020. Evaluation of post-harvest value and quality of cured Black turmeric (Curcuma caesia) by different processing method. Presented in the National Webinar on "Spice Improvement, Processing and Marketing", organized by College of Agriculture, KAU, Vellayani held on 7, 8 September, 2020.
2. **Kulkarni S**. 2020. Economic analysis of Ajwain (Trachyspermum ammi (L.). Sprague) cultivation in Melia dubia based agroforestry system under organic production system. Presented as a lead paper in international conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS -2020) held during December 28 - 30, 2020
3. **Kulkarni S**. 2020. Suitability of medicinal plants in Melia dubia based agroforestry in north eastern dry zone of Karnataka. Presented as a poster presentation in international conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS -2020) held during December 28 - 30, 2020.

Technical Bulletin

1. **Kulkarni S**. Importance of medicinal plants and their cultivation aspects (in Kannada).

Intercropping of medicinal plants with fruit trees



We are dependent on its bounty for our health, happiness and progress. Deprived of it, we suffer. Deprived of it, we are in dark. Let us keep the light burning. Let us keep our forests green- it is life itself, our life.

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