CULTIVATION OF SELECTED NWFPs

A Manual

Indian Council of Forestry Research & Education

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
P.O. New Forest, Dehradun - 248 006

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Foreword

Dr. Suresh Gairola, IFS
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ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The Council that came into being in 1986 has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. Since then research in different fields of forestry has been a major focus of ICFRE.

There is an earnest need of publication of its research to the stakeholders in a simple and lucid manner, to improve the visibility and relevance of ICFRE. Therefore it was decided that the information available on the technologies, processes, protocols and practices developed by ICFRE has to be updated and may be published in the form of operational manuals/user manuals. It was also expressed that the manuals should be a comprehensive national level document depicting extent of knowledge in applicable form.

Accordingly, 18 scientists of ICFRE were nominated as National Subject Matter Coordinators (NSMCs) to carry out the task on the specified subject. These NSMCs were assigned the task to select and nominate nodal officers from other Institutes of ICFRE as well as other organizations if necessary, collect and collate the information on the subject from various sources in coordination with the nodal officers of ICFRE institutes.

This manual "Cultivation of Selected NWFPs" is compiled and developed in the form of operational manual having direct field applicability. Information pertaining to cultivation techniques of around 43 important NWFPs covering all the regions of the country has been included. The operational manual has been prepared to meet the requirements of individuals interested in setting up NWFPs nurseries, diversification of traditional agriculture/ horticulture through medicinal plants cultivation, local communities, farmers, field staff of state forest departments, NGO's etc.

All the NWFP species included in this manual have separate chapter focusing on cultivation and related practices. The manual has been prepared in simple language with very less technical words for greater acceptability among different stakeholders.

Further, the manual has got good number of new initiatives to facilitate research through innovation. I hope that the manual will provide useful information to the diverse stakeholders and prove to be helpful literature for planning future programmes in research for development.

Dr. Suresh Gairola

Preface

India has been striving hard for doubling the farm income by 2022. Many innovative ways need to be included in the existing farming practices to achieve this goal. To augment rural income/ farm income, allied sectors also need to play major role in this gigantic task. Around 23.34% of geographical area of the country is under forest on which rural communities are dependent for livelihood and some additional income generation since time-immemorial. Cultivation of Non Wood Forest Products (NWFPs) for diversification of traditional agriculture/ horticulture is the need of the hour and is the best practice against vagaries of climatic change i.e. global warming and shift in rainfall/ snowfall pattern, especially in Himalaya.

The country is endowed with huge amount of NWFP's which include products used as food and food additives (edible nuts, mushrooms, fruits, herbs, spices and condiments, aromatic plants), fibres (used in construction, furniture, clothing or utensils), resins, gums and plant and animal products used for medicinal, cosmetic or cultural purposes. The livelihood benefits of NWFPs have been widely acknowledged, however, it has not been economically evaluated to actual potential. They are attracting great attention in recent years as source of additional income to local communities. Sustainable use of these NWFPs in the country presents a challenge, requiring careful planning, vigilant maintenance and judicious exploitation. Many NWFP species are becoming increasingly vulnerable due to rapid developmental activities and excessive removal since last few decades. It is high time to meet the ever increasing demand of NWFPs by encouraging their cultivation outside forest areas particularly in farmer's field.

Among the various NWFPs, medicinal plants have recently attracted attention of the world community. These plants are globally valuable sources of herbal products and they are disappearing at alarming pace. It is estimated that 80% of people in developing countries are totally dependent on herbal drugs for their primary healthcare and over 25 % of prescribed medicines in developed countries are derived from wild plant species. More than 85% of herbal medicines used in traditional health care systems are derived from medicinal plants and ensure the livelihoods of millions of people, especially in the rural India. To meet the growing demand for these plants, it becomes important to popularize their commercial cultivation and by adopting various measures for their sustainable harvest from the wild. Emphasis on cultivation of the wild forms, rather than collecting from the wild would also ensure botanical identity, quality and continuity in supply. Also, in order to meet the escalating demand of these resources, cultivation of these plant species in farmers field is imperative. Apart from meeting the present demand, cultivation will result in conservation of the wild genetic diversity of Non-Wood Forest Products including medicinal plants.

Cultivation practices of many NWFP species have been developed in the past by ICFRE institutes and other organizations working in this field. The information available has been compiled and developed in the form of

operational manual having direct field applicability. In this Operational Manual, information pertaining to cultivation techniques of 43 important NWFPs covering all the regions of the country has been included. It provides a brief botanical description of each species, its distribution, economic importance, seed characteristics, methods of seed collection, treatments to enhance seed germination, nursery techniques, cultivation or field planting, harvesting, yield etc. The operational manual has been prepared to meet the requirements of individuals interested in setting up NWFPs nurseries, diversification of traditional agriculture/ horticulture through medicinal plants cultivation, local communities, farmers, field staff of state forest departments, NGO's etc.

All the nine ICFRE institutes and University of Horticulture and Forestry, Nauni, Solan (H.P.) have been actively involved in preparation of this operational manual. The nodal officers collected and compiled the information for this manual from their respective institutes/ organizations. Dr Joginder Singh, CTO and Sh. Kuldesh Kumar, STA, HFRI, Shimla immensely helped in compilation of this manual. All the NWFP species included in this manual have separate chapter focusing on cultivation and related practices. The manual has been prepared in simple language with very less technical words for greater acceptability among different stakeholders.

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Cultivation of Selected NWFPs

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Contents

INTENT AND PURPOSE OF MANUAL

This manual is a step towards providing basic information about cultivation of NWFP's, especially medicinal plants. It has been attempted to bring together the available information on the cultivation techniques of important NWFP species. The manual has developed in such a way so as to make the information available in a user friendly manner. Species included in the manual are of the following category:

- NWFP species, which are in high trade and demand by the herbal industry.
- NWFP species, which are commercially important and can augment the income of the growing community.
- Medicinal plant species, which witness a high degree of collection from the wild and hence, require possible remedial measures to sustain the population.
- NWFP species which are recommended by the local communities as they are found in the local trade.
- Species which are already in cultivation to a certain extent.
- NWFP species, which are red listed, hence require possible remedial measures to replenish the stock.

Objectives of Manual

Preparation of the manual focuses on the following objectives:

- To make the stakeholders understand the significance of raising nurseries of commercially important NWFP species including medicinal plants.
- To orient the stakeholders towards the techniques for raising and managing NWFP species including their nurseries.
- To familiarize the stakeholders with the propagation/cultivation methods of commercially important NWFP species including medicinal plants.
- To provide an overview of the cultivation status of commercially important NWFPs including medicinal plants.

HOW TO USE THIS MANUAL

The manual is user friendly. It can readily serve as a training tool. The manual has to be referred and used by stakeholders as a field guide for training and orientation of the local communities about the propagation and cultivation of NWFPs including medicinal plants. Details of the cultivation techniques of selected NWFPs have been included to guide even the beginners in this field. Manual explains the methods and shows the techniques of propagating selected NWFPs. All the prescriptions and procedure of the individual species as detailed in the manual need to be followed carefully for the cultivation success.

INTRODUCTION

Non Wood Forest Products (NWFPs) is a term used generally to forest products other than wood. NWFPs may be gathered from the wild, or produced in forest plantations, agro-forestry schemes and from trees outside forests. The other synonymous terms used for NWFPs are forest by-products, minor forest products, non-wood goods and benefits, non-wood goods and services, other forest products, secondary forest products, special forest products, etc., by different groups and countries. NWFPs include products used as food and food additives (edible nuts, mushrooms, fruits, herbs, spices and condiments, aromatic plants, game), fibres (used in construction, furniture, clothing or utensils), resins, gums and plant and animal products used for medicinal, cosmetic or cultural purposes. The use of NWFPs is as old as human existence. Several million households worldwide depend heavily on NWFPs for subsistence and for income. About 80 per cent of the population of the developing world use NWFPs for health and nutritional needs. At local level, NWFPs also provide raw materials for small-scale and cottage industrial processing. Some NWFPs are also important export commodities.

At present, at least 150 NWFPs are significant in terms of international trade. These mainly include honey, gum arabic, rattan, bamboo, cork, nuts, mushrooms, resins, essential oils and plant and animal parts for pharmaceutical products. NWFPs have also attracted considerable global interest in recent years due to the increasing recognition of their contribution to environmental objectives, including the conservation of biological diversity. Work on NWFPs assessment is an important activity in the FAO Forestry Department, involving expertise from various technical units, in particular the Forest Resources Division and its flagship programme for the Global Forest Resources Assessment (FRA) and the Forest Products Division (through its Non-Wood Forest Products Programme). With the sprawling global market there has been a spurt of trade in NWFPs including medicinal and aromatic plants. The international market for medicinal plant based products is estimated to be US$ 60 billion and is growing at the rate of 7 percent per annum. The unethical growth of pharmaceutical industry is taking its toll. For immediate financial gains, the sustainable harvesting practices have been over looked. Plants and their parts are being exploited without taking into consideration their further regeneration. With the increasing demand and the low and unpredictable prices, the markets encourage unsustainable harvesting practices.

Over the past two decades an increasing number of governmental and non-governmental organizations (NGOs) and institutions, as well as the private sector have become involved with the promotion and utilization of NWFPs. Plenty of new information has been collected on the socio-economic importance and potential of NWFPs utilization and their effect on the environment. A better understanding of NWFPs' overall socio-economic contributions to the subsistence and income of local communities and to national economies facilitates better programme response. NWFPs play an important role in food security, nutrition and community health. Their benefits are relatively more important for poorer households, women and disadvantaged groups and this has important consequences for planning NWFPs activities. For harnessing the full benefit of NWFPs, it is essential to involve people's participation in the development process and the equitable distribution of benefits among all the members.

Approaches for cultivation, sustainable harvesting and protection against existing threats should be developed for the conservation of medicinal plants and other Non-wood Forest Products and for livelihood enhancement of local communities. In order to meet the escalating demand of NWFPs, cultivation of these plant species need to be encouraged. Besides, meeting the present demand, cultivation will conserve the wild genetic diversity of those species. The frontline field functionaries of state forest departments, NGO's involved in this sector and farmers are major target groups of this operational manual on Cultivation of NWFPs'. Target groups presently do not have updated any field applicable information on 'Cultivation of NWFPs'. Taking this into consideration, the present operational manual has been designed and developed. This manual will be of great use for various stakeholders.

Challenges for Medicinal Plants and other NWFPs Development

- Most of the medicinal plants and other NWFPs are often associated with traditional uses that are not widely known
- Transactions related to NWFPs largely take place in households and small-scale units, mostly outside the established marketing systems/channels, thus forming part of unorganized and informal sector.
- They are often seasonal and for these reasons, they are often overlooked by planners and their local uses go unrecorded.
- Timber-orientation of forestry profession and the bias of planners in favour of large-scale enterprises often leave NWFPs including medicinal plants at disadvantage.
- Lack of knowledge about the potential of NWFPs to support sustainable and remunerative enterprises is a major constraint.
- Unorganized market for NWFPs is also big bottleneck in development of this resource.

Management of Medicinal Plants and other NWFPs

Management of NWFPs resources is critical to the future of remaining natural forests. A first step is better assessment of the resource and sustainable harvest level of different forest produces. NWFPs can play a role in sustainable forestry through multiple use management for wood and non-wood products. Sustainable NWFPs harvesting can also take place in forest reserves and buffer areas. Domestication of species (e.g. through agro-forestry) is one alternative for minimizing the impact of increasing NWFPs especially medicinal plants demand. Research is needed to assess and learn from local knowledge and to improve management systems, harvesting and post-harvest technologies for NWFPs especially for medicinal plants in high demand.

Marketing and Trade in Medicinal Plants and Other NWFPs

Information on NWFPs including medicinal plant resources, harvests, processing and trade is scarce and dispersed. Many of the medicinal plants and other NWFPs contribute significantly to augment the rural income of the local communities and many NWFPs products contribute to the national economy. The main example of contribution to national economy in India is Tendu leaves collection. However, there is not much organized market for medicinal plants. Actual status of the trade in medicinal plants is not known and this aspect deserves utmost attention. With increasing pressure on forest resources, well-informed NWFPs marketing strategies could be crucial for maintaining the resource. Producers need better information on the nature and volume of existing medicinal plants and other NWFPs trade, markets and product standards. With the increase in green consumerism, knowledge of international market concerns and quality standards of products is needed. More reliable, rational and transparent market transactions throughout the production/market chain are needed for producers to receive a more equitable share of the product value. A greater appreciation of marketing and market information is needed by producers, medicinal plants and other NWFPs - programme planners and NGOs.The role of middlemen and their profit need to be marginalized. Minimum Support Price (MSP) for NWFPs under commercial cultivation need to be fixed along with procurement by corporations or cooperatives under state governments.

NWFPs STATUS IN THE COUNTRY

India is a country of vast diversity lying at the juncture of the big-geographic provinces of Afro-Eurasia and the Orient. Because of the country's diversified climatic and physiographic factors, India is blessed with all types of vegetation ranging from tropical, subtropical, temperate to sub alpine and alpine. Due to its wide-ranging environmental regimes and diverse biological communities, the country is one of the world's top 12 'mega diversity' nations. Non Wood Forest Products (NWFPs) are derived from over 3,000 species. These products are classified as leaves, bamboos, gums, resins and oleoresins, oil seeds, essential oils, fibres and flosses, grasses and fodder trees, tans and dyes, medicinal plants and spices, animal products, edible products etc. It is estimated that 60 percent of all NWFPs are consumed locally and are not accounted in the calculation of revenues. There are many products which are not extracted fully or which go to waste because of insufficient knowledge of their use or because they occur in inaccessible locations. The basic objectives of the National Forest Policy of 1988 include conserving the national flora and fauna, meeting the needs of rural and tribal populations and encouraging efficient utilization of all forest produce. The policy states that NWFPs which provide sustenance to local communities should be protected and improved. It provides for research into the conservation and management of forest resources and for increasing productivity through the application of modern scientific and technological methods.

Traditionally, the collection of NWFPs have been of low intensity and generally sustainable. However, as the economic potential of NWFPs has become apparent, the intensity of collection has increased and more significant infrastructures for trade and processing have developed. This has raised concerns for the sustainability of the resources and the distribution of the benefits derived from them and hence, many state governments have taken over the control of a number of NWFPs. The state regulations bringing certain NWFPs under monopoly trade with the objective of preventing unscrupulous intermediaries and their agents from exploiting NWFPs collectors, to ensure fair wages to collectors, to enhance revenue for the state, to ensure quality and to maximize the collection of produce. In most cases, trading is controlled through state-owned institutions such as state forest development corporations, federations, cooperatives and tribal societies.

Among different NWFPs species, medicinal plants are attracting greater attention. Medicinal plants are globally valuable sources of herbal products and they are disappearing fast. These plants are source of new drugs. With the increasing demand for herbal drugs, natural health products and secondary metabolites of medicinal plants, the use of medicinal plants is growing rapidly throughout the world (Chen *et al.*, 2016). Unplanned development and overexploitation of medicinal plants from un-managed natural resources has not only resulted in shortage of various herbs but extinction of several species in nature. According to the International Union for Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF), there are between 50,000 to 80,000 flowering plant species used for medicinal purposes worldwide. Among these, about 15,000 species are threatened with extinction from overharvesting and habitat destruction (Bentley, 2010) and 20 % of their wild resources have already been nearly exhausted with the increasing human population and plant consumption (Ross, 2005).

More than 85% of herbal medicines used in traditional health care systems are derived from medicinal plants (Prasad and Bhattacharya, 2003) and ensure the livelihoods of millions of people, especially in the Indian Himalayan region (Phondani

et al., 2011). The wide altitudinal variation, different habitat types and varying microclimatic conditions in the Himalayan region form an ideal environment for the growth and development of MAPs (Kala, 2005). In order to meet the growing demand for these plants, it becomes important to conserve these plant species either by way of domestication and cultivation or by other *ex-situ* and *in-situ* conservation measures for their sustainable use. Commercial cultivation may have to be initiated under well defined conditions showing micro-climates similar to the niche requirements of the various species. In many countries medicinal plants are collected from the wild vegetation. But in response to the combined impacts of dwindling supplies due to overexploitation of the natural resources and increasing demands due to population growth and growing global markets, now medicinal plants are also increasingly introduced into farming systems. Such cultivation often takes place in multiple cropping systems including agro-forestry systems. For instance, medicinal plants may be planted in the lower strata of multi-strata systems such as home-gardens (Rao *et al.*, 2004).

Keeping in the view the indiscriminate extraction of medicinal plants from the wild and other concerns, approaches for cultivation, sustainable harvesting and protection against existing threats should be developed for the conservation of medicinal plants and livelihood enhancement of local communities. This has become a priority agenda as part of meeting the international obligations under the biodiversity convention (Rao *et al.*, 2003). As such, medicinal plants cultivation is emerging as a sector of self-employment generation and an option for livelihood enhancement versus the cultivation of traditional food crops (Phondani *et al.*, 2011). Cultivation of many medicinal plants on private land is required both to conserve the species and to ensure the supply of quality raw material to the industry. This is particularly important when demand for a variety of MAP species is increasing with the expanding growth of human population (Maikhuri *et al.*, 2003). Information on the propagation of medicinal plants is available for less than 10% and agro-technology is available only for 1% of the total known plants globally. This trend shows that developing agro-technology should be one of the thrust areas for research. Furthermore, in order to meet the escalating demand of NWFPs including medicinal plants, farming of these plant species is imperative. Apart from meeting the present demand, farming may conserve the wild genetic diversity of medicinal plants. Farming permits the production of uniform material, from which standardized products can be consistently obtained. Cultivation also permits better species identification, improved quality control and increased prospects for genetic improvements. Selection of planting material for large-scale farming is also an important task. The planting material therefore should be of good quality, rich in active ingredients, pest and disease-resistant and environmental tolerant (Kala *et al.*, 2006).

1

SPECIFIC CULTIVATION PRACTICES OF NWFPs OF REGIONAL IMPORTANCE:

SOME IMPORTANT SPECIES

A FOREST RESEARCH INSTITUTE (FRI) DEHRADUN

1 *Aloe barbadensis* (Miller) Syn. *Aloe vera*

• English Name/ Trade Name :	Aloe
• Common/Local Name :	Hindi: Ghikanvar, Ghikuamr, Gar pattha and Rambans Sanskrit: Ghritakumari, Ghritkumari, Ghrtakumari and Grhakumari
• Family :	Liliaceae
• Part Used (s):	Leaves

Aloe vera Plant

INTRODUCTION

Aloe barbadensis (Aloe vera) is a popular medicinal plant. Aloe belongs to the old world and is indigenous to Eastern and Southern Africa, the Canary Island and Spain. The species spread to the Mediterranean basin and reached the West Indies, India China and other countries in the 16th century; and certain species are now cultivated for commercial purposes, especially in some of the West Indian islands of the north coast of South America. It is also cultivated throughout India. Of late, because of high price of allopathic medicines with its known side effects, medicinal plants and Ayurvedic medicines are becoming popular. World trade worth about 80 million US$ exists now and this is likely to increase by 35-40 percent within 5 years. USA dominates the market (65%) while India and China have a share of 10 percent each which could be enhanced by its commercial cultivation.

GEOGRAPHICAL DISTRIBUTION

Aloe species are indigenous to Africa, but now have wide distribution in the tropical and subtropical regions of the world. Species is grown in warm climates, both as wild and cultivated plants, in southern, eastern and northern African countries, in countries bordering the Mediterranean and Red Seas, islands of the Indian Ocean, in India and in China.

Aloe plants may be found in temperate zones as cultivated crops or ornamentals, but must be protected from freezing water.

BOTANICAL DESCRIPTION

It is a perennial plant; growing to the height of 45 - 70 cm. Aloe does not have a true stem but produces bloom-stalks. Its fleshy leaves are about 60 cm long, 10 cm broad and 1.5 to 2.0 cm thick and have spiny margin with thin walled tubular cells. The two sides of the leaves have thorny structure with a thorny tip. The inner substance of the leaves is jelly like. Normally it flowers during October to January and the long inflorescence has large number of small pink flowers all around arranged in auxiliary spikes. Most of the species are male, sterile, with scarcely any fertile pollen. Fruits develop during February to April, which do not produce many viable seeds.

USES

A. vera plant has been known and used for centuries for its health, beauty, medicinal and skin care properties. Leaves are used for stomach disorder, cosmetics and piles. The juice of leaves and flowers are used as medicine. Intake of juice of leave, improves hunger and indigestion. Juice when mixed with sugar cures cough and cold. Besides these, it also cures nervous weakness, asthma, jaundice, etc. The leaf flesh (about 7-8g) mixed with honey, taken in morning and evening cures constipation. It contains various organic compounds, which cures diseases. Of these, the main compound is aloine. Besides, it contains 12 types of vitamin, 20 kinds of amino acids, 20 kinds of minerals, 200 different types of polysaccharides and various kinds of glycol-protein, which are used for human health. Aloine A and Aloine B, are principle constituents of the ayurvedic medicine.

PROPAGATION

A. vera is found as wild herb along the coast of South India. It is under cultivation in fairly large areas in many parts of India, viz. Chhatisgarh, Maharashtra, Madhya Pradesh, Gujarat etc. and also grown as ornamental plant. It is a sure cash spinner and progressive farmers can go for plantation of the species. Cultivation of this herb in large scale can make India move towards the leadership in global herbal market and this will fetch India good foreign reserves as well as domestic economic prosperity. Indiscriminate over exploitation coupled with insufficient attempts for replenishment of wild stock have contributed to its threatened status requiring scientific efforts for conservation and commercial cultivation. Commercial cultivation of Aloe has been started in many parts of India.

Natural Regeneration

Regeneration through seeds is less due to low seed viability and germination rate. In nature, species regenerate through rhizome. However, due to over exploitation of species from its natural habitat, natural regeneration of species is less.

Artificial Propagation

It is normally not propagated through seeds. Vegetative propagation is easy and convenient.

Nursery Raising

Aloe is hardy plant and grows on a variety of soil. It does well in the sandy coastal to loamy soils of the plains with pH up to 8.5. Waterlogged condition and problematic soil do not suit it cultivation. Aloe is usually cultivated between March and June. The plant has a wide adaptability. It grows well in warm, humid or dry climate.

Vegetative Propagation

The plants are generally propagated through root suckers. Plant raised in polythene bags during the previous year will be best for planting during April and May.


Seedlings raised through vegetative propagation in F.R.I nursery beds

Transplantation and Planting Density

About 2-3 ploughings are done to make the soil weed free and friable. After that land leveling is done. Along the slope, 15-20 feet apart drainage are made. Before land preparation, about 8-10 tonnes FYM/ ha is applied. Before the last ploughing, 35 kg N, 70 kg P_2O_5 and 70 kg K_2O/ha are added. In September-October about 35-40 kg N as top-dressing may be applied. If the soil is rich in organic matter, N dose can be reduced.

Plantation is done in April–May. About 15-18 cm tall root suckers are planted at the spacing of 60 x 45cm in such a way that two-third portion of the root-sucker should be under ground. Soon after planting, the land should be irrigated. Generally, 4-5 irrigation per year is sufficient. However, water should not be allowed to stagnate near the plant. Leaf mulching is useful to suppress weeds and save the labour.

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

Species is slightly tolerant to drought, but very sensitive to water logging. Therefore, proper drainage is more important than irrigation. As per need, light irrigation during drought is enough. In India, number of irrigations in this crop may be required between 4 and 10 depending on the area and climate.

Weeding

Generally, two weedings are enough in a year. In the beginning, when plants are small weeding is essential. In fully-grown crop, neither the weeds could become dominant on the crop nor is it easy to perform weeding operation in the field by conventional implements. At this stage, entire land is covered with crop. The leaves are full of gel and juice. If they are disturbed in the weeding operation, they might break, causing damage to the crop. After 40 days, weeding and earthing up are done. Earthing up is also practiced after top dressing of fertilizer.

Diseases and its Management

A. vera is infested by various insets and pests. Special care is needed for their control in medicinal plants like *Aloe-vera* where the juice of the leaves is directly taken as medicine. Use of organic source of plant protection materials like raw garlic juice, neem oil (10,000 ppm) 2-3 ml /litres, tobacco extractant 20 ml / litres gave reasonably good result. For controlling termites problem, 350-400 kg Neem Cake / ha may be applied.

HARVESTING OF CROP

Plucking of old leaves can be started eight months after planting and older leaves must be harvested first. The leaves can be carefully removed manually at the base in a rotating style, 2 or 3 leaves at time. An aloe plantation gives a commercial

yield from the second year up to the age of five years. Sharp knife is used for harvesting. Care has to be taken to reduce the loss of juice from the cut portion. If harvesting is done once in a year, October-November are the best period for harvesting. Second year gives maximum yield and upto 4-5 years, plant can be harvested. To harvest leaves, start by selecting mature leaves from the outermost section of the plant. Cut them from as close to the base as possible without disturbing roots. Too much old leaves do not give good quality gel. New and immature small leaves also contain least quantity of gel.

POST HARVEST MANAGEMENT

After harvesting, leaves are thoroughly washed with fresh water with mechanical washer, shade dried first and then in sun before storage. Flowers are collected in December – January and preserved after proper drying. Yearly 110-115 quintals raw leaves and 350 – 400 kg flowers / ha are obtained.

Drying and Storage

For the purpose of gel or juice the plant has to be used immediately after harvesting. But in many 'Ayurvedic' preparations whole plant is used in dried form. For this, it may be stored after drying the whole plants. Since its leaves contain pulp and more than 90% water, they take long time to dry. For fast drying they may be dried in oven fitted with fan. While drying the temperature of oven should not exceed 60^0C and preferably it should be between 50 and 60^0C. The plants should not be kept in the oven immediately after harvest. Before keeping in the oven they should be dried in open air in the sun light for some time to reduce the moisture level of the leaves. Excess moisture at high temperature in the oven may decompose some important plant constituents. The dried plant material may be kept in jute bags for one year.

YIELD

The yield of dried rhizomes and roots varies from 110 to 115 quintals / ha.

ECONOMICS OF THE SPECIES

S. No	Expenses and Income	Rs./ha
1	First year expenditure	2,25,000.00
2.	2nd year cost	75,000.00
3.	3rd Year cost	75,000.00
4.	Total cost	3,75,000.00
5.	Estimated income in 3 years (Price Rs.15/Kg)	25,59,000.00
6.	Profit at the end of 3 years (estimated)	21,84,300.00
7.	Profit / year / ha (average)	7,19,766.00

Maitra Sagar, Annadata, January (2010).

Note: In the business of herbs, there is still a situation of uncertainty, so in this economics the change/shuffle is possible according to the market prices nowadays. Market price of this species vary from Rs. 1/kg to Rs. 15/kg and accordingly profit may reduce drastically.

2 *Crepidium acuminatum* (D.Don) Szlach. Syn. *Malaxis acuminata* D. Don and *Microstylis wallichii* Lindl.

• English Name/ Trade Name :	Jeevak
• Common/Local Name :	Jeevak
• Family :	Orchidaceae
• Part Used (s) :	Pseudo-bulbs, Tubers

Jeevak

INTRODUCTION

Jeevak is a highly exploited medicinal terrestrial orchid. The orchid is a critically endangered species because of its extensive use in Ayurvedic preparations like Ashtaverga, Jivinyaverga, Maduraverga and also in Chyvanprash as a health tonic, blood purifier, aphrodisiac and also as an antioxidant. In Uttarakhand, its collection from the wild has been banned because of its dwindling population. However illegal exploitation of the orchid continues and the resource may vanish unless concrete steps are taken-up immediately. The rapid socio-economic changes in recent years and unscientific collection of the plant without focused conservation lead to the depletion of the plant density in natural habitat of the Himalayan region. The medicinal orchid is already highly endangered in its natural habitat due to increasing demand for herbal drug. No scientific and sustainable harvesting procedures are available so far. Therefore, Forest Research Institute, Dehradun (UK) developed techniques for its conservation and replenishment in natural habitat.

GEOGRAPHICAL DISTRIBUTION

The species is found in temperate to sub-alpine ranges of the Himalayas, between 1800 m and 2300 m altitude. Its distribution is scarce and restricted. It is a shade loving species and needs rich humus and soil moisture. It is distributed in temperate to sub-alpine areas of the Himalayan region. Uttarakhand is the richest hub of the orchid species having total 237 species of orchids have been recorded from the state of Uttarakhand, of which 127 are terrestrial, 99 epiphytic and 11 saprophytic. *Jeevak* shows the highest density in the Banj-oak, mixed oak and Oak- pine forests. This species

grows in colonies and one colony may contain 5-25 individuals. The species forms colonies in shady places, moist ground and in the area that are wet and mossy.

BOTANICAL DESCRIPTION

Jeevak is an erect, tuberous, small, terrestrial orchid, having 20–25 cm height. The stem tends to be pseudo-bulbous at the base. New plants arise from the rootstock and the mother plant decays as the daughter plant grow. Leaves are simple, three or five in number and sheathing at the base. Flower deep pink in bunches, terminal dense to lax racemes, bracts deflexed, bloom in mid-May and the plant remains in full bloom until October. Fruiting is completed in October–November, after which it enters into dormant stage. Fruit is a capsule, 6-8 mm long, broadly ovoid-oblong, ribbed and of light yellow colour.

USES

Jeevak is important for its medicinal uses in traditional system of medicine since Vedic period. *Jeevak* plant is rejuvenating tonic, styptic aphrodisiac and antioxidant. It has a cooling action and cures bleeding diathesis, fever and burning sensation. It is an important ingredient of *Ashtaverga*, under *Jivaniya Verga* of *Charaka Samhita*, which literally means 'life-giver. The pseudo-bulbs form an ingredient of *Ashtavarga* and are used in the preparation of *Chyawanprash*. It is considered as nutritive tonic, enhance sperm formulation and as a cure for tuberculosis. Paste of pseudo bulb can be applied externally in case of insect bites.

PROPAGATION

Demand for a wide variety of wild species is increasing with growth in human needs, numbers and commercial trade. With the increased realization that some wild species are being over-exploited, a number of agencies are recommending that wild species be brought into cultivation systems. No report on its commercial cultivation is available in the market for the pharmaceutical industries and medical practitioners. Therefore, its collection is from forest areas alone. Samples collected from the market contain pseudo-bulbs which are too small to be harvested or used. Collectors take out the whole plant mass and do not leave even the small bulbs for future growth thus endangering its survival in the wild. The Forest Research Institute, Dehradun developed *ex-situ* and *in-situ* cultivation of the species in natural area as well in nurseries.

Natural Regeneration

In nature, species regenerate through seeds and pseudo-bulbs. However, due to over exploitation of species from its natural habitat, natural regeneration of species is less. Seeds are very minute, difficult to separate them and germination percentage is also very low.

Artificial Propagation

Species is propagated through seeds and vegetative propagation.

Nursery Raising

It grows in loose sandy loam soil, rich in humus, mainly on upper stratum of organic layer, in the wet localities. The

requirement of mean annual rainfall ranges between 1000 mm and 1500 mm and the optimal mean annual temperature range is 10–15 °C. Mycorrhizal association is necessary for increasing nutrient uptake efficiency in this orchid is recommended. Application of FYM and leaf mould @ 40–50 tonnes per hectare is optimum for the crop growth. The organic manure is applied in two doses. Mature bulbs may be collected from the wild sources in the rainy season. The crop is raised by planting whole, half or segmented pseudo-bulbs directly in main field in the first fortnight of May.

Propagation through Seeds

Orchids are characterized by very small seeds that are not fit for propagation. Studies conducted on this species suggest that seeds show poor germination and produce seedlings of low vigour. Also, the fruiting pods are very small and most of the seeds are dispersed before collection. Seed viability studies are also not available (Fig: 1-3)

Fig 1: Mature Pods of Jeevak

Fig 2: Pod of Jeevak

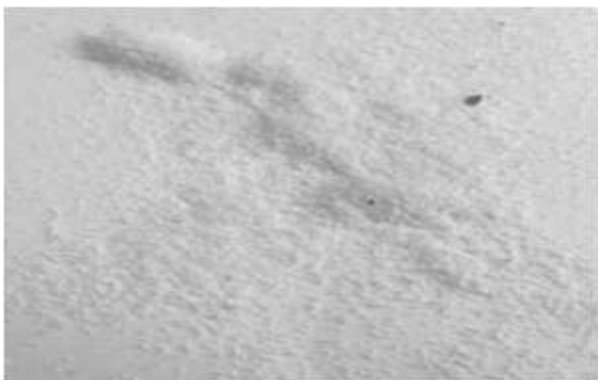
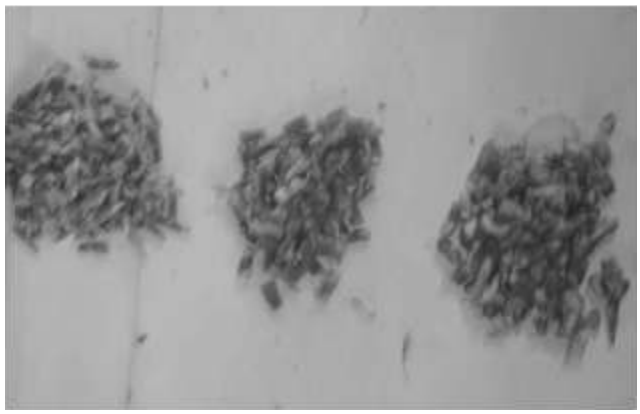


Fig 3: Seeds of Jeevak

Vegetative Propagation

Only vegetative parts, such as pseudo-bulbs, daughter plants, nodal segments of rhizomes or tubers, are feasible as propagation materials. Each pseudo-bulb has four to five nodal segments. These pseudo-bulbs are collected in the first half of November. Mature bulbs may be collected from the wild sources in the rainy season. The crop is raised by planting whole, half or segmented pseudo-bulbs directly in main field in the first fortnight of May. The soil is treated with fungicide or solarized to check the fungal attack. About 250 000 nodal segments or125 000 bulbs are required for planting as a sole crop in one hectare of land at a spacing of 20 cm × 20 cm. Experiments carried out on transplanting of pseudo-bulbs cuttings in natural habitat of species showed better performance in tip portion and whole bulbs.

Tip Middle Basal Whole



Tip Middle Basal

Transplantation and Planting Density

For field plantings, the initial land preparation is done in November or December. The field is left fallow for the entire winter. It needs large quantity of organic manure and layering of leaf litter (40–50 tonnes/ hectare), which are applied in two doses. The land is again ploughed in next May, followed by mixing of half the amount of FYM and leaf litter in the soil in a pulverized form. Remaining half of the organic manure is added to the field after planting. Raised beds are prepared to provide good drainage. Bulbs are planted in the field in the first fortnight of May, before they sprout. Under the optimum favorable conditions, a pure crop of *Jeevak* with a spacing of 20 cm × 20 cm requires about 125 000 bulbs (250 000 nodal segments) per hectare of land. Orchid can be grown as a sole crop as well as an intercrop with plants like colocasia, ginger and turmeric.

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

This species is planted just before the onset of the rain, so irrigation is needed immediately. However, if rains do not commence within a week of planting, repeated irrigation becomes necessary to save the sprouting bulbs. Frequent watering is required in the early stages of the cropping. Thereafter, sprinkler irrigation may be done twice a week.

Weeding

Frequent weeding is required in the rainy season. Mulching of the beds with leaf litter ensures control of weed growth, checks soil erosion and helps to conserve moisture during the dry period.

Diseases and its Management

Attack of white grub, June-beetle, a sub-terranean pest, is occasionally noticed on the bulbs. Application of phorate @10 g/liter as a basal treatment at the time of planting can check the white grub attack. Manual picking or solarization of soil also helps in countering the grub. No fungal attack has been reported in the field. Moist bulbs are susceptible to attack of rot fungus during storage. Beds under open conditions show leaves tinged yellow, which is not the case in beds in shade.

HARVESTING OF CROP

The crop matures in five months and the tubers are ready for harvest when pseudo-bulbs are of marketable size (length more than 5 cm and diameter more than 1 cm) when dormancy sets in during the last week of October or first week of November were harvested. The yield of the bulbs after 1 or 2 years could be 3 to 4 folds and therefore, suggested to take up sustainable management.

Bulbs are dug carefully after watering. The injured bulbs cannot be stored as these are prone to decay. Biochemical studies of pseudo-bulbs have shown major constituents as carbohydrates (23%–28%), proteins (30–42 mg/g), total sugars (29–32 mg/g)and phenols (1.2–2.1 mg/g). Collections from wild sources are generally rich in these constituents than the cultivated produce. However, phenolic content is marginally higher in the cultivated crop.

POST HARVEST MANAGEMENT

After harvesting the crop, fresh pseudo-bulbs should be immediately washed thoroughly with running water so that all the foreign material is removed.

Grading of the Pseudo bulbs

Drying and Storage

The produce is cleaned, dried in shade and stored in cool dry place for marketing. Storage of harvested tubers is done by burying them in sand/soil. Pseudo-bulbs can also be stored in pots or brick chambers filled with sand or inside the pits made on the sloping walls of terraces. Storage in sand and inside sloping pits gives 100% protection for future plantation, but there are chances of damage due to rodent attack and accumulation of water inside the pits.

YIELD

Average yield of dried tubers varies from 600 kg to 750 kg per hectare. An annual expenditure of nearly Rs.1,10,000 is incurred on cultivating the crop on 1 hectare of land.

3 *Ocimum sanctum* Linn.

• English Name/ Trade Name :	Sacred Basil, Holy Basil
• Common/Local Name :	Hindi: Tulsi Sanskrit: Ajaka, Manjari
• Family :	Laminaceae
• Part Used (s) :	Leaves

O. sanctum in Nursery

INTRODUCTION

The aromatic plants belonging to genus *Ocimum* is popularly known as Basil. The word Basil is derived from Greek word "Basilica" means royal plant. It is an aromatic herb and is thought to have originated in north central India and now grows throughout the eastern world tropics. Within Ayurveda, tulsi is known as "The Incomparable One," "Mother Medicine of Nature" and "The Queen of Herbs," and is revered as an "elixir of life" because of its medicinal properties and spiritual importance. Within India, tulsi has been adopted into spiritual rituals and lifestyle practices that provide a vast array of health benefits that are just beginning to be confirmed by modern science. This emerging science on tulsi, which reinforces ancient Ayurvedic wisdom, suggests that tulsi is a tonic for the body, mind and spirit that offers solutions to many modern day health problems.

GEOGRAPHICAL DISTRIBUTION

The geographical distribution shows three main centres of *Ocimum* diversity viz. tropical and subtropical regions of Africa; tropical Asia and tropical parts of South America. The maximum numbers of species are found in the tropical rain forests of Africa; however, few species of Basil are native to India. In India, about nine species of *Ocimum* have been reported including three exotic species namely *O. americanum, O. minimum and O. africanum*. The genus is well represented in the warmer parts of both the hemispheres from sea level to1800 m. *O. sanctum* being considered as sacred by Hindus is cultivated in almost every part in India and found in the most of households.

BOTANICAL DESCRIPTION

Tulsi is an erect, much branched, fragrant and having hair all over and branch is usually purplish. It attains the height of about 60-90 cm. It has oval shaped leaves which are up to 5 cm long. The leaves are 2- 4 cm in length and 1.6-3.2 cm wide

elliptic, oblong obtuse, pubescent on both side and minutely gland-dotted. Tulsi with the green leaves is called the Shri Tulsi and one with the reddish leaves is called the Krishna Tulsi. Leaves of Tulsi contain essential oil. Its seeds are flat and yellow to reddish in colour. The Tulsi flowers are small having purple to reddish color, present in small compact clusters on cylindrical spikes. Stalk less heart - shaped bracts are there at the base of each flower cluster. Sepal cup is not hairy within. Flowers are rarely longer than 5 mm, calyx tube bearded outside near base. Flower tube is hairy. Flowers are in racemes. The fruits are small and the seeds yellow to reddish in colour.

USES

Tulsi is aromatic, carminative, antipyretic and antibacterial, diaphoretic and expectorant. Leaves are used for herbal tea and inflorescence for aromatic oils. It is very effective in treatment of viral encephalitis. The plant is also used in snakebite and scorpion sting. It gives relief in cold and cough. Tulsi contains vitamin C and antioxidants such as eugenol, which protects the heart from the harmful effects of free radicals. Eugenol also proves useful in reducing cholesterol levels in the blood. Tulsi acts as a mild diuretic and detoxifying agent, which helps in lowering the uric acid levels in the body.

PROPAGATION

This aromatic plant is native to Indian subcontinent and cultivated throughout Southeast Asian tropics. Basil is cultivated over an area of 25,000 ha in India and it accounts for annual production of about 250-300 tons of oil. As the demand in aromatic industry is growing high, concerns are growing over the improved production and quality of raw materials used. Hence, farmers shall take up Basil cultivation and increase the production by adopting the proper cultivation practices.

Natural Regeneration

In nature, species regenerate through seeds. However, due to over exploitation of species from its natural habitat, natural regeneration of species is less.

Artificial Propagation

Species is propagated through seeds and stem cuttings.

Nursery Raising

Grows well on variety of soils such as rich loam to poor laterite, saline and alkaline to moderately acidic soils are well suited. Well-drained soil helps better vegetative growth. Water-logging causes root-rot and results into stunted growth. Long days and high temperature are favorable for plant growth and oil production. Plough land to fine tilth and lay-out plots of convenient sizes for irrigation. Add 15 tonnes of farmyard manure per hectare during the preparation of land and mix well in the soil. The nursery can be raised in the third week of February and transplanting is generally started in the middle of April. This can be undertaken in the month of March.

Vegetative Propagation

Tulsi can also be propagated by vegetative method using terminal cuttings. About 90-100 per cent success when planted during October-December months is achieved. For this purpose, cuttings with 8-10 nodes and 10-15 cm length are used. They are so prepared that except for the first 2-3 pair of leaves the rest are trimmed off. Later, they are planted in the well prepared nursery beds or polythene bags. In about 4-6 weeks time, the rooting is complete and they are ready for transplanting into the main field. The plants are transplanted at a spacing of 40 cm between the rows.

Propagation through Seeds

Raised seed beds should be thoroughly prepared and well manured by adding FYM. Sow seeds 2 cm deep in the nursery beds in the 3rd week of February, about 200-300g seeds are enough for planting one-hectare area. After

sowing the seed in the nursery, a mixture of FYM and soil is thinly spread over the seeds and irrigated with a sprinkler. Seed germination is completed in 8-12 days.

Transplantation and Planting Density

Seedlings are ready for transplanting in 6 weeks time. Transplanting during middle April at 40 x 40cm and 40 x 50cm is done to get high herbage and oil yield. Tulsi allow to grow at different stages of harvesting (Figure:1-4).

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

It depends upon the moisture content of soil. In summer, 3 irrigations per month are necessary. 12-15 irrigations are enough during the year.

Weeding

Mulching reduces weeding requirements. First weeding is carried out one month after planting and the next as per requirements. One hoeing after two months of planting is sufficient.

Diseases and its Management

The plant is susceptible to powdery mildew caused by *Oidium* spp., seedlings blight caused by *Rhizoctonia solani* and root-rot caused by *Rhizoctonia bataticola*. To prevent diseases, bio-pesticides should be prepared (either single or mixture) from Neem (kernel, seeds and leaves), Chitrakmool, Dhatura, Cow's urine etc. For powdery mildew, spraying the plants with water jet washes down the fungus and spraying of wetable sulphur (4 g/L of water). Latter two diseases are managed by improved phyto-sanitary measures and by drenching the nursery-beds with a solution of mercurial fungicides. The larvae of leaf-rollers sticking to the undersurface of the leaves fold them backwards length-wise, thus webbing them. Malathion (0.2%) may be sprayed to control this insect.

HARVESTING OF CROP

For oil production, crop is harvested when it is in full bloom stage. The first harvest is obtained after 90-95 days of planting. Do harvesting every 65-75 days interval on bright sunny days. Delay harvest by a day or two if there is rain before planned harvesting schedule.

1st Harvest

After 60-65 days of planting, when the plants starts initiating flowers, carry out the first harvest by cutting down the plants at 6 to 8 inch above the ground level.

2nd Harvest

Done after about 45 days of first harvest. Pluck all buds having 6 leaves by hand.

3rd Harvest

Done after about 25 days of 2nd harvest, carry out the 3rd harvest by cutting down the plants at 2 feet height above the ground and collect all the buds and leaves.

4th Harvest

After about 25 days of 3rd harvest, cut all leaves and buds from the plant. There is no requirement for leaving any leaves on the plant because the plant dies out during winter in Dehradun areas.

Fig 1: Tulsi for Harvesting

Fig 2: 1st Harvest

(Cut at 6 to 8inch above ground after 60days)

Fig 3: 2nd Harvesting

Fig 4: 3rd Harvest

(Pluck Buds after 45 days of 1st Harvest) (After 25 days cut at 2 feet height- pluck)

Fig 5: Plucking buds by hand ensures quality

Fig 6: Plucked young bud

(4th Harvest (Last harvest) Pluck all the buds and leaves)

POST HARVEST MANAGEMENT

After harvesting the crop, leaves should be immediately washed with running water so that all the foreign material is removed. The harvested produce may be allowed to wilt in the field itself for 4-5 hours so as to reduce the moisture and also the bulkiness. Oil quality and its yield do not diminish up to 6-8 hours after harvest, but further delay may cause considerable loss in yield and quality of oil.

Oil Extraction

Steam distillation is found to be superior to hydro distillation and hydro cum steam distillation. Distillation unit should be clean, rust free and free of any other odour. The oil obtained is then decanted and filtered. The distilled oil is treated with anhydrous sodium sulphate or common salt at the rate of 20 g per liter to remove the moisture.

Drying and Storage

Harvested materials must be spread thinly in the shade over a flat surface having good ventilation and dust free. Turn or move the material at least twice a day. Do not spread directly on the ground or on bricks; spread over papers but not on printed papers like newspaper, magazines, etc. Leaves/buds should not be piled up. The oil should be stored in sealed amber coloured glass bottles or containers made of stainless steel, galvanised tanks, aluminium containers and stored in a cool and dry place.

Fig 7: Fungus infested buds and leaves

Fig 8: Dried products stored in a dark, dry place

YIELD

About 8 to 10 tonnes of fresh herbage per acre can be obtained by two to three harvests in a year. The oil yield varies with type, season and place of origin. Oil recovery ranges from 0.30-0.4%. Present market rate is ranging from Rs.800 to Rs.3000 per liter.

4 *Oroxylum indicum* Vent

• English Name/ Trade Name :	Sonapatha
• Common/Local Name :	Shyonak (Ayurvedic) Sonapatha (Hindi)
• Family :	Bignoniaceae
• Part Used (s) :	Root Bark

Oroxylum indicum

INTRODUCTION

Oroxylum indicum is a high demanded medicinal plant for pharmaceutical and perfumery as well as incenses industries. It is gradually depleting from its natural habitat due to unscientific exploitation. Due to rapidly increasing demand, there is tremendous pressure on the supply base. This has reached crisis point for some species including *O. indicum*. Further, there are also concerns about maintaining the quality of supplies. Hence, it is important to assess its distribution and to develop easy means for cultivation either *in-situ* or *ex-situ*. According to a NMPB report, demand of *O. indicum* is 100MT/year and supply is very less. Therefore, to meet the present demand and supply gap it is important to conserve the germplasm area for these particular species so that the demand and supply gap may be filled up to the some extent. Hence, there is an urgent need for conservation and multiplication of this important species. The NTFP Discipline of Silviculture and Forest Management Division of FRI, Dehradun explored the natural distribution and mapping of the species. Very low density of this species in 4 state namely Uttarakhnad, Uttar Pradesh, Haryana and Punjab was found.

GEOGRAPHICAL DISTRIBUTION

O. indicum is native to the Indian sub-continent, in the Himalayan foothills with a part extending to Bhutan and southern China, in Indo-China and the Malaysia eco-zone. It is also found in Sri Lanka, Taiwan, Yunnan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Thailand and Vietnam. The species is found throughout the tropical forests of India, i.e. north-eastern, central and southern India. It is more frequent in Vindhyas and southwards in mix-deciduous forests, ascending to 1200 a msl altitude and naturally found in forests near rivers and streams. The species is generally absent in dry climate of western India.

BOTANICAL DESCRIPTION

O. indicum is a medium-sized, soft-wooded tree attaining a height of 10–16 m. Stem bark is dull brown in colour; leaves are broad, 60–120 cm in length and pinnately compound. Leaflets are ovate, wavy and acuminate. Leaf fall occurs during winter season each year. The tree is recognized by ternately bipinnate leaves. Inflorescence is generally situated at the apices of branches and its length is about 30 cm or more. Lower inflorescence is large, fleshy, violet colored and foul smelling with 2.5-cm-long pedicle. Calyx and corolla are about 2.5 cm and 6.5 cm in size, respectively. Stamens are slightly exerted and base of filaments is wooly. Fruit is a follicle, 30–90 cm long and 5–10 cm broad, strap/sword shaped, compressed and two-valved. Seeds are flattened and silvery winged. Flowering occurs from July to August, while fruiting occurs from December to March.

USES

O. indicum is widely used for multiple purposes and Ayurveda has recognized its medicinal importance for centuries. Being an important medicinal plant, it is used extensively for treating a variety of ailments. The plant is used in many Ayurvedic preparations like, *Shyonakapatpak, Dashmula* and *Chyawanprash*. Root bark is an astringent, tonic, anti-diarrhoea, diuretic, anodyne and is used to cure dropsy.

Stem bark is anti-rheumatic. An infusion of bark powder is diaphoretic. Tender fruits have spasmolytic, carminative and stomachic properties, while seeds are purgative. Young shoots and unripe fruits are eaten as vegetables. Thin and light seed are used as stuffing materials for hats and umbrellas. Bark and fruits are used for dyeing and tanning. Mature fruits of the tree are used in treating cough, bronchitis, jaundice, piles, smallpox, dyspepsia, colic, leucoderma, pharyngodymia, cardiac disorder, helminthiasis, gastropathy, hemorrhoids and cholera. The root bark of *O. indicum* is acrid, bitter, pungent, astringent to the bowels, cooling, aphrodisiac, tonic, increases appetite, useful in biliousness, fevers, bronchitis, intestinal worms, vomiting, dysentery, leucoderma, asthma, inflammation and anal troubles.

PROPAGATION

Owing to the indiscriminate collection, over exploitation and uprooting of whole plants bearing roots, this valuable tree has become vulnerable in Karnataka and Andhra Pradesh and endangered in Kerala, Maharastra, M.P. and Chhatisgarh (Darshan and Ved, 2003; Jayram and Prasad, 2008) and is feared to become endangered soon in other states too. Some herb traders are reported to supply Sonpatha tree parts to some leading pharmaceutical companies and twigs of the tree are traded in Indian as well as international markets. Local healers and local as well as cross border traders are rampantly collecting this species from the wild which is causing a severe threat to its existence in India. Industrial requirements for production of different commodities are met through wild collections from forests. For the conservation of this species, rapid multiplication and rehabilitation in its natural habitat is necessary. Besides, reliable method of quick multiplication like tissue culture and methods of *in-situ* as well as *ex-situ* conservation could well provide a viable solution to the problem.

Natural Regeneration

It regenerates naturally by seeds, which germinate in the beginning of the rainy season. Seedlings require moderate shade in the early stages. However, the seed set is poor and seed viability is low. Problems related with its natural propagation and indiscriminate exploitation for medicinal purpose has pushed *O. indicum* to the list of endangered plant species of India.

Artificial Propagation

Species is propagated through seeds and vegetative propagation.

Nursery Raising

Before field preparation, a nursery of the plants is raised in polythene bags during second half of March. The polybags should be filled with sandy-loam soil with good quality, well-decomposed FYM added to it in the ratio 2:1. After emergence of the seedlings, the plants are watered regularly to maintain optimum moisture level.

Propagation through Seeds

Seed is the best propagation material and should be collected before splitting of pods during February-March. Seed germination percentage is 80%-90% without any pretreatment, 250 g of seeds are sufficient to raise stock for plantation on one hectare of land. By following grading only matured good seeds are required. Prepare the mother beds in a well-drained location, irrigate the bed well and keep it as such for 2 days. Place the seeds with wing horizontally on the prepared bed at the spacing of 4 inches seed to seed. Keep the seeds exposed and not cover the seeds with soil and maintain proper humidity and drainage as well till germination starts. The plants are ready for field planting in the next season.

Vegetative Propagation

Root Suckers

The tree can be propagated by transplanting root suckers which are produced in profuse, often forming a dense growth round the parent stem.

Transplantation and Planting Density

The land is tilled to make it porous, friable and weed-free. Pits of appropriate size, preferably 60 cm^3 are dug in a square planting geometry (2 m × 2 m). Approximately, 20 kg FYM, 150 g of nitrogen and 250 g of super phosphate are mixed in the top soil and the pit is loosely filled back before planting.

Transplanting in the main field is done in the first week of July. A spacing of 2 m × 2 m is considered appropriate. An optimum crop stand of 2500 plants/hectare is achieved with this spacing. Gap filling is done in September. The plant can be grown as a sole crop as well as in a mixed plantation. Short-term seasonal herbs can be grown in the inter-spaces after first year of growth.

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

In the first year, irrigation should be done at least six to eight times but more frequent irrigation during the summer months (at an interval of 7–10 days) is desirable for maximum productivity.

Fertilization and Weeding

About 20 kg of well-decomposed FYM, 150 g of nitrogen and 250 g of super phosphate are required per plant in three split doses at intervals of six months for two years after transplanting. Potash is required only in potassium-deficient soils. Normally, two weeding along with hoeing are considered sufficient.

Diseases and its management

Leaf-eating caterpillars like Bihar hairy caterpillar (*Diacrisia obliqua*) and grasshoppers damage leaves during rainy season. Besides, termite attack causes serious damage to root bark in crops grown on drier lands. These insects can be controlled by applying Endosulphan 30 EC spray @ 0.03% in water solution twice at 15-day interval as soon as the termites attack the plants.

HARVESTING OF CROP

The tree starts flowering and fruiting after three years and forms viable seeds even in first fruiting. It takes about three to five months for fruits to attain maturity. A pit is dug around the tree and filled with water to facilitate uprooting. The plants are uprooted for harvesting of root bark only after six to eight years, i.e. from October-December.

POST HARVEST MANAGEMENT

After uprooting, the roots are thoroughly cleaned. Thereafter, the bark is peeled off and the root is cut into small pieces, which are shade-dried to reduce their moisture level to less than 12%. The dried material is stored in moisture-proof bags.

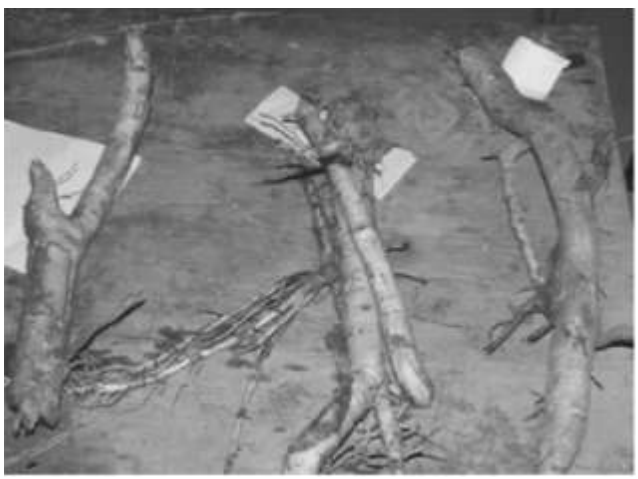


Fig1: Exploration of side root

Fig 2: Cutting of the root

Fig 3: Selection of root for analysis

Fig 4-5:
Root size reduction and shade drying

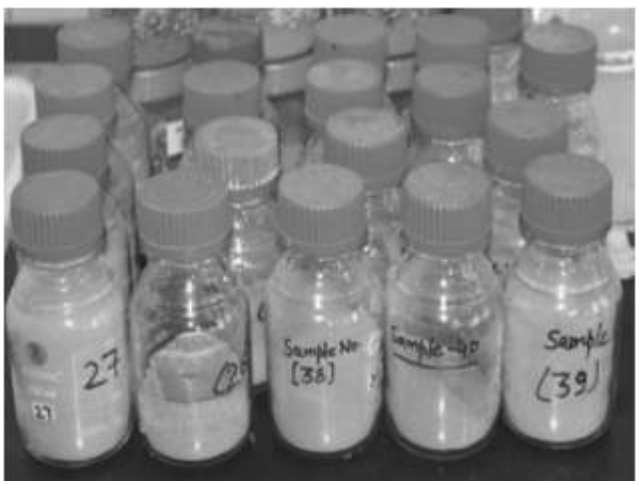


Fig 6: Processed fine powder

YIELD

A six-year-old tree yields only 1 kg of dried root bark. Therefore, the estimated yield of root bark is about 4.0 quintals/ hectare per year from sixth year onwards. An expenditure of about Rs. 45, 000 is incurred for cultivating crop on 1 hectare of land for the duration of six years.

5 *Rauvolfia serpentina* (L.) Benth. ex Kurj

• English Name/ Trade Name :	Sarpagandha
• Common/Local Name :	Sarpagandha
• Family :	Apocynaceae
• Part Used (s) :	Roots

GEOGRAPHICAL DISTRIBUTION

Sarpagandha grows in humid tropical areas of India. It occurs in the foothills of Himalayan ranges up to an elevation of 1300 -1400 a msl and almost throughout the country. In its habitats annual rainfall varies from 150 to 350 cm and annual temperature ranges from 10-38^0 C. The total 170 species of genus *Raulvofia* are distributed in the tropical and subtropical parts of the word including 5 species native to India. Other species of sarpgandha are *R. canescens, R. micrantha, R. densiflora* and *R. perakensis*.

BOTANICAL DESCRIPTION

It is perennial native shrub, erect, branched and almost evergreen herb about 75 cm in height, leaves simple with short petiolate, glandular at the base. The inflorescence with red pedicels and calyx and white corolla; flowers abundant, small, pedicillate, 1.2 to 2.5 cm long white to pinkish in cymes. Fruits are a drupe obliquely ovoid and seed wrinkled and ovoid.

USES

Sarpagandha roots are used for treating high blood pressure, insomnia, epilepsy, asthma etc. It is also used in various Ayurvedic preparations like Sarpagandha ghanavati, Sarpagandha yoga, Sarpagandha churna, Mahesvari Vati etc. It contains about 30 important alkaloids like serpentine, serpentinine, rauvolfinine, reserpine, ajmaline, ajmalinine etc.

PROPAGATION

Species grows well in deep, loamy to clay loam soil rich in organic matter and having pH 6 to 8.5. Avoid water logged lands and frosty conditions.

Climate, Soil and Intercropping

It grows better in hot humid areas -both in open and in partial shade areas. Plants cultivated in open areas are found to be more prone to fungal diseases during monsoon rains than in the partial shade areas. Well drained soils are

preferred by the species. It grows well in forest areas having tall tree canopies. It can also be intercropped with soyabean, garlic, ginger and other vegetables having shallow roots.

Land Preparation

Plough the land into a fine tilth and lay out plots of convenient sizes for management and irrigation.

Seed propagation

It is recommended to grow through seeds. Sow freshly collected seeds during June-July after removing the pulp. Six kg seeds are required for raising plants in one hectare. Fresh seeds are collected during June-July. Seeds germinate immediately, therefore de-pulp the seeds and sow immediately before seeds are dry. Germination is highly variable; it varies from 20-45 percent under natural condition. During May to June after soaking them in water for 24 hours results in 20-50 percent germination. The ripe seeds collected from June retain their viability for about six months.

Nursery Preparation

Raised beds (15-20 cm) of 5 x1.0 m under partial shade are prepared. Add one-third of well matured FYM and leaf mould and two-third amount medium silt-loam soil in the beds. It is treated with 10% BHC. Seed sowing is done in April and seeds are soaked overnight in water and sown 5 cm apart and in 30 cm row to row distance. Germination starts after 15-20 days and continues up to 30-40 days. Seedlings are ready in mid-July for transplantation. Before transplantation, seedlings are treated with 0.1% bavistin to protect them against soil born diseases. They are transplanted into the polybags or root trainers for next year plantation. Planting is carried out before the onset of monsoon. Watering after plantation is required to ensure establishment.

Fig 1 & 2: Sarpagandha Seedlings Polybegs & Nursery beds

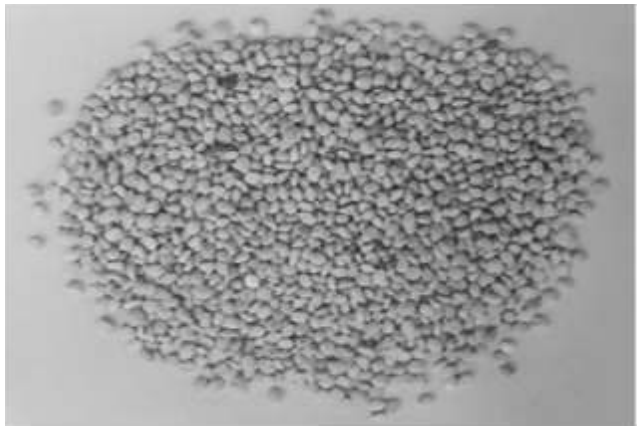



Fig 3 & 4: Sarpagandha Fruits & Seeds


Fig 5 & 6: Sarpagandha layout for Planting in Nursery and Roots formation by seedlings

Root Cuttings

5 cm long root cutting are planted during spring in nursery beds. Manure beds with FYM, sand and sawdust. The beds should be kept moist with watering. Root cutting sprout within three weeks and can be planted in field during rainy season. Root cutting raised stock is planted at the spacing of 30x30 cm in rows at 45x45 cm distance.

Stem Cuttings

Hard woody stem cutting measuring 15 to 22 cm. length, consisting of about 2-4 nodes, are required and planted in the month of June in nursery beds. To ensure proper rooting maintain moistures in the beds. Stem cuttings planted during early monsoon gives about 55 to 65% success. Hard wood cuttings perform better than soft wood cuttings.

Root Stumps

Species can also be propagated through root stumps. About 5-10 cm long roots with some portion of stem is required for raising the plant.

SILVICULTURE AND MANAGEMENT PRACTICES

Irrigation

It is a deep-rooted plant and can withstand a long period of drought. Irrigations at 20 days interval in summer and 30 days interval in winter are sufficient for the growth of the plant.

Weeding

Weeding should be performed as per requirement. Five to six weedings are required, when intercrop is raised with the species. In dry conditions before monsoon, mulching proves beneficial.

Pest and Diseases Management

Fusarium sanbucinum causes stem blight during July-August. *Fusarium oxysporum* causes wilt. Leaf blight incidences in sarpagandha are also observed, which is caused by fungus *Alternaria alternata*. Leaf blight symptoms include brownish dark coloured circular spot with yellowish margin on the ventral side. Diseased leaves finally turn brown. Leaf spot caused by *Cercospora rauvolfiae* is also found in the species. The affected leaves turn yellow, dry and subsequently fall and result in defoliation (Fig 7-9). The various diseases can be controlled by spraying the infected plants with Dithane M-45 (0.3%). Seed treatment with fungicides also reduces the infection to a great extent. Cultural practices such as crop rotation, mixed cropping, sanitation and timely sowing are important for controlling the plant disease. Seeds sown after bio control treatment (*Trichoderma* 0.25 g) and fungicide show good results.

Fig 7: Stem blight

Fig 8: Leaf spot

Fig 9: Caterpillar

IMPORTANT KEY POINTS FOR MANAGEMENT

- Plants raised from cuttings produce small and branchy roots. Mortality rate is very high since the roots do not go down deep like the plants from seed origin.
- The vegetative parts can be used for multiplication of plants, which can be closely planted for future seed production.
- While weeding, do not leave any cut materials of weeds adhered on the plant. They induce diseases.
- It is a perennial shrub growing wild in Sal forest areas. Seeds can be dibbled lightly in the forest areas during rains.
- Seeds ripen from July onwards. Collect seeds from healthy plants only.
- De-pulp the seeds and sow immediately before seeds are dried.
- When seeds are dried, they become dormant.
- Older seedlings give better survival rate in the field.
- Mulch the plantation with tree leaf litters if planted before monsoon rains.
- Do not allow water to stagnate around the plants.
- Supplement soil with FYM and Vermicompost.

HARVESTING/POST HARVESTING

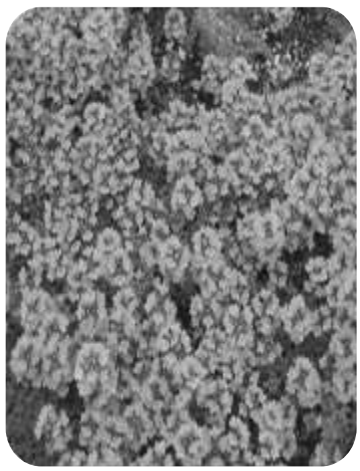
Roots mature in 18-24 months and should be harvested during autumn (Nov. and Dec). They should be cut into 12-15 cm pieces to facilitate drying and storage. Roots can be stored for 1-3 years in proper ventilated store rooms.

YIELD

20-25 quintals dry weight/ha

6 *Thymus serpyllum* Linn.

• English Name/ Trade Name :	Thyme
• Common/Local Name :	Vanajvain
• Family :	Labiatae/ Lamiaceae
• Part Used (s) :	Arial part



Thymus in Bloom

INTRODUCTION

Thyme is an important medicinal and essential oil producing plant. Spain stands first in thyme oil production followed by France, Morocco and the mediterranean countries. The bulk of the world demand for thyme oil is met by Spain and Turkey.

GEOGRAPHICAL DISTRIBUTION

Thyme is globally distributed from Africa to Asia. In India, it is found in the Himalayas of Jammu and Kashmir, Himachal Pradesh and Uttarakhand between an altitude ranging from 1500-4500 m. It is also grown in the gardens of western India.

BOTANICAL DESCRIPTION

This is a perennial and evergreen herb with 10-25cm height. Leaves are small, elliptical or oblong-ovate or lanceolate, 6-15 mm. long, glandular; flowers polygamous in whorls, males larger and nutlets smooth.

USES

Leaves and flowers are used as food flavourants, stomachic and tonic, good for the kidney & eye and also known as blood purifier. The extract of whole plant is anthelmintic, strongly antiseptic, carminative. It is taken orally in the treatment of bronchitis, catarrah and laryngitis. Externally, it is applied over minor injuries, mouth and throat infection. Oil is used in preparation of mouth gurglers. The yield of oil from fresh plants is 0.27 % and from the dried plants yield is up to 0.60 %.

PROPAGATION

Climate and Soil

A warm climate is best suited for this crop. It can be grown both in the hills and in the plains. Hilly regions are best suited for its cultivation. However, the plants are susceptible to frost. The plant prefers a light but fertile and calcareous soil for good growth and oil content. On heavy and wet soils, the aroma of the leaves will be less and there are chances that the plants may soon dry up.

Propagation through Seeds

Thyme can be propagated by seeds. The seeds are sown directly in rows in well prepared nursery beds in March and April. Seed can be sown 9 cm apart and later, when the seeds germinate, the seedlings may be thinned out to 30-45 cm within the rows. While planting the seedlings or rooted cuttings or layers, they are planted 30-45 cm apart in rows and 60 cm apart.

Vegetative Propagation

Ex-situ germplasm conservation technique for thyme has been developed by FRI, Dehradun and was cultivated in its natural habitat at field stone-wall in Pauri hill area (figures). This high altitude herb can also be domesticated in the lower plain like Dehradun (700 msl).

Ex-situ germplasm bank

Thyme growth in stone wall

Thyme harvesting

Details of *Ex-situ* Germplasm Conservation Technique

Lay bricks in the form of a box having height of 1m and convenient length. Keep sufficient gap between the bricks and fill up space with soil preferably having high percentage of clay. Obtain healthy shoot cuttings of the plant about 10 cm length by the start of rainy season. Planting 2-3 cuttings together in the soil between the bricks and the top surface of the box and regular watering will be required.

SILVICULTURAL AND MANAGEMENT PRACTICES

Land preparation

The land is prepared by repeated ploughing or digging and brought to a fine tilth and divided into plots of convenient size.

Weeding and Irrigation

Weeding is done in regular intervals to encourage the good growth of the plants. The crop is planted late in summer; it requires frequent irrigations during the dry period.

Pest and Diseases

Wilt disease is a major problem. The disease can be controlled by improving the phyto-sanitation and by drenching the soil with suitable fungicide like Blitox or Dithane M-45 with 0.3 % concentration.

HARVESTING AND POST HARVEST MANAGEMENT

The leaves and flowers which are used for culinary and medicinal purposes are harvested five months after sowing or planting. The leaves and flowers are plucked from the plants or shoots of about 15 cm are cut off from the plants. For extracting the oil, fresh herb is collected, on dry days, at the stage when it just has started flowering. At the time of collection, the lower portion of the stem, along with any yellow or brown leaves should be rejected.

The harvest materials are dried in the shade or in dryer immediately after harvest and stored in airtight containers to prevent the loss of flavor. The dry shoots may also be powdered and packed.

YIELD

Under favorable conditions, the yield of dry herb is around 1100-2200 kg/ha. The yield is comparatively low during the first year. The plants become woody which necessitates their replanting after three or four years.

The oil is distilled from the fresh flowering-tops by steam-distillation. The herb contains about 0.2% essential oil and the total oil up to 21 kg/ha can be obtained by distillation process.

B ARID FOREST RESEARCH INSTITUTE (AFRI) JODHPUR

7 *Commiphora wightii* (Arn.) Bhandari

• English Name/ Trade Name :	Indian Bdellium Tree
• Common/Local Name :	Sanskrit: Guggal, Gugul, Mukul, Myrrh Tree, Devadhupa
• Family :	Burseraceae
• Part Used (s) :	Exudate/Resin

INTRODUCTION

Commiphora wightii is an important medicinal plant, native to India and yields gum guggal (Anon, 1950). The demand supply gap of gum guggal is increasing very fast. However, the raw material is already inadequate in the country to meet the demand of the indigenous medicines. According to an estimate, the domestic demand of gum guggal is to the tune of 300 tonnes, while the supply is only 75 tonnes. To meet the domestic demand, presently India is importing substantial quantity of guggal. Over-exploitation, narrow extent of occurrence, small area of occupancy, severe fragmentation of populations, very low regeneration and invasion of alien species to its habitat relieved that *C. wightii* is facing severe conservation threat and extinction risk. It should be prioritized for "endangered category" by ensuring the habitat conservation, sustainable utilization and cultivation of this economically important species (Reddy *et al.*, 2012). IUCN has considered it as Data Deficient species (IUCN, 2012).

GEOGRAPHICAL DISTRIBUTION

The genus *Commiphora* is widely distributed in tropical region of Africa, Madagascar and Asia. The distribution further extends to Australia and pacific islands. In Indian sub-continent Commiphora species occur in India, Pakistan and Baluchistan, etc. In India, six species of Commiphora including *C. wightii* are distributed in Kerala, Karnataka, Tamilnadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan states. *C. wightii* is widely distributed in Gujarat and Rajasthan, also found occasionally in some parts of Maharashtra, Madhya Pradesh and Karnataka (Atal *et al.,* 1975).

In Rajasthan, it occurs in the districts of Jaisalmer, Jodhpur, Barmer, Sirohi, Pali, Nagour, Sikar, Churu, Bikaner and Jhunjhunu. Plants in low density are also found in Jalore, Siwana, Jaswantpura (Jalore district), Bhinamal, lassi, Bisala, Chohtan etc. Also found in Udaipur, Alwar, Ajmer, Sawai Madhpur, Bundi, Kota and Jaipur areas of Rajasthan (Atal *et al.*, 1975; Billore *et al.,* 1987).

Habitat

Guggal grows in a wide range of habitats. The plant grows wild in the arid, rocky tracts of North-western region of India as well as in the ravines of Chambel river (Billore *et al.*, 1987) and river Mahi (Shah *et al.*, 1983) in Rajasthan and Gujarat respectively. It occurs not only in the extremely arid areas such as Jaisalmer/Barmer etc. but also in sub humid regions along deciduous/scrub forests such as Ajmer, Falna and other areas (400-500 mm average rainfall). This indicates the diverse range of habitat of the species . Some of the plants associated with *C. wightii* in a cross section of the areas from the Aravallias to the international border in Jaisalmer include *Cassia auriculata, Euphorbia caducifolia, Salvadora oleoides, Ziziphus nummularia, Grewia tenax, Capparis decidua, Acacia senegal, Maytenus arginata* etc.

BOTANICAL DESCRIPTION

Guggal is slow growing branched and spinous shrub or small tree with crooked, knotty and aromatic branches ending in sharp spines, reaching height up to 3-4 m. It has an ash-colored papery bark that comes off in large flakes from the older parts of the stem whereas, the younger branches are pubescent and glandular. Leaves are small, trifoliate, shining green on top and grayish below, sessile and obovate in shape. Flowers are small, sessile and usually red. Fruits are ovoid drupes of 6-8 mm in diameter and turn reddish on ripening. Plants are diamorphic, one having bisexual and male flowers and the other having female flower with sterile pollen grains. The plant remains leafless for most of the year expect rainy season.

USES

Guggul oleo-gum-resin helps in reducing high cholesterol, because it lowers harmful low-density lipoproteins while elevating the beneficial high-density lipoproteins. It prevents blood platelet aggregation and breaks up already formed blood clots. Hence, it is beneficial for heart related ailments. Guggul is also widely promoted as a weight loss agent that enhances thyroid function. Guggul stimulates the activity of white blood cells in the body, contributing to the build-up of the immune system. Guggul also helps in eliminating and expelling dead tissues, wastes and toxins from the body. Inhalation of fumes of burnt guggul has been known to relieve cough and lung congestion, soothe mucous membranes and alleviate other respiratory problems. It is also used in rheumatism, nervous diseases, urinary disorders and skin diseases. Important preparations of guggul are Yogaraja guggul, Trayodasanga guggul, Vatari rasa, Kaisora guggul, Sadanga guggul, Amrita guggul and Kanchanara guggul. It is also used in incense, lacquers and varnishes, ointments and in perfumes.

PROPAGATION

Black colour seeds may be used as planting material, although germination averages around 40% only. Seeds can be collected during February-March. Yellowish white seeds are non-viable. The plant can be easily propagated through leafless stem cuttings, prepared in May, or through air layering of leafless stem of 5-6 year old mother plants in July-August.

Raising propagules

The planting stock for raising the crop can be prepared in a nursery through seeds, stem cuttings or air layering of 5-8 year-old mother plants. Only the black-coloured seeds are viable and sown during March to June, preferably in polybags. One seed may produce more than one seedling due to its polyembryonic nature. However, due to poor germination, two seeds are sown in each polybags. Seeds germinate within 7-10 days after sowing in the rainy

season. Leafless stem cuttings are planted in the nursery in May. Similarly, air layering can be done during rainy season in July- August; roots developed in 15-20 days after settings.

Approximately, 100 g of black seeds are required for raising plantation in one hectare of land at a spacing of 2m x2m. Treatment of seeds is not required. Stem cuttings planted without any treatment show approximately 90% rooting. However, cutting can be pretreated with IBA (Indole-3 butyric acid @ 10 mg/l) to hasten rooting and to achieve better survival rate.

PLANTING IN THE FIELD

- Land preparation and fertilizer application: Pits of size 45 cm x 45 cm x45cm are dug at requisite spacing of 2 x 2m and refilled after mixing the sand, soil and FYM in the ratio of 1:1:1.
- Transplanting and optimum spacing: The plantlets obtained from seeds and rooted twigs from cutting or air layering are transplanted from polybags in the rainy season (July/ August) to the pits containing a mixture of sand: Soil: FYM(1:1:1). A crop stand of 2500 plants/ hectare is obtained with a spacing of 2m x 2m.

Intercropping System

Guggal can be intercropped with crops like pearl millet and cluster bean. Experiments indicate a synergistic relationship between the intercropped species and guggal, resulting in better yield of pearl millet and cluster bean, while the quality and yield of guggal plantation remain unaffected. In Rajasthan, it is planted on the boundaries of the cultivated fields because of its very slow growing nature. Presence of spinous branches makes the field impenetrable.

Intercultural and maintenance practices

Besides the basal dose of FYM provided in the pits, the plants may be provided with growth regulators like IBA (10 mg/liter) along with organic manures like hexameal @ 100 plants every month or NPK (nitrogen, phosphorus, potassium) @ 75:130:30 g/plant after every three months up to a period of one year, which helps in the better survival of plants. After one year, quarterly dose of compost or hexameal @ 100 g/plant is good for growth and survival of plants. The pits should always be kept weed-free. Manual weeding and hoeing are recommended at an interval of 15-20 days during rainy season. After rainy season, weeding may be done at monthly intervals.

Irrigation practice

Irrigation with 8 liters of water per plant at an interval of 15 days result in best growth of plants.

Disease and pest control

No serious disease is observed in *C. wightii* except for collar rot during rainy season, which is caused by *Sclerotium rolfsii*. The plant is infected at collar region when the water remains stagnant near the base at early growing stage.

The condition may be controlled by avoiding stagnation of water around the base of the plant and spraying Diathane M-45 fungicide @ 2g/litre of water on the crop. In desert areas, the early growth of the plant is often checked by termite attack and in some cases, whole plant is damaged by the termite colony. Termite can be controlled successfully by drenching the soil with chlorophyrophos @ 4 ml/litre of water.

HARVESTING

Gum extraction

Generally, the gum is extracted from the stem by making 2-3 incision on the main stem and thick branches through a process called tapping. The plant takes eight to ten years to achieve physiological maturity for tapping, but should

not be tapped before 5 years of age. Thick branches are incised during the winter to extract oleo-gum resin. The gum exudes as a creamy sap from the plant and after some time gradually solidifies often forming big lumps. The cut part is completely covered with resin in about a month time. The exuded gum secreted is collected every week, up to one month after which further exudation of gum stops. To increase secretion of the gum resin the collectors and tappers apply a paste around the incision consisting mixture of horse or ass urine, oleo-gum resin and copper sulphate. This crude method increases the amount of guggul gum three to four times over that obtained under normal tapping procedures, but the shrub become unfit for tapping for the next couple of years and ultimately dies due to the injurious effect. Traditional tapping methods for gum extraction were crude, destructive and responsible for the rapid depletion of the valuable medicinal plant species (Yadav *et al*., 1999).

Disease Management

Leaf eating caterpillar, white fly and termites are major pest and plants are also infested by leaf spot and leaf blight.

Schedule

During land preparation the pits are filled with FYM and top soil mixed with Chloropyriphos (0.5ml per liter of water) to prevent termites. To control leaf eating caterpillar and white fly, spray 0.2% metacid aqueous solution. To control disease spray the crop with Blitox 4g with O.1g of agromycin in 1 liter of water.

Post-harvest management

After collection, the oleo-gum resin is stored in airtight plastic containers.

Yield and Economics

A yield of 120-130 kg oleo-gum resin is obtained per hectare after about eight years of plantation. The per hectare cost of cultivation is approximately Rs. 1,10,000 plus maintenance cost of Rs. 5,000 every year; thus, total input for eight years will be approximately Rs. 1,60,000/hectare.

8 *Momordica dioica* Roxb. ex Willd.

• English Name/ Trade Name :	Spine Gourd
• Common/Local Name :	Jangli Karela,Teasle Gourd, Kankro, Kartoli kantoli, Kantola, Kantroli, Ban Karola or small bitter gourd.
• Family :	Cucurbitaceae
• Part Used (s) :	Fruits

INTRODUCTION

The gourd family of vegetables is a large family. There are so many types of gourd which are consumed. Some of them are very common. There is also the uncommon type of gourd vegetables. Spine gourd is a popular nutritious vegetable that is cultivated all over India from ancient time. Generally, people confuse bitter gourd with this vegetable due to its closely related features but both have different taste. It is round in shape and is shorter in length. The commercial production of spine gourd is done but not on a very large scale. The cultivation of spine gourd is very easy. But it is only produced in only a few places. The cultivation of spine gourd must be increased. Since it is good for health; the more farming of this vegetable will help to make this vegetable popular. It must be cultivated using proper cultivation techniques. It must be done so that the yield can be increased.

GEOGRAPHICAL DISTRIBUTION

Momordica dioica can grow well in warmer season and it is cultivated over a wide range of soils but have good results in tropical and sub-tropical areas. In India, West Bengal and Karnataka states producing commercially spine gourd and small size fresh and healthy fruits are in good demand. It can grow well in Uttar Pradesh, Orissa, Maharashtra, Jharkhand, Chhatisgarh, Rajasthan and in many areas of Meghalaya. Indira Kankoda I (RMF 37) is one of the hybrid or improved variety of spine gourd.

BOTANICAL DESCRIPTION

Varieties of Spine Gourd-Kiron Mala

This variety of spine gourd shows early flowering. The stem is green in color and is ridged in habitat. The leaves of this

variety are long and wide. It is dark green in color. The fruits are green in color. They have a conical shape. The fruit skin has spines which are soft and conical in shape. The spines are thicker in texture. Each fruit can have a length about 14-16 cm. The weight of the fruits may be 150g. There are about 25-35 seeds contained in each fruit. This variety of spine gourd plant produces a very good yield. The average yield can be 20-25kg per plant. The fruit maturity time is early for this variety. The fruits take about five months to reach maturity.

Indira Kankoda I- also known as RMF 37, this variety of spine gourd is new. The plant is resistant to the major pests and diseases. The fruits are also very attractive in color with a dark green skin. The plant gains maturity in 75-80 days. The farmers popularly cultivate this variety of spine gourd. It is because the fruits have a long shelf life. It also has many nutritional values. After the first harvest, the fruits reach harvest time at 35-40 days from the second year onwards. The plants can produce fruits until 5-6 years.

USES

The spine gourd is not so common among other vegetables. It is uncommon yet is very rich in several nutritional benefits. Spine gourd also makes a delicious vegetable. The subtle flavor of the vegetable is what makes it so popular. It might not be a popular vegetable to be cultivated, but it must be commercialized. The spine gourd is an important vegetable. So, it must be cultivated on a large scale.

Nutritional Values

M. dioica contains lectins, proteins, triterpenes and vitamin (Naik, 1951). The fruit contains a high amount of vitamin C (Bhuiya, 1977). The fruit is rich in ascorbic acid and contain iodine. The fruit also contain alkaloid, flavonoids, glycosides and amino acids. It is rich in Vitamin A. It can be eaten to improve the eye sight. So, it must be included in the regular diet. The spine gourd is very beneficial in case of cough. So, to get relief from the cough, spine gourd must be included in the diet. The foliage of spine gourd is also beneficial. It can be taken to reduce fever. The water boiled with spine gourd vine and mixed with honey can be taken to reduce fever. The spine gourd is rich in fibers. The fibers help in curing constipation and other stomach problems. It can also help in digesting the food better.

PROPAGATION

Soil Requirements

The spine gourd is one of those plants which can survive in almost any soil condition. However, sandy to loamy can be used for its cultivation. The soil must have a good drainage system. It must also be rich in organic nutrients. The soil must be well drained and well aerated. The ideal pH for spine gourd cultivation is 5.5-7.0. The pH can be adjusted based on the soil texture.

Climatic Conditions

The climate for spine gourd cultivation is specific. The plants can adjust themselves to any condition. A warm and sunny weather is needed for the cultivation of spine gourd. Plenty of sunshine is needed to grow the plants. The ideal temperature for spine gourd cultivation is 27-33^{0}C. This crop is best suited for cultivation in summer and frost must be avoided when the plants are cultivated in Winter.

Land Preparation

The land must be cleared of all the weeds and other planting matter from the previous cultivation. After that, the land must be ploughed several times. The plowing can be done by tractor or plow. The land must be ploughed till the soil achieves a fine tilth. On an average, 2-3 ploughings are sufficient. After the land is ploughed, well-decomposed farmyard manure must be added to the soil. Based on the planting methods, the seed beds must be made in the

field. Leveling of the soil must be done. Proper drainage channels must be made in the field. Waterlogged conditions are not good for the spine gourd plants.

Propagation Methods

The propagation method for the cultivation of spine gourd includes tubers and by seeds. Seeds are most commonly used.

TRANSPLANTATION AND PLANTING DENSITY

Planting Method

To plant the seeds directly in the field, sowing equipment can be used. The seeds must be placed at least 2 cm deep inside the soil. About 3-4 seeds must be sown in each bed. Broadcasting or dibbling method can be used for sowing the seeds. The seedlings also can be transplanted from the nursery. For that, pits must be dug in the main field. The seedlings must be planted in the pits. After that, it must be filled with manure and topsoil. A light irrigation must be given after planting of the seeds or seedlings.

Seed Rate and Planting Season

On an average, 1-2 kg of seeds are enough to be sown in one hectare of land. If tuber planting is to be done, 3500-5000 tubers are enough. The spine gourd is sown in two seasons. It can be grown in monsoon from July to August. It can also be grown in January to February.

Spacing

At least a distance of 2 m must be provided between the rows. Between plants, a spacing of 75-80 cm must be given. A proper spacing must be provided so that the plants can grow properly.

SILVICULTURAL AND MANAGEMENT PRACTICES

Irrigation

The first irrigation must be provided after sowing the seeds. After that, irrigation at regular intervals must be given. In fact, if there is heavy rainfall, the water must be drained away. During summer months, regular watering must be done so that the plants do not dry out. The plants must be kept away from waterlogged and drought conditions. Drainage channels must be present in the field so that extra water can be drained out. For saving water, drip irrigation or sprinkler irrigation must be given.

Manure and Fertilizer

Well-decomposed farmyard manure must be applied when the ploughing is done. Proper quantities of nitrogen, phosphorus and potassium must be given to the spine gourd plant. If needed, micronutrients must be applied to avoid the deficiency.

Pest and Disease Control

The most common pest in spine gourd crop is the fruit flies and nematodes. The improved varieties of spine gourd are resistant to the disease. In case of the disease and pest attack, proper protection measures must be taken. Seed treatment will help to control many diseases.

HARVESTING OF CROP

The fruits are ready when it is green. Ripe fruits are not suitable for vegitable. The maturity time is a bit longer in the first year of cultivation. Subsequently maturity time decreases.

POST-HARVEST MANAGEMENT

After harvesting the fruits, they must be graded and sorted properly. It is better to sell the fresh fruits in the market. They can be packed in boxes or cartons and sold to the market.

YIELD

The average yield of spine gourd is about 75-100 quintals per hectare. The yield depends upon the crop management practices and the variety.

C TROPICAL FOREST RESEARCH INSTITUTE (TFRI) JABALPUR

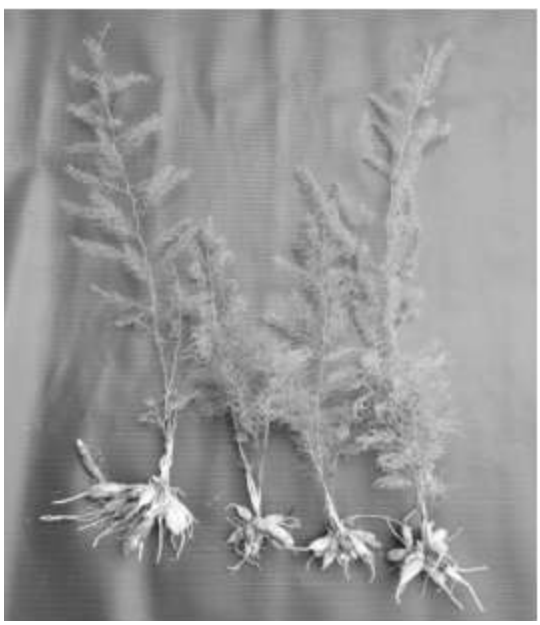
9 *Asparagus racemosus* Willd.

• English Name/ Trade Name :	Asparagus, Buttermilk roots, Climbing Asparagus, Satawari
• Common/Local Name :	Shatawari, Satavar
• Family :	Asparagaceae
• Part Used (s) :	Tubers and roots

INTRODUCTION

Asparagus racemosus is a highly valuable plant species having therapeutical and nutraceutical importance in addition to being consumed as vegetable. Ayurveda considers it as a powerful rasayana drug capable of improving memory power, intelligence, physical strength and maintaining youthfulness. Plant has also ornamental value both for indoor and out-door decorations. It is found throughout India, in all districts up to 1500 m elevation.

Asparagus, one of the important genera of family Asparagaceae represents around 150 species world wide and are distributed in temperate and subtropical regions.



6 month old seedlings

Flowering twig

Dry roots

Apart from *A. racemosus, A. adscendens, A. filicinus, A. gonoclados, A. offcinalis* and *A. saramentosus* are other important medicinal plant species of the genus.

USES

Tuber is demulcent, diuretic, aphrodisiac, tonic, alterative, antiseptic, anti-dysenteric and antispasmodic. In Ayurveda, it is prescribed as a cooling agent. Besides quenching thirst, its root juice helps in cooling down the body from summer heat, curing hyper-acidity and peptic ulcer. It contains good amount of mucilage that soothes inner cavity of stomach. It relieves burning sensation while passing urine and is used in urinary tract infections. It contains an anticancer agent asparagin that is useful against leukemia. It also contains active antioxytoxic saponins that have good antispasmodic effect and specific action on uterine musculature. It is a very good relaxant to uterine muscles, especially during pregnancy and is used to prevent abortion and pre-term labour on place of progesterone preparations. Its powder boiled with milk is generally used to prevent abortion. It is a good remedy for vaginal discharges like leucorrhoea, uterine disorders, excess of bleeding and colic pain. Its preparations in milk help in increasing breast milk in lactating women. Its preparations helps in avoiding excessive blood loss during periods.

PROPAGATION

Soil and climate

Fertile moist sandy loam soils are ideal for its cultivation though it grows in a wide range of soils. Better root development is observed in soils having increased proportion of sand. However, a decline in yield of crop in noticed in soils containing previous year's residue of roots. Plant comes up well under a wide range of tropical and subtropical climate.

Propagation

Asparagus plant is best grown from its stem disc but commercially propagated through seeds. Seeds are soaked in water for 12 h and then sown in nursery beds. Seeds usually start germinating after 40 days and average germination is 70%.

Land Preparation and Planting

For cultivation of crop, land is ploughed well with onset of monsoon in June- July. It can be planted on ridges, beds or mounds. Ridges are spaced at 75 cm and the closets planted at 30 cm are found beneficial (Kurian, 1999). In beds, ideal spacing is 30x30 cm (Shrivastava and Pahapalkar, 1997). For planting on mounds, pits of size 30 cm are dug at

a spacing of 60-100 cm, filled with soil and formed into mounds. Applying sand (5%) along with FYM (15 t ha^{-1}) recorded maximum yield of tubers (Shrivastava and Pahapalkar, 1997).

Manures and Fertilizers

FYM or compost applied at 15 t ha^{-1} as basal dressing and 2 months old seedlings are transplanted. Application of N, P_2O_5 and K_2O at 60:30:30 kg per ha increased root yield.

Irrigation and Weeding

Regular irrigation and weeding are required to realize higher yields.

CROPPING SYSTEMS

Asparagus performed well as intercrop in coconut plantation recording high root yield and high BCR (1.25) as inter crop when compared to pure crop (0.88). Total saponin which is responsible for therapeutic value of *Asparagus* and soluble sugar and insoluble sugar were high for inter crop. Whereas total free amino acids was high for pure crop (Kurian, 1999).

CROP PROTECTION

Stem blight caused by *Alternaria tenuissima* is seen during May-November. Lesions appear on stem and branches that turn necrotic resulting in drying up of appear on stem. Spraying Dithane M-45 at 39g / litre of water controls the disease.

HARVEST AND POST-HARVEST MANAGEMENT

Harvesting crop after two years provides higher root yield. Irrigating field prior to harvest enables easy harvesting of root tubers. Average yield is 10-15 t/ha of fresh root tubers however, yields over 60 t/ha are reported.

Roots are marketed fresh or as dry in pieces of 5-15 cm in length and 2 cm in thickness. They are silvery white or light ash colored externally and white internally. More or less smooth when fresh, roots develop longitudinal wrinkles when dry. They lack well- marked odors but are sweet and bitter in taste. Adequate care should be taken in storage of dried samples to avoid fungal contamination.

10 *Buchanania lanzan* Spreng. Syn. *B. latifolia*

• English Name/ Trade Name :	Almondette Tree, Calumpong- nut, Hamilton mombin
• Common/Local Name :	Achaar, Chironji
• Family :	Anacardiaceae
• Part Used (s) :	Fruits, Kernel

INTRODUCTION

Buchanania lanzan is an important tree species, found in deciduous forests throughout the greater part of India. A medium sized tree, with a straight trunk has dark grey or black, regularly divided into small rectangular plates somewhat resembling a crocodile hide and reddish inside. The fruit is a drupe, ovoid and black when ripe. The kernels, which have a flavor somewhat between that of pistachio and almond and eaten raw or roasted and are commonly used in the preparation of milk- based sweetmeats.

Natural Habitat

Chironji tree is found in deciduous forests almost throughout India, except in the arid regions of the north-west. In the sub-Himalayan tracts and Siwalik Hills the tree is found up to 900 m. It is commonly found growing in association with *Shorea robusta, Anogeissus latifolia* and other deciduous trees of drier situations and mixed deciduous forests. It is susceptible to frost and less resistant to drought. It avoids water-logged conditions.

GEOGRAPHICAL DISTRIBUTION

The tree is found commonly in the hot and dry parts of India, from the Sutlej eastward to Kumaun. State wise distribution of the species shows that the tree is found in Madhya Pradesh, Uttar Pradesh, Karnataka, Kerala, Tamil Nadu, Punjab, Rajasthan and Gujarat. It is also found in Nepal, Myanmar, Vietnam, Laos, Cambodia and Thailand.

BOTANICAL DESCRIPTION

Morphology

B. lanzan is a medium sized tree with straight trunk and the young branches clothed in silky hairs. The bark is dark-grey or black, furrowed into thick small quadrangular plates, reddish inside, 1.25 to 2 cm thick leaves are alternate,

thickly coriaceous, 12.5-25 X 6.3-12.15 cm, broadly oblong, obtuse, sometimes emarginated, glabrescent above, more or less villous beneath, reticulately veined, the nerves and veins impressed on the upper surface, base rounded; main nerves 10-20 pairs petionles about 12 mm long. Flowers are small, bisexual, sessile, greenish- white in terminal and axillary pyramidal panicles, which are shorter than the leaves; Bracts small, caduceus. Drupes are ovoid- oblong, 8-15 m in diameter, black when ripe; Stone hard, 2- valved; seeds oily.

Phenology

The tree is leafless or nearly so for a very short time during the summer season. In most parts of India, it sheds its leaves in April- May and renews them in June. The pyramidal panicles of small greenish white flowers appear from January to March and the fruits ripen from April to June. The fruit is an ovoid drupe about 1.3 cm long, black when ripe, with a hard two-valve stone enclosing an oily seed. The seeds fall before or at the commencement of rainy season.

Buchnania lanzan tree

Flowering twig

Fruiting twig

Kernel (Chironji)

Silvicultural Characters

The tree is a moderate- light-demander, tolerating however a fair amount of shade. It is very sensitive to frost, but is fairly resistant to drought and can stand grazing without damage. It avoids damp localities. It has a moderate coppicing capacity and produces root-suckers. It is a useful tree for covering bare hill-slopes, such as the dry hills of the Siwaliks. It is equally at home on newly formed land slip as on gentle slopes with fairly good soil.

Growth Characteristics

A medium- sized tree, attaining a height up to 15 m and a girth up to 1.25 m, almost evergreen, leafless only for a short time during summer. The development of the seedling is slow even under favorable conditions. The seedlings are sensitive to frost, drought and water logging.

Habitat

The tree grows on a variety of soils and is often found in gregarious patches on clayey soil. On shallow gravelly soil, the growth is stunted. The climate in its natural habitat is subtropical, characterized by hot and dry summer and mild winter. The absolute maximum shade temperature varies from about 40°C to 46°C, the absolute minimum shade temperature varies from about -1°C to 13°C and the normal annual rainfall from about 750 to 2, 120 mm.

USES

The wood is easy to saw and works to moderate finish. It has been used locally for boxes, bedsteads, posts, poles, doors and cheap furniture. It has been reported to be suitable for match industry. The wood is very cheap compared to other timbers.

The tree is lopped for fodder, especially for buffaloes in Madhya Pradesh, Maharashtra, Orissa and Uttar Pradesh and is classified as medium or good fodder tree in these states. Mature leaves collected in October-November were found to contain 11.90 percent ash, 2.42 per cent calcium, 44.30 per cent carbon and 1,62 per cent nitrogen.

Within its natural habitat, it is a useful tree and is abundant in certain common types of forests. It is a useful species for dry hill slopes and has been recommended for rehabilitation of degraded forests and also for agroforestry systems.

Fruit Kernels

The flesh of ripe fruit is very palatable and is largely eaten raw or roasted. The oily kernels are, however, the most important part of the food. The kernels are, used in preparation of sweetmeats, puddings, etc. The hill tribes of Madhya Pradesh are reported to eat the kernels of this species after pounding and drying them in sun and baking them into a kind of bread. The seeds yield edible oil and is often used as a substitute for almond oil. *B. lanzan* is reported to be an alternative host for kusmi lac insect. The settlement of the larvae is good and fairly uniform. Larval mortality is only slight. Continuous encrustation with well-developed lac cells is on a large number of twigs. Comparatively thick shoots do not carry any lac.

Other Uses

The gum that exudes from the wounds in the stems fairly soluble in water. It is said to resemble Bassera gum, having adhesive properties like inferior gum Arabic and is suitable for dressing textiles. The bark and the fruits furnish natural varnish.

PROPAGATION

Natural Regeneration of the Species

In the region of its natural occurrence, it regenerates well through seeds. The fruits fall immediately before or at the commencement of the rainy season. If they are quickly covered with soil or debris by the rain, or are protected by grass or other low cover, germination commences soon after and the seedlings have a chance of establishing themselves. Seeds lying on the surface of the ground exposed to the sun either fails to germinate and soon lose their vitality or if they germinate, the radicles tend to dry up. Much mortality is caused in this way. Another major cause of mortality is the destruction of the radical by insects.

NURSERY PRACTICES

Nursery Site

Soil should be well- drained sandy loam. Clayey soils should not be used because of their poor aeration and drainage. Well-decomposed compost is added to the soil before sowing the seeds. The seeds lose viability when exposed to sunlight; hence overhead shade is required at the nursery site.

Seed collection and Storage

Ripened fruits should be collected from the trees during the fruiting season of the tree i.e., (April-June). After collection, the seeds should be dried in shade and stored in an air-tight tin containers for one year viability of 50-70 per cent. Fresh seeds were found to have a viability of about 70 per cent. One kg of seed has 3500-5000 seeds.

Sowing

Best time for seed sowing in nursery is June. This means that as soon as the seed ripens, it should be collected and sown in the bed. Dry seeds are soaked in water for 24 hours and sown in sunken beds or in polythene bags. Nursery beds are irrigated after sowing. Germination starts in about 16 to 25 days. The seed exhibits no dormancy and germinates on being provided adequate moisture and temperature. Germination is epigeous. The primary root is long, thick, tapering, with lateral fibrous roots and distributed down the main root. Studies conducted at State Forest Research Institute, Jabalpur in 1989 revealed that irrigated conditions do not suit the young germinants although in respect of germination per cent irrigated conditions were found to have better effects than unirrigated conditions.

Vegetative propagation/Cloning Techniques

There is no usual method by planting cuttings and stumps. However, it can be propagated through root suckers where the roots are liable to be exposed particularly on hilly ground.

Pricking Out

Generally pricking out is not done in the nursery because of its slow growth.

Fertilization

In the nursery, the application of inorganic fertilizer is not required. However, compost encourages seedling growth. Compost should be well decomposed and thoroughly mixed with the soil for use in nursery beds.

Irrigation

Under irrigation, seed germination is better than under unirrigated conditions. They require well-drained soil, as the roots tend to rot-off in water- logged conditions.

Weeding

Nursery beds should be well maintained. During the first season the seedlings develop fairly well in a moderate growth of grass and weeds, subsequently, the weeds tend to hamper their growth. Regular weeding is a must in nursery beds.

TRANSPLANTATION AND PLANTING DENSITY

Planting Site and its Preparation

The tree grows on a variety of soils and is frequently found abundant in clayey soils. It avoids water-logged areas. On shallow gravely soil the growth is very stunted. This species appears to have comparatively less liking for very moist conditions. Therefore, the above factors should be taken into consideration while selecting the planting site for *B.*

lanzan. After selecting the site, the area is cleared. 45 cm x 45 cm x 45 cm pits are dug out for planting the one-year-old saplings. They are dug out during the summer season (March-May) so as to allow them to dry properly and through solarization treatment sterilization of soil is done. Plantation is done in the rainy season (July-August) so that the saplings develop roots quickly. The tree has been successfully raised by direct seeding in tangya plantation also.

Block Planting

For planting saplings, 3 x 3 m spacing should generally be adopted.

Row and line Plantations

For planting saplings, 2.5-3 m spacing is maintained in case of row or line planting. It is a suitable species for afforesting dry hill slopes.

Mixed Plantations

It can be raised as mixed plantation under agro-forestry systems. The slow rate of growth of this species will be compensated by the yield of fruits which gives high priced kernels.

SILVICULTURAL AND MANAGEMENT PRACTICES

Weeding

Regular weeding in the plantations is essential. Collar weeding is to be carried out in the initial stages of the plantation. If regular weeding is carried out, maximum height of 30 cm to 1.5m may be attained by the end of the second and third seasons respectively, but on un-weeded ground the growth of this species is considerably slower. First weeding should be done in the month of August and subsequent weedings are to be done in the months of October and December.

Cleaning

Cleaning of the site is essential to remove the unwanted species before raising plantation. Further cleaning around saplings should be done whenever required.

Thinning

Generally thinning is not practiced for this species because of its slow growth when raised as plantations.

Fertilization

This species does not require any organic or inorganic fertilizers in plantations.

Irrigation

Watering is required once in a week during the summer season in the first year of plantation. After successful growth, watering is not required at all as it is a fairly hardy species. This species does not require profuse irrigation for its growth.

PESTS AND DISEASES MANAGEMENT

Pests

Out of nearly 62 insects feeding on *B. lanzan* in nurseries, plantations, natural forests and in timber depot, the following are the major insect pests damaging trees in different parts of India:

Batocera rufomaculata (Coleoptera: Cerambycidae)

It is about 50x15 mm in size, grey coloured with orange and / or white patches on the elytra. They are nocturnal and

feed on the bark and green tips of the tree. The female bites incisions in bark and oviposit the eggs, the grubs feed on the meristem for a few days and then penetrate deeper in sapwood. The tunnels formed are irregular and remain packed with wooden coarse fibres. Pupation occurs in the wood and the young adult emerges through an elliptical flight hole.

Control Measures

- Severely attacked trees should be felled before the emergence of beetles and removed from the field to prevent the spread of beetles.
- Infested trees should be located and after cleaning the ejection holes, either 5 gm crystals or 5 ml saturated solution of para-dichlorobenzene in kerosene should be poured inside each hole and sealed with moist soil.

Plocaederus ferruginous L. (Coleoptera: Cerambycidae)

It is a dark brown long horn beetle or polyphagous nature which measures from 25 to 40 mm in length. Female lays the eggs under the loose bark on the stem or surface of the roots of host and the grub makes irregular, frass filled tunnels beneath the bark and in wood. The injury to the cambial tissues arrests the flow of sap and weakens the host and may kill the plant.

Control Measures

Holes in the trees may be fumigated with para-dichlorobenzene in the manner described under *B. rufomaculata, Euproctis scintillas* (Lepidoptera: Lymantriidae). The moth of this polyphagus pest, lays eggs in groups usually on the leaves of the host. The larvae are about 30 mm long when fully grown and are yellow with tufts of dark hair. They feed gregariously on leaves, flowers and young fruits. This larva undergoes pupation in thin cocoon on leaves. The life cycle lasts for about 6 to 7 weeks and the breeding continues throughout the year. Spraying endosulfan 0.03 per cent or fevnalerate 0.01 per cent can be used against the larvae of this insect. The other insects of minor importance are defoliator, *Bambotelia mugatrix* Guenee, a wax scale insect, *Ceroplastes ceriferus*; and the borers like *Lycaenesthes lycaenina, Crossotarsus* spp, etc. So far only two foliar diseases have been recorded on this host:

- Leaf spots by *Pestalotiopsis versicolor*

  The leaf spots are circular to irregular on the leaf lamina, typical reddish brown in periphery of the spots with greyish center and 1-3 cm in diameter. The acervuli of the pathogen can be seen on the upper surface of the leaves as minute black dots. The disease affects the plants of all age groups and occurs after rainy season and continues till leaf fall. The disease does not cause any significant damage to the plants.

- Leaf spots by *Colleotrichum gloeosporioides*

  The leaf spots are circular to irregular, up-to 1 cm in diameter and dark brown in colour. The disease comes after rainy season in plants of all age groups and continues till leaf fall; however, no significant damage to the plants has been reported.

HARVESTING

The peak harvesting season starts from April and ends with June and it is mainly collected by the poor, mostly tribals. According to a survey conducted by FRI, Dehra Dun, it is estimated that in Lalitpur forest division of U.P., 75 % of the *B. lanzan* trees are found in the village Community and Forest lands, while 25 % of these are on private land holdings. The collection of fruits from community and forest land resources does not involve any royalty payment and all the community has right to collect the fruits. However, in certain places the collection right is being misused by local influential persons, who pay the poor people a meager amount of money as guards for this forest/ community trees and thus exploits both the manpower and the resources.

Collection

For collecting the fruits of Chironji, the villagers clean the ground below the tree and then shake the branches of the tree. The ripe fruits fall on the ground. If some of the fruits remain on the tree, the twigs along with the fruits are plucked.

Collection Period

The tree flowers in January-February and the fruit ripens in May-June. The fruit becomes red on ripening. The fruit collection starts from mid-May and ends by mid-June, but is generally completed in 15-20 days only, with even unripe fruits are being extracted/harvested.

POST HAVEST MANAGEMENT

Processing

The collected fleshy fruits are beaten with the wooden sticks so that the fleshy portion is removed and then the seeds are washed with water to remove the remaining fleshy pulp. The seeds so obtained are dried in the sun. The dried seeds are then subjected to hand driven grinding to remove seed coat from kernel. After sieving the crushed seeds the kernel is removed. However, mechanical grinding is not available and hence needs to be developed.

YIELD

Average Yield per Tree

The average yield from the tree of 35-40 cm diameter is about 1-15 kg Chironji. On an average 40-50 kg fresh fruit is produced per tree, which yields 8-10 kg on drying resulting in 1-1.5 kg of the finished produce per tree.

ECONOMICS OF THE SPECIES

Marketing

The local people sell the Chironji in two ways:

i) The traders purchase the Chironji at a very nominal cost in the village.

ii) To get good amount, the villagers sell their material in the market. In his way they get better profit.

The present prevalent prices for the finished and unfinished products are as under:

Fresh fruits fetch a price of Rs. 6-7 per Kg; and Dried fruits fetch a price of Rs. 8-9 per kg,

While the actual finished product is sold at Rs. 100-125 per kg in the open market. However, the prices vary from place to place and are generally dependent on production and market demands.

When compared with other commercial crops, this species has a higher market value and it plays an important role in rural and tribal welfare. The rural people, particularly the tribal, collect the fruits of this tree to earn their livelihood through its sale. As the fruits as well as seeds are edible and they are commonly used in preparation of sweetmeats, puddings, etc. the seeds fetch quite high rate. The leaves and wood of the species are also utilizable. In a study carried out in Madhya Pradesh by the State Forest Research Institute, Jabalpur it has been estimated that in the study period, quantity varying from about 300 to 12,000 quintals of seeds per year was collected by the rural people fetched a sum ranging from about Rs. 0.90 to 11.5 lakhs.

11 *Madhuca indica* J. F. Gmel.

• English Name/ Trade Name :	Butter Tree, Mahua, Indian Butter Tree
• Common/Local Name :	Mahua
• Family :	Sapotaceae
• Part Used (s) :	Fruits, Kernel

INTRODUCTION

Madhuca indica grows throughout the greater part of India. Two varieties viz. *M. longifolia* and *M. latifolia* the former grows in Southern India while the latter is common throughout India. It is a tree of dry tropical and sub-tropical climate. In its natural habitat, the absolute maximum shade temperature varies from about 41^{0}C to 48^{0}C the absolute minimum temperature from about 1^{0}C to 8^{0}C and the normal annual rainfall from 750 mm to 1875 mm. The mean relative humidity in its natural range varies from about 40 to 80% in January and from 60 to 90% in July.

The tree grows on a wide variety of soils, but prefers sandy soil. It can grow on shallow boulder soil and can also thrive on the Deccan trap soils. It grows well on alluvial soil in Indo- Gangetic plains. In Sal Forests, it is found growing on stiff clay and even on calcareous soil.

BOTANICAL DESCRIPTION

Mahua is an economically important plant of the family Sapotaceae. It is deciduous in nature. The tree is a strong light demander and gets readily suppressed under shade. The tree is frost hardy, but the seedlings and saplings are sensitive to frost. It is drought resistant, but severe and prolonged drought may kill even the tree because of the superficial root system. The tree has a large spreading root system though many of the roots are superficial. It is a large tree with a short bole and round spreading crown. The bark is nearly smooth, grey or brown, with vertical cracks.

GEOGRAPHICAL DISTRIBUTION

Mahua grows throughout the greater part of India except the temperate and arid areas and some southern parts of the Indian Peninsula. It is a common tree of Madhya Pradesh, Orissa extending to the sub- Himalayan tract between the Ravi

and Gandak. It is a constituent species of South and North Indian Tropical Moist Deciduous Forests, Southern and Northern Tropical Dry Deciduous Forests, in various forest types. It is however, usually not found on the hottest aspects of hilly areas, as the seed lines are unable to stand such exposure.

Tree

Fruit

Flowering twig

Flowers

Growth Characteristics

Mahua is a slow growing species. Growth of seedlings of seed origin is slow; the plant attains a height of about 8 cm by the end of the first year; 30 cm at the end of the second year and 0.9 to 1.2 m at the end of the fourth year.

As a Plantation tree

Mahua is an important plant having vital socio-economic value. National commission on Agriculture (1976) recommended this species for planting on road side, canal banks etc. on commercial considerations. This plant has considerable scope in social forestry program in Tribal belts. Every state has more than a dozen afforestation schemes but Mahua has been given less importance despite its being an important commercial as well as livelihood tree species.

USES

- Use as Timber, Poles, Pulp and Paper etc

  The wood of Mahua is not widely used as the tree is so useful for its flowers and fruits that it is rarely cut for timber, but it gives good house posts out of saplings and the seasoned wood is used in house building for furniture and country vessels, the naves of wheels etc. The wood of *M. longifolia* is valued for ships keels and for planking below the water line, makes good treenails and is used in the construction of carts and for bridges. Timber of Mahua is also used for making tea boxes in South India. Wood yields sulphate pulp (average fiber length 1.03 mm, diam 0.016 mm); unbleached pulp in low yield and belched with satisfactory strength. Bark yields tannin (17%) which is used for dyeing; is reported to heal wounds.

- Use as Fodder

  Mahua leaves are of nutritive value for cattle. The trees are lopped for fodder in Madhya Pradesh, Maharashtra, Orissa and Uttar Pradesh.

- Ethno - Botanical uses of leaves

  The leaves are also used for making cups and plates on which food is served during festival days by tribal and poor villagers.

- Use as Fuel

  Wood is hard and heavy (Specific gravity 0.95 – 0.97); good fuel wood calorific value of sapwood is 4890-4978 Kcal/Kg and heartwood is 5005-5224 Kcal/Kg.

  Flowers yield alcohol which can be used as engine fuel. Seed cake with cow-dung yield biogas and fertilizer.

- Use for Environmental Conservation

  Madhuca is among the most suitable species for saline-alkaline (Usar) soils containing very low organic matter content Thus it is recommended for planting under Social Forestry Program particularly in community wastelands, which are not very productive due to their being either alkaline or rocky. It is a suitable tree species recommended for maintaining the aesthetic value of environment in the plains.

- Mahua flowers are rich sources of sugar, vitamins and calcium and offer wholesome nourishment when boiled with rice. Efforts are also being made to encourage the consumption of mahua flowers in processed form in urban areas. From a nutritional point of view, the flowers are richer than maize in carbohydrate, protein, minerals and vitamins. The flowers are considered good as food as well as tonic and demulcent. In view of their high sugar content and absence of any toxic effects, the flowers of Mahua are traditionally eaten by tribal and other rural people.

- Mahua cake is used as manure either single or in mixture with other cakes and nitrogenous fertilizers like ammonium sulphate.

NATURAL REGENERATION OF THE SPECIES INCLUDING CALENDAR

The tree reproduces through seed and coppice. The seeds germinate after a good shower of monsoon rains. The seeds which get covered under the soil, germinate better and give rise to the seedlings while those lying exposed are either attacked by insects or dry up before getting a hold in the soil. Some seedlings get suppressed and killed by tall weeds and grasses. Forest fires, trampling and browsing by animals also take a heavy toll of the seedlings. Seedling growth of seed origin is slow. Seedling regeneration is quite scanty. The mature fruit falling period is between, May-July in North and

August-September in South India. One to two good seed years may be expected every three years. The rate of seed setting in mahua under normal environmental conditions is very low.

Coppice Regeneration

Coppice regeneration is more reliable. The trees felled during the hot season coppice well. The growth of coppice shoots is fairly rapid.

PROPAGATION OF THE SPECIES

Both seed and vegetative method can be used for propagation of Mahua.

- Nursery Site

  The soil of the nursery should be sandy in nature, though Mahua can be grown in all types of soils. Hotter aspects should be avoided.

- Seed Collection and Storage

  Collection of seeds and kernel separation is done by tribals and rural people in an unorganized manner. Hence, there is considerable loss during drying and storage of kernel. The storage condition of kernel determines the quality of expelled oil, as the kernels are susceptible to both fungus (*Aspergillus flavus* and *Rhizopus* sp.) and insect attack during the storage. Studies carried out on storage have revealed that it is better to store the kernel at 5 to 6% moisture level in gunny bags with Cephos (Aluminum phosphide). Recovery of neutral oil free from colour and odour arising partly from fungal growth.

- Seeds Sowing

  The soil of nursery beds should be sandy in nature. Seeds are sown, after collection, in the nursery beds and covered with about 2 cm of soil. Beds are irrigated after sowing. Germination takes place in about 10 days. For planting out entire, seeds may be sown direct also in long pots, polythene bags or baskets.

- Vegetative Propagation/Cloning Techniques

  Mahua tree propagated by means of cuttings and layering has been found to be unsuccessful.

  Vegetative propagation by grafting and budding experiments carried out at the Gannoruwa Research Station in Sri Lanka showed very promising results. Grafting trials using one-year-old seedling in the field as stock and scion taken from a defoliated tree (so that the apical buds were dormant) achieved a success rate of 87% after 46 days using either whip or cleft grafting methods. Budding trials were carried out using similar seedling stock and buds taken from branches with semi-hard wood. All the three methods of budding viz. patch, modified forkert and H-Budding, used in this trial showed 100% success. Further trials are needed in different countries to standardize the method of vegetative propagation. Propagation techniques of Mahua have not attracted any efforts in India.

- Pricking Out

  One month old small seedlings from mother beds are pricked out into baskets or other containers and kept till fit for planting. For stump planting, seedlings are pricked out into transplant beds at 20-25 cm apart.

- Fertilizer Application

  Soil, sand and FYM in the ratio of 3:2:1 is generally used as potting mixture for poly pot raising.

- Irrigation

  In nursery, watering is done immediately after sowing and thereafter at regular intervals for proper growth.

- Weeding

  Sown lines should be kept weeded for the first two years. Loosening of soil along with weeding stimulates growth

TRANSPLANTATION AND PLANTING DENSITY

- Planting Site and its Preparation

  Mahua grows well on alluvial soil. The sites having shallow boulder soil, hard lateritic soils are also suitable for planting this species. Thus, it is a good tree species for wastelands development. Hottest aspects of hilly areas should be avoided for its planting because the seedling of Mahua is unable to stand much exposure due to its superficial root system. The planting site should be free from recurring drought and frost. Planting site should be cleared by cutting and burning all woody growth. Pits at a distance of 9 m x 9 m or 10 m x 10 m should be dug in the month of May. Pits size of 60 cm^3 is best for planting of Mahua in lateritic soil. Pits of sizes 30 cm^3 or 45 cm^3 can also be used, depending on the nature of soil thickness of the site

- Block Planting/Row and Line Planting

  Both block and line planting, methods are used for planting Mahua. The tree can be raised by direct sowing or by planting the nursery raised seedlings. Pits of suitable sizes (30 cm^3, 45 cm^3, depending on the site conditions) are dug in summer.

  - Direct Sowing: It is done in prepared lines or blocks. Four to five seeds should be sown in each pit, covering them with 1.5- 2.5 cm of soils in June-July. Before sowing the seeds, pits should be refilled with mixture of soil, sand and farm yard manure in the ratio of 3:2:1. After sowing, pits should be watered if monsoon rains are delayed. Direct sowings give survival of 24-66% with a mean height of 5.30m in 18 years and 11.35 m in 38 years in Madhya Pradesh.

  - Planting out Entire Trans Plant (ETP): The seedlings are raised in nursery beds or in containers (bamboo baskets, earthware pots or polythene bags). One-year-old seedlings are planted out in the field during monsoon. The method gives a survival of more than 66%.

  - Stump Planting: Experiments in Tamil Nadu have shown that stump planting is the best method, followed by direct sowing, as judged by the survival percentage and mean height at the end of second growing season. The stumps are prepared from about one-year-old seedlings. Planting of stumps is done either in crow bar holes or in 30 cm^3 pits.

- Spacing

  Spacing should not be closer than 8 meters. It may vary from 8 m x 8 m to 10 x 10 m, depending upon the availability of land and seedling stock. The inter-space may be utilized for raising other crops.

- Mixed Plantations

Mahua is an important tree species which has been planted in different parts of the country to prevent soil erosion and to provide fuel and fodder. A suitable mixture of tree species used in planting with Mahua includes *Acacia auriculiformis, A. catechu, Ailanthus excela, Albizia lebbeck, Azadirachta indica, Cassia fistula, Cleistanthus collinus, Dalbergia sissoo, Eucalyptus tereticornis, Gmelina arborea* and *Terminalia tomentosa*.

SILVICULTURAL AND MANAGEMENT PRACTICES

Fertilization

A report regarding Mahua plantation at Chhapara (M.P) indicates that maximum causality of plants was observed in the pits that were heavily manured with cow dung. Pits without manure and leaf mould were, however, reported to have given better results. It has also been reported that before planting, the lower half of the pits should be filled up with the dug up soil and upper half with the mixture of humus rich soil and FYM in the ratio 3:2:1 to boost plant survival and growth.

Irrigation

Irrigation is also an important input required to give initial impetus to the plant growth. Watering may be done if the rains are not received within 10 days of sowing (direct sowing) or planting.

DISEASE MANAGEMENT

- Seeds/Fruits

The fungi causing deterioration to seeds/ fruits are *Aspergillus flavus, A. niger, Penicillium* sp. and *Stathmapoda basipectra.*

- Leaf Spots and Leaf Blights

Leaf spots and leaf blights are common diseases of Mahua both in nurseries and in plantations. These symptoms of diseases are caused by *Pestolotiopsis dichacta, Cercospora haticola* and *Pestalotia paraguariensis.*

- Leaf Rust

This is also a serious disease of Mahua occurring both in nurseries and in plantations. The main causal organism of leaf rust disease is *Scopella echimulata.*

- Insect Pests

The flowers and leaves of Mahua are often defoliated by the looper, *Acharajanata Linn., Anuga multiplicans, Bombotelia, Nugatris, Guenee* and *Metanastricahvrtaca cramer.*

12 *Tinospora cordifolia* (Willd.) Miers ex. Hk. F.Th.

• English Name/ Trade Name :	Giloy, Indian Tinospora
• Common/Local Name :	Giloe, Giloy, Guduchi, Amrta, Cinnodbhava
• Family :	Menispermaceae
• Part Used (s) :	Climber shoots (Stem, Root, Whole Plant)

Giloy

Gurcha/Giloy is a gregarious glabrous twiner. Older stems are up to 2 cm in diameter and have corky bark. Aerial roots arise from nodal scars of branches. Stem and branches are specked with white vertical lenticels. Bark is grey-brown or creamy white, warty, papery thin and peels off easily. Leaves are 5–15 cm, ovate and acute. They are membranous when young but become more or less leathery with age.

Flowers are yellow, unisexual, minute and less than 2 mm in size. Male flowers are grouped in axillary racemes, while female flowers are solitary. Fruit is an ovoid and succulent drupe, lustrous, red in colour and of the size of a large pea, having a single seed. Seed is fleshy and curved. Flowering occurs in May–June, while fruiting is witnessed in September–October.

DISTRIBUTION

The species is endemic to India and is common throughout tropical and subtropical zones at an altitude of 600 m.

PROPAGATION

Raising Propagules

The stem cuttings are planted directly in the field. Cuttings are obtained from older stems with nodes. Cuttings should

be sown within 24 hours of their removal from the mother plant. Meanwhile, they should be half-dipped in water vertically.

Propagule rate and pretreatment

About 2500 cuttings are required for plantation in 1 hectare of land. No specific treatment is required before planting.

PLANTING IN THE FIELD

Land preparation and fertilizer application

The land is ploughed, harrowed and made weed-free. A basal dose of FYM (farm yard manure) @ 10 tonnes per hectare and half dose of nitrogen (75 kg/ha) are applied at the time of land preparation.

Transplanting and optimum spacing

The stem cuttings with nodes are sown directly in the field. An optimum spacing of 3 m × 3 m is recommended for better yield. The plant requires support to grow, which can be provided by raising wooden stakes or trellis. Already growing shrubs or trees can also support the plant.

Intercropping system

Being a large twiner, it needs a host to twine and covers the host in a very short period. If the stem cuttings with aerial roots are thrown over trees, they start growing and strike roots in the ground.

Cultivation

The plant is very hardy and it can be grown in almost all climates but prefers warm climate. It grows well in almost any type of soils but Medium black soil or red soil is the best for the cultivation of *T. cordifolia*. It can be propagated by seeds and also vegetative cuttings. The best way is vegetative method. The cuttings of the small finger thickness with 6 to 8-inch length long stem having two nodes are used. Promotion of rooting of shoot cuttings by exogenous auxins application in several species has been reported. The cuttings are dipped by quick dip method in 2500 ppm of IBA to get greater success of rooting. This may be planted in poly bags of 4 inch × 6 inch size. The poly bags filled with mud, sand and dry cow dung in the ratio 1:1:1. The rooting of the cuttings takes almost 4 to 5 weeks. The cuttings of *T. cordifolia* will be ready for planting into the main field in the month of May-June. Flowers appear during the summer and fruits during the winter. It requires some support preferably Neem and Mango trees, such plants are supposed to possess better medicinal values. Periodical hoeing is done, both in the nursery and field as per requirement. The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, Farm Yard Manure (FYM), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds and leaves), Chitrakmool, Dhatura, Cow's urine etc. The field after plantation should be irrigated periodically as and when required weekly or fortnightly. Mature plants are collected, cut into small pieces and dried in shade.

SILVICULTURAL AND MANAGEMENT PRACTICES

Interculture and maintenance practices

Follow-up dose of 10 tonnes of FYM with 75 kg nitrogen (50% nitrogen content) is recommended. About two to three weedings and hoeings are required for good growth of twiner. The inter-row spaces between plants should be kept weed-free by frequent weeding and hoeing, as the plants may get suppressed by weeds, especially during early stages of growth.

Weeding and Hoeing

Periodical hoeing is done, both in the nursery and field as per requirement.

Irrigation practices

The crop is grown under rain-fed conditions. However, occasional irrigation during extremes of cold and hot weather may help the crop survive adverse conditions.

Disease and pest control

No serious insect pest infestation or disease has been reported in this crop.

HARVESTING

The stem is harvested during autumn when it develops to a diameter of more than 2.5 cm. Basal part is left for further growth.

POST-HARVEST MANAGEMENT

The stem should be cut into small pieces and dried in shade. It should be stored in gunny bags and kept in cool and airy storage godowns. Stem bark peels off even by touch, thus stem should be cut very cautiously as peeled stem decays very soon.

YIELD

Yield is approximately 8-10 q/ ha and the market rate for one kg. of dried stem ranges from Rs. 15-20. The plant yields about 1500 kg of fresh woody stem, reduced to 300 kg of dry weight per hectare in about two years. Cost of cultivation is estimated to be Rs 27, 600 per hectare.

13 *Terminalia arjuna* (Roxb. ex DC.) Wight. and Arn.

• English Name/ Trade Name :	Arjun
• Common/Local Name :	Arjun
• Family :	Combretaceae
• Part Used (s) :	Stem Bark

Arjun Tree

INTRODUCTION

Commonly known Arjun is common in mixed dry deciduous tropical forests throughout the greater part of India. The fruits and bark possess antioxidant properties and form an important ingredient of many Ayurvedic preparations. Arjuna is a large deciduous tree with spreading crown and drooping branches. It attains a height of up to 35 m. Its bark is thick, grey to pinkish green, smooth, thin, coming off in irregular sheets. Leaves are usually sub-opposite, 10-15 cm long and 4-7 cm broad; base is rounded or heart shaped, often unequal sided; veins are reticulate. Flowers are sessile and occur in simple or panicled spikes. Calyx is glabrous and has five short triangular lobes. Fruit is a fibrous-woody drupe, about 2.5–5 cm in size. It is dark brown when mature and has five hard, projecting, veined wings. Flowering occurs from May to June, while fruits mature from January to March.

Arjun Bark

PROPAGATION OF THE SPECIES

Agro- Technique

Seeds are sown in nursery beds in early summer, usually just after collection. Germination commences in 8–12 days and is completed in seven to eight weeks. Germinated seeds may be transplanted in polybags with clay, manure and sand in equal ratio. Alternatively, the pretreated fruits are directly put in polythene bags in April, with half of the fruit above the soil. Pre-germinated seeds are preferred to save time and ensure uniform germination. The seedlings are sensitive to drought during the germination stage as well as during the growth stage.

Propagule Rate and Pre-treatment

The number of fruits per kg varies from about 200 to 1200, depending on the size of the fruits. Hence, about 4-10 kg of seeds may be required for raising 1 hectare of plantation at a spacing of 6 m × 6 m. The seeds should be pretreated by soaking them in cool water for 48 hours. Alternatively, the seeds may be soaked in boiling water and allowed to cool. The seeds should remain soaked for 24 hours. The germination rate of pretreated seeds is up to 90%, while that of untreated seeds is 50% - 60%.

Land Preparation and Fertilizer Application

Preparatory tillage is done in the field, which should be leveled and pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 6 m × 6 m.

About 10 kg FYM (Farm Yard Manure) and NPK (Nitrogen, Phosphorus and Potassium) @ 75:50:30 g are added per pit and thoroughly mixed with soil as basal dose.

Transplanting and Optimum Spacing

About 10-month-old saplings are transplanted in the field in pits in July–August at a spacing of 6 m × 6 m. About 280–300 saplings are required per hectare.

SILVICULTURAL AND MANAGEMENT PRACTICES

Intercropping System

The crop can be grown as a sole plantation in early growth stage or as a border of other crops. Climbers like *Tinospora cordifolia* (Giloy), *Operculina turpethum* (Trivrit), *Opercullina petaloidea* (Nishoth) and *Celastrus paniculata* (Malkangni) may be planted beneath the fully grown tree that serves as host for these climbers.

Irrigation Practices

Irrigation is recommended at 15-days intervals in the summer season for young plantations. Irrigation is generally not done during the winter season in the peninsular region.

Disease and Pest Control

Aphids (*Aphis* sp.) attack tender leaves and form galls on it. Spraying of bio-pesticides like Azadirachtin controls this pest.

HARVESTING

The Arjun tree starts flowering from sixth year onwards. Lifespan of the tree is 50 years and above. Bark is repeatedly scrapped in winter season. The bark is removed from well- grown trees, preferably 10th year onwards, in spiral or vertical

strips of not more than 5 cm width and 25 cm length.

POST-HARVEST MANAGEMENT

The collected bark is dried in well-ventilated shade and stored in boxes or polybags in dry and airy locations.

YIELD

About 500 kg dried bark can be obtained from 1 hectare of plantation every year from the 10th year.

14 *Withania somnifera* (L.) Dunal.

• English Name/ Trade Name :	Indian Ginseng
• Common/Local Name :	Ashwagandha
• Family :	Solanceae
• Part Used (s) :	Climber shoots

Withania somnifera

INTRODUCTION

It is an important ancient plant, the roots of which have been employed in Indian traditional systems of medicine, Ayurveda and Unani. It is an erect branching under shrub reaching about 1.50 m in height. It grows in dry and sub-tropical regions. Being hardy and drought tolerant species with its enormous biocompounds, its usage is highly regarded in traditional system and continuous to enjoy the monopoly in many parts of India, particularly in Madhya Pradesh. It grows in dry parts in sub-tropical regions. Rajasthan, Punjab, Haryana, Uttar Pradesh, Gujarat, Maharashtra and Madhya

Fruit bearing plant of *W. somnifera*

Roots of *W. somnifera*

Pradesh are the major Ashwagandha producing states of the country. In Madhya Pradesh alone, it is cultivated in more than 5000 hectare. The estimated production of Ashwagandha roots in India is more than 1500 tonnes and the annual requirement is about 7000 tonnes necessitating the increase in its cultivation and higher production.

USE

Ashwagandha is considered to be one of the best rejuvenating agents in Ayurveda. Its roots, seeds and leaves are used in Ayurvedic and Unani medicines. Ashwagandha root drug finds an important place in treatment of rheumatic pain, inflammation of joints, nervous disorders and epilepsy. Dried roots are used as tonic for hiccup, cold, cough, female disorders, as a sedative, in care of senile debility, ulcers, etc. Leaves are applied for carbuncles, inflammation and swellings. Leaf juice is useful in conjunctivitis. Bark decoction is taken for asthma and applied locally to bed sores. Ashwagandha and its extracts are used in preparation of herbal tea, powders, tablets and syrups.

PROPAGATION OF THE SPECIES

- ### Soil

  Ashwagandha grows well in sandy loam or light red soil having pH 7.5 to 8.0 with good drainage. Black soils or heavy soils are suitable for cultivation.

- ### Climate

  It is grown as late rainy season (kharif) crop. The semi-tropical areas receiving 500 to 750 mm rainfall are suitable for its cultivation as rainfed crop. If one or two winter rains are received, the root development improves. The crop requires relatively dry season during its growing period. It can tolerate a temperature range of 20^0C to 38^0C and even low temperature as low as 10^0C. The plant grows from sea level to an altitude of 1500 meter above sea level.

- ### Varieties

  The Jawaharlal Nehru Krishi Vishwa Vidyalay, Madhya Pradesh, has released one high alkaloid variety "Jawahar" which is short in stature and most amenable for high density planting. The variety matures in 180 days and yields a total with alkaloid content of 0.30 per cent in dry roots.

Nursery Raising

It is propagated by seeds. Fresh seeds are sown in well prepared nursery beds. Although it can be sown by broadcast method in the main field, transplanting method is preferred for better quality and export purpose. For export, a well maintained nursery is a prerequisite. The nursery bed usually raised from ground level is prepared by thorough mixing with compost and sand. About 5 kg of seeds are required for planting in 1 hectare of the land. Nursery is raised in the month of June-July. Seeds are treated in carbendazim to control wilt and seed borne diseases. Seeds are sown just before the onset of monsoon and covered thinly using sand. The seeds germinate in 5 to 7 days. About 35 days old seedlings are transplanted in the main field.

Field Preparation

2 to 3 ploughing and harrowing should be done before rains. The land is well ploughed and pulverized and brought to a fine tilth. 10 to 20 tonnes farm yard manure is applied. Field is then levelled.

Transplantation and Planting Density

After the manures are incorporated in the soil, ridges are prepared at 60 cm spacing. Healthy seedlings are planted at 30 cm spacing. In some places, 60 cm x 60 cm or 45 cm x 30 cm spacing is also followed. However, a spacing of 60 cm x 30 cm with a plant population of about 55000 seedlings per hectare is considered optimum.

- Seed Rate and Sowing Method

A seed rate of 10 to 12 kg per ha is sufficient for broadcasting method. They can be sown in lines also. Line to line method is preferred as it increases root production and helps in performing intercultural operations smoothly. The seeds are usually sown about 1 to 3 cm deep. Seeds should be covered with light soil in both the methods. Line to line distance of 20 to 25 cm and plant to plant distance of 8 to 10 cm should be maintained.

SILVICULTURAL AND MANAGEMENT PRACTICES

Seed Treatment

Seed should be treated with thirum or dithane M45 (Indofil M45) at the rate of 3 g/kg seed before sowing to protect the seedlings from the seed borne diseases.

Thinning and Weeding

Seedlings raised by broadcasting sowing method or in line in furrows should be thinned out by hand after 25 to 30 days of sowing the seeds to maintain a plant population of about 30 to 60 plants per sq.m. The plant density to be maintained finally may depend on the nature and fertility of the soil. On marginal soil, the population is maintained high. If some fertilizer is applied, the population should preferably be kept at lower level. Generally two weedings are required to keep the field free from weeds, the first within 20-25 days of sowing and the second after 20-25 days of the first weeding.

Manures and Fertilizers

The crop does not require heavy doses of manures and fertilizers. It responds well to organic manures and addition of 10 tonnes FYM or 1 tonne vermi-compost per hectare is recommended. Application of 15 kg of Nitrogen and 15 kg of Phosphorous per hectare is beneficial for higher production.

Irrigation

Excessive rainfall or water is harmful for this crop. Light shower after transplantation ensures better establishment of seedlings. Life saving irrigation may be applied, if required. Under irrigated conditions, the crop can be irrigated once in 10 days.

Pests and Diseases Management

No serious pest is reported in this crop. Whenever the crop is damaged by insect, 2 to 3 sprays of rogor or nuvan should be applied @ 0.6%. A combination of 0.5% malathion and 0.1% - 0.3% kelthane as foliar spray at 10-15 days interval was found highly useful for aphids, mites and insect attack. Diseases like seedling rock and blight are observed. Seedling mortality becomes severe under high temperature and humid conditions. Disease can be minimised by use of disease free seeds and by giving seed proper treatment before sowing as stated earlier. Carbofuran should be applied @ 2-2.5 kg/ha at the time of sowing. Neem cake also can be applied. It will save root damage done by nematodes and insects.Further, adoption of crop rotation, timely sowing and keeping field well drained also protect the crop.

HARVESTING

Maturity of the crop is judged by drying out of leaves and yellow-red berries. Flowering and bearing of fruits start from December onwards. The crop is harvested for roots by digging in January to March i.e. 150 to 180 days after sowing. There should be moisture in soil at the time of digging. Roots are dug out or ploughed using power tiller or a country plough. The tap root should be carefully pulled out not damaging even the small lateral roots.

POST HARVEST MANAGEMENT

The roots are separated from the aerial portion by cutting the stem 1 to 2 cm above the ground. After digging, the roots are washed, cut into 7 to 10 cm small pieces and dried in sun or shed. Roots should be dried to 10 - 12 % moisture content. Root pieces can be graded in following 3-4 grades as per its length and thickness:

- A Grade Root : Root pieces upto 7cm and diameter 1.0 - 1.5 cm, solid, bright and pure white
- B Grade Root : Root piece upto 5 cm and diameter 1 cm, bright and white
- C Grade Root : Root pieces upto 3-4 cms in length, diameter less than 1 cm, solid, side branches
- Lower Grade : Small root pieces, semi-solid, very thick, yellowish, chopped

The superior grade has stout and long root which fetches premium price. To avoid moisture and fungal attack on the dried roots, it should be stored in tin containers.

Berries are hand plucked separately. They are dried and crushed to take out the seeds.

YIELD

On an average, the yield from 1 hectare of commercial cultivation is approximately 3 to 5 q. of dry roots and 50 to 75 kg of seeds. A maximum yield can be procured upto 6.5 to 7.0 q/ha. There are instances where farmers have achieved root yields as high as 1 tonne. Commercially, 6 to 15 mm diameter and 7 to 10 cm length root species are better. Alkaloid percentage in roots ranges from 0.13 to 0.31%.

MARKETING

The Neemuch and Mandasaur markets of Madhya Pradesh are popular world over for Ashwagandha. Importers, buyers within the country, processors, traditional practitioners, Ayurvedic and Siddha Drug manufacturers throng these markets for procurement of Ashwagandha roots every year. The domestic demand for Ashwagandha roots as stated earlier is about 7000 tonnes annually. As the production is much less (around 1500 tonnes) in India, the internal market itself is highly potential.

D INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY (IWST) BANGALURU

15 *Ailanthus malabarica* DC.

• English Name/ Trade Name :	*Ailanthus,* Halmaddi
• Common/Local Name :	Guggul dhup, Baga-dhoopa, Hal-maddi, Mahanimba, Perumaram, Peddamanu
• Family :	Simaroubaceae
• Part Used (s) :	Roots, leaves, bark and gum exudates

Ailanthus malabarica

INTRODUCTION

Ailanthus malabarica is a medium to tall evergreen rainforest tree found in Asia and Australia. The wood may be used for matchwood and plywood.

GEOGRAPHICAL DISTRIBUTION

A. malabarica is native to India, Myanmar and Nepal. In India, it is mostly found in wet evergreen climax forests of the Western Ghats, from the Konkan, North Kanara and Karnataka southwards to Travancore. It is also found in Sri Lanka, China, Cambodia, Vietnam, Thailand, Malaysia and Australia.

Ailanthus Tree

BOTANICAL DESCRIPTION

Trees of *Ailanthus* are large, deciduous, 30-40 m high; bark grey, rough. Leaves crowded, mostly paripinnate, 20 - 70 cm long; leaflets 6 - 10 pairs, opposite or alternate or sub opposite, falcate, obliquely ovate-oblong or oblong-lanceolate, unequal at base, acute or acuminate at apex, entire or wavy along margins, glabrous, glaucous beneath.(Orwa *et al.*, 2009). Flowers are present in dense axillary branched, pubescent 20 - 50 cm long panicles; bracts small, caducous.

USES

- ### Traditional Uses

  The bark and leaves are renowned as a tonic, especially in debility after childbirth; they also possess febrifuge properties and are useful in dyspeptic complaints. Resin from the bark is used in asthma, bronchial affections, dysentery; bark decoction is used in typhoid and constipation.

- ### Therapeutic Uses

  The bark is used in dysentery and diarrhea, leucorrhoea etc. The leaves and bark in powder or in the form of an aqueous or of an alcoholic extract is used in removing the tape-worm. Root bark is used for cardiac palpitation, asthma and epilepsy.

PROPAGATION OF THE SPECIES

It is propagated by direct sowing. It has been raised successfully by planting nursery-raised seedlings. *Ailanthus* trees flower in February-March and the fruits ripen in March-April, which is ideal time for seed collection. The seeds can be stored only for a few months. Alternate wetting and drying improves seed germination. The procedure involves soaking the entire quantity of seeds in water in the evening and draining the water next morning, followed by drying the seeds under shade during the day. The cycle is repeated for two to three days.

Nursery Practices

Raised beds of 10 m x 1 m size are formed. Preferably sand, soil and farm yard manure (1:1:1 ratio) must form the top layer of the beds. Sowing is done after the bed is watered. Usually sowing is done by broadcast method (or dibbling) in November-December, for June planting and in March-April for October-November planting. After sowing, a thin layer of soil is sprinkled on the beds to cover the seeds. The beds are also mulched with green leaves to reduce the evaporation losses and dusted with carbaryl 10 per cent to prevent insect attack. After sowing, watering is done with a fine rose-can twice a day for 10-15 days and once a day afterwards.

Pricking Out

Germination takes place in about 8-10 days after sowing and the seedlings attain a height of 10-15 cm in six weeks time. They are then pricked out into polythene bags containing 1:1:1 mixture of sand, soil and farm yard manure.

Planting

Containerized stock (commonly in polybags, but also in root trainers) is planted in pits (25-30 cm^3) at 2 x 2 m spacing with the onset of rains

SILVICULTURAL AND MANAGEMENT PRACTICES

Weeding

Seedlings are vulnerable to weeds and shade. Two to three weedings may be necessary in the initial years to keep the plantation weed -free.

Fertilizer Application

Fertilizers may be applied at 30-40 g N, 15-20 g P_2O_5 and 15-20 g K_2O per year per sapling from the second year to the fifth year and thereafter once in three years for a pure plantation.

Disease Management

The two major pests are of the species are shoot webber (*Alteva fabriciella*) and defoliator (*Eligma narcissus*). Shoot Webber is economically more important because it damages the terminal shoot and can result in epicormic branch formation. It can be controlled by application of monocrotophos, quinalphos or methyl parathion at 0.05%.

HARVESTING

The trees can be harvested after the age of 8 to 10 years.

YIELD AND ECONOMICS

The data from Puttur range, Karnataka Forest Department shows that on an average the Oleoresin (Halmaddi yield) is 65 kg/ha and it is sold for Rs 950 /kg in market and major buyers are Agarbathi industries.

16 *Cinnamomum zeylanicum* Blume

• English Name/ Trade Name :	Cinnamon
• Common/Local Name :	Cinnamon, Tez part, Dalchini
• Family :	Lauraceae
• Part Used (s) :	Bark

Cinnamomum zeylanicum

INTRODUCTION

Cinnamomum zeylanicum is an ancient, aromatic highly prized spice. The cinnamons of the market are the inner barks obtained from trees of tropical countries and islands. It is used as a spice in our day to day life. It is principally employed in culinary as a condiment and flavoring agent. It has been acquainted as one of the healthiest spices and has medicinal properties. When it is checked for chemical constituents it reveals phenolic, flavonoid and carotenoid contents. They contain rich amount of polyphenols which are powerful antioxidants. It reduces the growth of cancer cells.

GEOGRAPHICAL DISTRIBUTION

Cinnamon is mostly cultivated in Sri Lanka, Malagasy Republic and Seychelles. It has originated in the central hills of Sri Lanka. In India, it is grown in one or two locations in Kerala. Cinnamon is a hardy plant and is cultivated in Sri Lanka under varying conditions ranging from semi-dried to wet zone conditions. The ideal temperature for growing cinnamon is between 20-30°C and rainfall between 1250 to 2500 mm.

BOTANICAL DESCRIPTION

It is an evergreen tree, attaining the height of about 6-8 m with thick, smooth, reddish brown bark. Opposite or sub-opposite leaves are ovate or ovate-lanceolate, hard and coriaceous, glabrous and shining above, slightly pale beneath with 3-5 main nerves. It has many minute flowers in axillary or sub-terminal cymes or panicles. Fruit is ovate or oblong, about 1.5 - 2 cm long, minutely apiculate, dry or slightly fleshy and dark purple in colour with single seed and persistent perianth. The whole plant gives the characteristic smell of eugenol when crushed.

USES

- The branches of the trees are lopped and their bark removed; the dried inner bark which is acrid, bitter, sweet and

aromatic constitutes the drug Cinnamon (Vangalapati *et al.*, 2012). The drug prepared is reported to be used in treating bronchitis, asthma, nausea, vomiting, flatulence, fever and for restoring normal skin, etc

- Cinnamon oil is used as a stomachic and carminative, (Jakhetia *et al.*, 2010)
- It cures gas, debility and flatulence; and also has the property of destroying certain germs and fungi
- The paste made of bark with lemon juice is applied for the pimples as herbal medicine; also the chewing of bark is very helpful in case of foul smell from the mouth
- It is reported to be useful in inflammations, vomiting and tubercular ulcers and diabetes. (Rao and Gan, 2014).

PROPAGATION

Soil and Climate

Sandy or lateritic soils with high humus are suitable for the species. The type of soil has a pronounced effect on the bark quality. Water-logged and marshy areas should be avoided, as they result in an undesirable, bitter product, which is less aromatic. Species can be grown up to an altitude of 800 - 1000 m amsl receiving an annual rainfall of 150 to 250 cm. It requires a warm and wet climate with an average temperature of about 27ºC and no extremes of heat or cold.

Propagation

Seeds / Semi Hardwood Cuttings.

- Seed: Seeds should be collected as soon as it ripe and must be sown immediately as seeds have less viability. Before sowing pulp should be removed as it inhibits germination. Seeds can be sown in July –August in the nursery beds and later on transplanted in poly bags. Germination can take 1 - 6 months at 20ºC. The seeds may be sown in nurseries or directly in the field. Nursery beds should be well-prepared having rich sandy soil free from roots and stones, with an adequate supply of fresh water nearby and be lightly shaded. After about 4 months, clumps of seedlings may be transplanted into baskets and are planted out 4 or 5 months later. Alternatively, the seedlings may be left in the nursery until the final transplanting (Rema *et al.*, 1997). The hardening process before transplantation in the field should be carried by exposing seedlings to open conditions.
- Planting: One year old seedlings are planted in pit size of 60 cm^3 at the spacing of 2 m x 2 m during rainy seasons. It is advisable to fill pits with top soil and FYM.

SILVICULTURAL AND MANAGEMENT PRACTICES

Irrigation

Watering during summer is beneficial. Watering of newly planted seedling is done periodically.

Weeding

In the first 3-4 years, weeding is done 3-4 times in a year. Subsequently one or two weedings are required.

Manure & Fertilizer

1st year: 20 g N, 18 g P_20_5 and 25 g K_20/ seedling.

Three years after Planting

29 kg F.Y.M., 4 kg neem cake, 150 g N, 75 g P_2O_5 and 150 g K_2O per plant should be applied (Thantsin *et al.*, 2008). The fertilizers are applied in two doses during first week of September and in March.

After Care

Immediately after transplanting, provision of temporary partial shade should be made by erecting a small pandal. Young trees are cut close to the ground to produce side shoots.

Disease Management

- Shoot Borer: Shoot borer can be controlled by smearing the stem and branches with Carbaryl 50 WP @ 2 g/lit of water once in a month.
- Leaf eating caterpillar, red ants and termites can be controlled by dusting the plant with Methyl parathion 1.3%.
- Leaf spot can be controlled by spraying 1 % Bordeaux mixture or 0.25 % copper oxy chloride (Grunewald *et al.*, 2010).

HARVESTING

Cinnamon is harvested by growing the tree for two years and after that practice of coppicing is followed to produce more branches. Two-year-old plants are coppiced during June–July to a height of about 15 cm from the stump. Afterwards, main stem produces a bunch of side shoots and subsequently the plants assume the shape of a low bush of about 2 m height and a bunch of canes suitable for peeling crop up in a period of about 4 years. Regular peeling operations could be commenced in case of seedling bushes, from fourth or fifth year onwards, depending upon the extent of development of peeler shoots. Usually coppicing is done in alternate years.

Cinnamon is ready for harvesting after 2-3 years from planting when the plant reaches height of 1.5-2 m with three to four shoots and the bark turns brown in colour. The main shoot is coppiced or cut back to a height of about 6 cm from ground level. Two to three crops are taken annually depending upon the rainfall. Ideal time for harvesting shoots is from September to November. Side shoots having finger thickness and uniform brown colour are ideal for bark extraction. A 'test cut' can be made on the stem with a sharp knife to judge the suitability of time of peeling. If the bark separates readily, the cutting can be commenced immediately. Harvested shoots are bundled together and transported to the pack house for further post harvest procedures.

POST HARVEST MANAGEMENT

The post harvest include following steps:

- Peeling of the inner bark
- Drying of the peels
- Grading of cinnamon rolls
- Preparation of cinnamon powder

YIELD

The expected yield of bark is 56-67 kg/ha after 3-4 years, subsequently increasing to 168-224 kg/ha. About 63 kg/ha of chips and approximately 2.5 tonnes/ha of undried leaves can also be obtained. 35 kg of leaf oil/ha/year can be obtained.

ECONOMICS

The marketable produce is the inner barks obtained from trees of tropical countries and islands. *C. zeylanicum* is an ancient, highly prized spice. The genus *Cinnamomum* is of considerable economic importance, cultivated for its bark which is used as a spice, in perfumery and also in ayurvedic and traditional Chinese medicine for its hypoglycemic, digestive, antispasmodic and antiseptic properties. About 75 kg of quillings and featherings are obtained. Further, ton of leaves which yield 1 to 1.25 kg of oil are obtained per year. The cinnamon bark costs up to Rs 650/ Kg.

17 *Embelia ribes* Burm.f.

• English Name/ Trade Name :	False Black pepper, White-flowered embelia
• Common/Local Name :	Vidanga, Baoberang, Embelia
• Family :	Myrsinaceae
• Part Used (s) :	Froots and Roots

Embelia ribes

INTRODUCTION

Embelia ribes is commonly known as False Black Pepper or White-flowered *Embelia*. It was originally described by Nicolaas Laurens Burman in his 1768 publication, *Flora Indica*. In India, it is one of the widely and commonly used Ayurvedic herbs (Ved and Goraya, 2007). *Embelia ribes* have a long history of use in ayurvedic system of medicine in various forms like churna, asava, aristha, lauha, bati and taila. This species is reported to be vulnerable in the Western Ghats of Tamil Nadu and Karnataka states of India and at a lower risk in Kerala state of peninsular India. It is considered to be vulnerable due to excessive harvesting.

GEOGRAPHICAL DISTRIBUTION

E. ribes is highly restricted to hilly parts of India up to 1500 m elevation from outer Himalayas to Western Ghats. It is also found in Sri Lanka, Singapore, South China and Malayan archipelago. It is also distributed in moist deciduous forests of the Western Ghats of South India, Jammu and Kashmir, Arunachal Pradesh, Himachal Pradesh, Madhya Pradesh, Uttar Pradesh, Assam and Maharashtra.

BOTANICAL DESCRIPTION

E. ribes is a large scandent shrub; branches are long, slender, flexible and terete with long internodes, the bark studded with lenticels. Leaves coriaceous, elliptic or elliptic lanceolate (Raghu *et al.*, 2006). Shortly and obtusely acuminate, entire, glabrous on both sides, shining above, paler and somewhat silvery beneath, the whole surface covered with scattered minute reddish sunken gland, base rounded or acute; main nerves numerous, slender; petioles 6-16 mm. long, more or less margined, glabrous. Flowers pentamerous, numerous, small, in panicled racemes which are terminal and from the upper axils; branches of the panicle often 7.5-10 cm long with more or less glandular pubescent; bracts minute, setaceous, deciduous. Fruit is globose, 3-4 mm in diameter; smooth, succulent, black when ripe.

USES

The fruits of *E. ribes* are known as Baibidang and are recommended for relieving headache, rhinitis, haemorrhage, epilepsy and insomnia. The decoction of dried fruits is used for fever and for chest and skin disease. Paste is applied for skin infection (Suthar, 2009). The drug also exhibits significant anti-fertility, antipyretic and antibacterial activity (Sharma, 2002). The fruit powder, when taken with milk, followed by a purgative has been one of the ancient remedies to get rid of tapeworms. An infusion of the roots is given in the treatment of cough and diarrhoea. Fruits show antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*.

PROPAGATION

Soil and Climate

The plant can be grown in variety of soils including light black cotton soil, sandy or rocky in different agro-climatic conditions in tropical regions up to 800-1500 m altitude. The optimum temperature required for the crop is 18ºC-35ºC, with annual precipitation of 700 to 1500 mm.

Seed Collection

The ideal time for seed collection is from June to August. Mature seeds of *E. ribes* are purple to black (Khan *et al.*, 2010). Propagation can be done through seeds and through stem cuttings.

By Seeds

Matured and ripened fruits are packed in polythene covers and placed under the artificial light source for 8 h per day. The cycle is continued for a period of 4-5 days. Pre sowing treatment of H_2SO_4 @10% for 10 min + GA_3 (4000 ppm) is the best treatment for *E. ribes*. By this method, 40 per cent seed germination can be achieved successfully. Sand media are sufficient to achieve the seed germination. Sand bed with at least 9 cm thickness prepared in large tray is sufficient for raising seedlings under nursery conditions. Seeds are sown in a row inside the handmade furrows. Uniform and thin layer of sand should be spread over the seeds. Immediate watering should be done. The trays thus prepared should be placed inside the poly tunnel. Watering should be done regularly or as and when required. Compost/vermi compost and organic manure are preferred. Seed germination starts after 50 days of sowing.

Through Stem Cuttings

Pencil sized stem cuttings of 1.0-1.5 cm thickness bearing 3 nodes are planted 3 cm deep in polybags and kept in shade. Cuttings are treated with two types of root regulators such as Indole Butyric Acid (IBA), 200 ppm and commercial quick root solution before planting. Post-monsoon season is the best time for collection of stem cuttings. Pre treated stem cuttings are placed in root trainers and transferred to poly chambers. Rooting media is prepared from sand, coir pith and perlite. Microclimate with ambient condition is created inside the micro-poly chambers. By this method nearly 10 per cent of the stem cuttings sprout immediately. The rooting commences only after 35-40 days and within 3 weeks one or two axillary buds above the leaf scars develop and grow into branches. After the formation of healthy root system, it is ready for transplanting.

Seedling Growth and Nutrient Management

Once the plants attain considerable growth, it should be transferred to polythene bags of bigger size. Periodical watering and weeding should be done. Additional boosting nutrients are necessary. The plants are also resistant to diseases and pests and hence protective sprays are not necessary. Seedlings should be nurtured under the nursery conditions until they are transferred to fields. About 50 kg seeds are required for preparing 10,000 plants.

Development in the Nursery

After thirty days seedlings should be transferred to polythene covers as soon as the radical growth begins. Polythene bags of 12 x18 cm size are ideal for transplanting. A potting mixture made out of sand, soil and farm yard manure in a ratio of 1: 1: 0.5 acts as good potting media. Seedlings should be protected from scorching sunlight by using shade

nets. Watering, weeding and shifting should be done as and when required. Capton (0.05%) is sprayed over the seedlings to protect plants from fungal infection.

Transplantation and Planting Density

The seedlings raised in polythene bags under nursery conditions can be transferred to natural conditions immediately. Area with partial shade is preferred for this species. June and July are ideal for planting. Since it is a woody climber supporting tree is required. Saplings should be planted next to tree species as it requires shade in the initial stages. Saplings of one year and above can be easily transferred to the fields. Pits of 15 to 30 cm^3 size should be made and filled with FYM, sand and forest soil (1: 1: 0.5). Soil should be tightened properly. The pit size should be always 2-3 times wider than the root balls. Saplings can be planted at a spacing of 2-5 m distance. Saucers should be made around the planting place so that water supplied or obtained naturally will trickle down into the hole and helps in growth of saplings. The plantation can be irrigated usually at an interval of 15 days. Harvesting is done after two years. The fruits are collected, dried in shade and stored in clean porous Jute-bags. The fruits are collected manually and the plant is allowed to grow further. Weeding and thinning of plants may be done as and when required usually after 15- 30 days for better growth of plants.

Disease and Pest Control/ Plant Protection

No major disease and pest is noted in the species. However, in case of severe infestation, bio-control measures are to be adopted.

Tissue Culture

Direct shoot organogenesis from leaf explants of *E. ribes* was reported by Raghu *et al.*, 2006. The in vitro procedure involved three steps that included induction of shoot initials from leaf tissue, regeneration and elongation of shoots from shoot initialsand rooting of shoots. The induction of shoot initials was achieved on Murashige and Skoog (MS) solid medium supplemented with different concentrations of thidiazuron (TDZ). The best medium for shoot induction was MS with 0.272 ìM TDZ. Numerous shoot primordia were observed within 2–3 weeks on leaf margin as well as on the midrib region, without any callus phase. In second step, the shoot clumps are seperated from the leaf explant on transfer to MS basal medium, resulting in differentiation of 90 per cent of the shoot initials into well-developed shoots. The 2 to 3 cm long shoots rooted on half-strength MS basal medium supplemented with 4.90ìM indole-3-butyric acid (IBA) and 3 per cent (w/v) sucrose in the third stage. The rooted plants could be established in soil with 70 per cent success. This protocol could be utilized for in vitro propagation and conservation of this important threatened medicinal plant.

YIELD AND ECONOMICS

The crop yield is 190-200 kg seeds per hectare. Rs. 42,500/- is the cost of cultivation for one hectare.

Vidanga is one of the most traded plants in volume with demand of > 100 metric tons/annum. The commercial importance of this plant drug is also confirmed by the study conducted by CERPA, New Delhi, under the aegis of Dept. of ISM and H (Indian System of Medicine and Homoeopathy) in 2000-2001. This study estimated the domestic consumption of Vidanga to be about 400 tons, valued approximately at Rs. 40 million, for 1999-2000 and is one of the top 50 traded plant drugs in India. Demand for Vidanga seeds saw a steep increase in this period, as its export market, especially to Middle Eastern countries, increased tremendously and rates went up to Rs. 200/kg. A study by FRLHT estimated the annual growth rate of about 23 per cent and projected demand to touch 1000 tons in near future.

18 *Garcinia indica* (Thwars) Choisy

• English Name/ Trade Name :	Goa butter tree Garcinia, Kokum
• Common/Local Name :	Kokum
• Family :	Clusiaceae
• Part Used (s) :	Fruits

Garcinia indica

INTRODUCTION

Garcinia indica is an Indian spice used in many parts of the country for making several vegetarian and non-vegetarian 'curry' preparations, including the popular 'solkadhi. The fruits are steeped in sugar syrup to make 'Amrut kokam', a healthy soft drink to relieve sunstroke, which is popular during summer. It is a traditional home remedy in case of flatulence, heat strokes and infections. Many therapeutic effects of the fruit have been described in traditional medicine based on Ayurveda (Elumalai and Eswaraiah, 2011). These include its usefulness as an infusion, in skin ailments such as rashes caused by allergies; treatment of burns, scalds and chaffed skin; to relieve sunstroke; remedy for dysentery and mucous diarrhoea; an appetizer and a good liver tonic; to improve appetite and to allay thirst; as a cardio-tonic and for bleeding, piles, dysentery, tumours and heart disease.

It requires a warm and humid tropical climate. It thrives well in coastal areas receiving over 250 cm of rainfall. It grows well in lateritic, alluvial soils having depth of 1.0 m and pH of 6.7. It has a generation length of 29 years.

GEOGRAPHICAL DISTRIBUTION

It is found in Maharashtra, Goa, Karnataka, Kerala, South Gujarat, Assam and West Bengal. In Karnataka it occurs along windward side of the Western Ghats in Dakshina Kannada, Coorg, Chickamagalur, Shimoga and Uttara Kannada districts. In Tamil Nadu, it is absent in the wild but planted in Nilgiris. In Maharashtra, it is common along the entire coastal forest and Western Ghats. It is abundant almost throughout Goa.

BOTANICAL DESCRIPTION

Kokum is a tree with a dense canopy of green leaves and red-tinged tender emerging leaves. The tree is large and handsome, having elliptic, oblong or oblong-lanceolate, deep-green glossy leaves, 5.5-8 cm long and 2.5-3 cm broad.

The flowers are fleshy, dark pink, solitary or in spreading cluster. The fruit is brownish or brownish-gray, marbled with yellow and is crowned by the 4-parted, stalk-less stigma. Seeds are 6 to 8 in number and the pulp is juicy, whiteand delicious in taste and odor. Unripe fruits are green and turn purple on ripening

USES

The Kokum rind is used widely in refreshing drinks and curries. The fruit is anthelmintic, cardio tonic, useful against piles, dysentery and is a heart tonic. Hydroxyl Citric Acid (HCA) extracted from Kokum is a fat-reducing medicine used against obesity and is available in the form of tablets in the market. The dry rind (Amsul) is mainly used for garnishing and is a good substitute of tamarind. The fruit can also be used for the manufacture of wine and liquor and could be a good substitute of grapes in the wine industry. The anthocyanin pigments obtained from it are used as natural colouring agents for food preservation. The edible fat 'Kokum butter' obtained from the seed kernels is used in the manufacture of soaps, candles ointments and pharmaceutical preparation especially in skin care products due to its ability to soften the skin and heal ulcers and also fissures on lips, hands and feet. It reduces the degradation of skin cells and restores elasticity. Kokum fruit contains compounds that have antioxidant, anti-bacterial and antifungal properties. The fruits are soaked in jiggery (sugar) syrup to prepare kokum juice, a refreshing and healthy drink.

PROPAGATION

Seed

The seed of most members of the genus are slow to germinate, even if sown fresh, often taking 6 months or more to germinate.

Planting Season

Pits of 60 cm^3 should be made during summer at 6x6 m distance and filled with well decomposed FYM and top soil at a ratio of 1:3 and 1 kg superphosphate. The planting of sapling be done at the onset of monsoon in June. At the time of planting 100 g carbaryl dust (10 %) should be mixed in each pit to avoid termite attack.

SILVICULTURAL AND MANAGEMENT PRACTICES

Inter-Culturing

Short duration, low growing, inter crops like cowpea or vegetables can be grown during first four five years with the species.

After Care

Young plants should be given support of bamboo sticks. Shoots arising from the main stem just before the bud /graft joint be removed regularly. Wherever, possible young saplings should be irrigated during dry period and summer months for initial 2/3 years. It is necessary to maintain 10 per cent male plants in an orchard for pollination.

Irrigation

Normally grown as rain-fed crop. Hence irrigations are required only during long dry spells.

Manures, Fertilizers and Pesticides

The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, Farm Yard Manure (FYM), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. For a period of One year, 2 kg FYM + 50 g nitrogen + 25 g phosphorus + 25 g potash should be supplied to the crop during August- September. The quantity should be increased by 2 kg FYM + 50 g nitrogen + 25 g each of phosphorus and potash every year. From 10 years onwards each tree should be supplied with 20 kg FYM + 500 g nitrogen and 250 g each of phosphorus and potash during August-September.

Disease Management

No serious pests/ diseases are reported in the species (Prajakta *et al.*, 2015). However to control incidences of disease, bio-pesticides should be prepared (either single or mixture) from Neem (kernel, seeds and leaves), Chitrakmool, Dhatura, Cow's urine etc.

HARVESTING

Seedling trees start fruiting after 7-8 years, while grafted/ budded plants bear fruits after 4-5 years. Flowering starts in October-November and continues up to February-March. Fruits are ready for harvest during April-May. Red ripe fruits are harvested with the help of 'Atul' harvester specially developed for this purpose by Konkan Krishi Vidyapeeth, Dapoli.

YIELD

Ripe fruit yield is 8.5 ton per hectare.

ECONOMICS

Expenditure per ha	:	Rs. 13,000/-
Return per ha	:	Rs. 47,300/-
Net income	:	Rs.34,300/-

(Market for medicinal plants is volatile and the economics may vary)

19 *Rubia cordifolia* Linn

• English Name/ Trade Name :	Indian Madder, Manjit
• Common/Local Name :	Common Madder and Manjista
• Family :	Rubiaceae
• Part Used (s) :	Roots

Rubia cordifolia

INTRODUCTION

Rubia cordifolia is a perennial, herbaceous prickly climber with long and cylindrical root with a thin red bark, well known for its versatile action.

GEOGRAPHICAL DISTRIBUTION

Indian Madder is found throughout the Himalayas, at altitudes of 300-2800 m. It is also found in the Western Ghats, Sri Lanka, Korea, Mongolia, Russia and Asia. *R. cordifolia* has a wide ecological adaptability (Dev, 2006). It is found in forest edges and clearings, scrub vegetation and dune forest, less commonly in grassland or open, rocky areas, from sea-level up to 2600 m altitude.

BOTANICAL DESCRIPTION

Manjista is a perennial, herbaceous climber with very long, cylindrical roots having a thin red bark. Stem is long, rough, slightly woody at the base, quadrangular and glabrous. Branches climb by means of numerous prickles. Leaves are heart shaped, about 5–10 cm in size, five-nerved from the leaf base and occur in whorls of four. Petiole is roughly triangular with many sharp recurved prickles on the edges. Flowers are small, yellow, scaly and occur in terminal cymes. (Chang *et al.*,2000). Bracts are ovate and leafy. Calyx is tubular, less than 1 cm long. Corolla is a greenish, divided to the base,

tubular with five lobes and about 3 mm long. Fruits are 4–6 mm in diameter, globose, smooth, shining, violet or purple black in colour with grey black seeds. Flowering occurs in August–September and fruiting in October–November.

USES

Manjistha is highly recommended in skin diseases associated with edema. The wound and ulcers dressed with Manjistha heal promptly and get dried up and well cleansed. One of its unique actions is anti-acne effect through anti-bacterial, anti-inflammatory, anti-oxidant and anti-androgen action.(Zhao *et al.*, 2011).The roots and stems are well known source of Anthraquinones, the roots have also been reported as antioxidant, anti-inflammatory, anticancer, immune-modulator and hepato-protective and are extensively used against blood, urinary and skin diseases.(Nadkarni, 2000). In ancient world, Manjistha is reputed as an efficient blood purifier and hence is extensively used against blood, skin and urinary diseases.

PROPAGATION

Soil and Climate

It can be grown in loamy soil rich in humus. The plant grows in such areas which receives heavy rainfall. Plant requires light shade.

Nursery Raising

It can be propagated by seed, cuttings and micro-propagation methods. The seeds can be collected from healthy, mature, plants in the August-September depending on the flowering season. The mature seeds are brownish-black and crescent shaped and should be collected and dried in partially shaded conditions before storage. The moisture content of the seeds should be minimum for optimal storage and maximum viability.

Nursery land is deeply ploughed twice or thrice to break the soil. Well rotten farmyard manure is mixed to an adequate amount. For seed propagation, the seed beds of standard size are prepared. Seeds are sown in line in the seedbeds and irrigated after the seed sowing. Beds of uniform size are prepared across the slope of the land depending on the area and shape of the land available. Raised beds can be prepared in areas of heavy rainfall or precipitation. The height of such beds should be determined by the soil texture and water holding capacity. The normal height for a raised bed should be 15-20 cm in areas of moderately heavy rainfall to facilitate the seepage of water into deeper layers of soil. Raised beds of 10-15 cm height can be prepared in high precipitation areas with a predominantly sandy soil. A preferable bed size of 4.5 x 6 feet is ideal in case of nurseries to facilitate tending and inter-cultural operations. Sunken beds are advisable for cold desert areas with low rainfall and precipitation rates. Sowing is done in lines at fixed spacing and depths of 1-2 cm. A layer of topsoil should be placed over the seeds prior to irrigation. Placing the seeds at depths greater than the recommended can lead to poor germination or increased mean germination time for the species. Light irrigation is necessary after seed sowing in the beds. The seedlings are picked out when they are large enough to handle and grow them on in light shade in the greenhouse for the first year.

Seed Treatment and Germination

Seed germination under ideal agronomic and weather conditions (20-25ºC) occurs from the 14^{th}-21^{st} day after sowing. Irrigation is recommended at weekly intervals to maintain moist conditions in the beds. In case of high solar radiation, leaf mulching can be done to avoid drying up of the plant or germinated seedling.

Vegetative Propagation

Root cutting is done in spring or at any time in the growing season and care is taken to keep the cuttings well watered

until they are established. The larger seedling can be planted out direct in the field and the smaller maintained in the nursery and planted in the summer.

Transplantation

Transplanting can be done after the crop attains a sufficient root girth by the end of 6-8 months. However, under field conditions, successful transplantation can be obtained in case of one-year old plants.

Intercropping

The plant is a climber and may be intercropped with shrubby perennial species.

SILVICULTURAL AND MANAGEMENT PRACTICES

Irrigation

The seedlings require frequent irrigation once a week or 10 days in the initial stages. The frequency can be extended to once in 10-14 days after the crop attains leaf differentiation. Light irrigation should be followed in the post-sowing phase to avoid erosion of nutrients and seeds. In areas with greater slopes and steeper gradients, a controlled irrigation once in 10-14 days is advisable. The number of irrigations depends on the stage of growth, soil texture and availability of irrigation.

Weed and Pest Control

Regular weeding in the initial stages of crop-establishment is necessary. Weeding once in 25 days would be ideal, as it would help to check the regeneration of weed growth. Weeding should be done after a light irrigation in the field, as it would help in easy uprooting of the weeds.

Powdery mildew infestation in the species can be controlled by application of sulphur-containing compounds of organic or inorganic nature. Common biocontrol agents used in the high altitude regions include neem oil and *Artemisia* based extracts. A prophylactic spray of neem-based formulations on a monthly basis is advisable for areas adjoining cultivated fields or areas with sizable weed population. Burning of weed and crop stubbles before seed sowing, avoiding water stagnation in the field can help in control of spread of pests and diseases.

HARVESTING

A light irrigation is given prior to the harvest of the roots. The roots are harvested in autumn from plants that are at least 3 years old. They are cut into small pieces, peeled and then dried. The roots can also be dug out and collected in mid-August to mid-September.

POST HARVEST MANAGEMENT

The harvested roots are washed thoroughly in running water and dried under partial shade. A moisture level of 18-22% should be maintained for longer shelf life of the roots (Verma *et al.*,2016). They are kept in closed containers or gunny bags to retain the aroma.

YIELD

Yield and cost of cultivation about 3 tonnes of dry root is obtained per hectare of cultivated crop. The estimated cost of cultivation for a two year crop is about Rs. 1 lakh per hectare.

E. INSTITUTE OF FOREST GENETICS AND TREE BREEDING (IFGTB) COIMBATORE

20 *Adhatoda zeylanica* Medik

• English Name :	Mulabar nut, Vasa, Yellow Vassa
• Common/Local Name :	Aadu muttada gida, Aadu soge Adusa, Adelodagam, Aadaathodai, Addasarapaku, Arus, Vajidantakahaatarusha, Simhaparni, Adalso, Arusho, Vasaka. Adulsa, Adusa, Vasuka.
• Family :	Acanthaceae
• Part Used (s) :	Leaves, Stem, Aerial Parts

INTRODUCTION

Adhatoda zeylanica also known as *A. vasica, Justicia adhatoda,* is a well-known in both Ayurvedic and Unani Systems of Medicine (Chopra *et al.*, 1956; Kapoor, 2001). In Ayurveda, the ancient system of Indian medicine it is commonly known as Vasaca (Prajapati *et al.*, 2003).

GEOGRAPHICAL DISTRIBUTION

It is a widespread small evergreen, sub-herbaceous bush distributed throughout India, especially in the lower Himalayas (up to 1300 meters above sea level), India, Sri Lanka, Burma and Malaysia (Singh *et al.*, 2017).

BOTANICAL DESCRIPTION

It is a tall dense evergreen shrub having thick branches. Leaves are oppositely arranged, 9-17 cm long and 3-10 cm wide, 8-10 pairs of lateral vein bearing few hairs, petiolate. Inflorescence is 3-7 cm long having 4-9 cm long peduncle. Spikes are terminal or axillary and ovoid to broadly ovoid in shape. Corolla is white in colour with purplish or pinkish stripes outside, tube cylindrical and bent upward; upper lip ovate-oblong and bi-lobed; lower lip oblong-circular and tri-lobed, lateral lobes ovate. Stamens exserted; anther thecae ellipsoid. Ovary pubescent; style recurved, basal part pubescent; stigma is simple and capsule is obovoid (Khuraijam and Huidrom, 2013).

USES

Medicinal Uses

It is a highly reputed Ayurvedic medicinal plant used in the treatment of cough, bronchitis, asthma, tuberculosis and recommended for other ailments of the respiratory & digestive system (Sivarajan and Balachandran, 1994). The plant is a source of *vasaka* which is well known in Indian system of medicine for curing bronchitis and asthma. The drug comprises fresh or dried leaves, stems and aerial parts. It relives cough and breathlessness. It is also prescribed for local bleeding due to peptic ulcer, piles etc. it gives relief in pyorrhea and in bleeding gums (Sutare and Kareppa, 2009).

Traditional Uses

The leaves and the roots of this plant are considered a very effective remedy for all sorts of coughs, being administered along with ginger (Chopra *et al.*, 1956). Leaf powder when boiled with sesame oil is used to prevent bleeding, ear aches and pus from ears. Also water extract of leaf is used to relieve acidity and root decoction is useful for gonorrhoea (Dhale and Kalme, 2012).The fresh flowers are used in ophthalmia (Nandkarni and Nandkarni, 2000). It has expectorant and antispasmodic properties and its use has been recommended in the treatment of cold, cough, asthma and even diphtheria (Shah and Seth, 2010). Fresh juice of leaves with honey relieves the irritable cough by its soothing action on the nerves and by liquefying the sputum which makes expectoration easier (Ansari, 2006). Plant is one of the ingredients of the preparations known as Vasavaleha (Dabur), Kasamrit Herbal (Baidyanath) and Vasaka capsule (Himalaya Drug Company). Daily application of massage of leaf extracts effectively reduces the inflammatory and bleeding condition of gums (Khare, 2007).

PROPAGATION

It is propagated by tender stem cuttings. Stem cuttings of 15-20 cm long and 3-4 nodes are ideal for planting. *Adhatoda* is obtained from commercial sources or collected from open fields. Propagation is also by means of seeds, can also propagate from cuttings in springs early summer with hardwoods cuttings (Bjaj and Williams, 1995).

Reproduction

Adhatoda flowers are protandrous and mostly pollinated by carpenter bees such as *Xylocopa verticalis* and *Xylocopa* sp. Though pollination efficiency under field conditions is high (95%), fruit set is poor (6%) which is mainly due to the limitation of compatible pollen. It is self-incompatible and about 50% of cross-pollinated flowers set fruits (Shivanna, 2009).

Nursery Raising

The plant is propagated using semi-hard wood and soft wood cuttings which are 8 to 10 cm long with 3 to 4 internodes. The cuttings are planted in raised beds during April- June. Cuttings take up to 20 days to sprout and a further 30 days to root. The rooted cuttings can be planted out after 10 days. The success of field establishment is about 80 percent.

Cultivation Techniques

Adhatoda is conventionally cultivated as a hedge plant but no systematic cultivation is so far undertaken. It can be raised from seeds or through cuttings. May-June or September- October are the best period for propagation.

Diseases and its Management

The plant is reported to be infected with fungal rust such as *Chnoospora butleri* and *Aecidium adhatodae* (Sydow and Butler, 1911).

YIELD

Since no systematic cultivation is undertaken, information on yield and economics of cultivation is not available. Leaves can be harvested from the first year of planting but roots can be harvested only two years after planting (Sutare and Kareppa, 2009).

21 *Cassia auriculata* L.

• English Name/ Trade Name :	Tanner's cassia, Tanner's Senna; Mature Tea Tree
• Common/Local Name :	Avartaki, Pitapuspa, Pitkalika, Manojyna, Awal, Tarval, Tangedu, Tarwar.
• Family :	Caesalpiniaceae
• Part Used (s) :	Seeds, Root and Bud powder

INTRODUCTION

Cassia auriculata is considered to be one of the important medicinal and dye yielding plants in India (Gupta and Sharma, 2007). *C. auriculata* is an evergreen shrub that grows in many parts of India and in other parts of Asia. The flower, leaves, stem, root and unripe fruit are used for treatment, especially in Ayurvedic medicine (Guruprasad *et al.*, 2015). It is the source of yellow colored dye, obtained from its flowers and seeds.

GEOGRAPHICAL DISTRIBUTION

C. auriculata is a native of India, Myanmar and Sri Lanka and has been successfully introduced into several African countries. It is cultivated in India and Sri Lanka and occasionally elsewhere (Jansen, 2005). It is distributed throughout hot deciduous forests of India and mainly thrives on dry stony hills and on black soils, along roadsides, in degraded forests and on wastelands. Ecologically, it tolerates a wide range of climate and temperature, yet it prefers to grow and flourish well in warmth. It can thrive on dry stony hills, on black soils, along road side, in degraded forest, waste land, railway embankments, etc. It is found in wild state in Rajasthan, Maharashtra, Madhya Pradesh, Gujarat, Tamil Nadu and Andhra Pradesh (Dahiya, 2016).

BOTANICAL DESCRIPTION

C. auriculata is a perennial shrub or small tree growing up to 7 m tall, with trunk growth around 20 cm in diameter. Stem is solid, strong, brown in color with several branches and bark is thin, brown and lenticellate. The leaves are alternate, paripinnate compound, stipulate, mucronate, glabrous or minutely downy, dull green, paler beneath, reniform-round, produced at base on side of next petiole into a filliform point and persistent. Rachis provided with a gland between each pair of leaflets; leaflets 6-13 pairs, oblong-elliptical to obovate-elliptical, 10-35 mm × 5-12 mm, rounded and mucronate at apex, glabrous to pubescent. Inflorescence is axillary raceme with 2-8 flowers. The racemes are few-flowered, short, erectand crowded in axils of upper leaves so as to form a large terminal inflorescence. Flowers are bright yellow which are irregular, bisexual. The fruit is a legume contains 7 – 10 seeds. Flowers are bisexual, zygomorphic, 5-merous; sepals

rounded at apex with free petals, unequal ranging from 1.5 to 3 cm long and yellow in color. Fruits are flattened cylindrical pod of 5-18 cm × 1-2 cm dimension; transversely undulate between the 10-20 seeds and indehiscent. Seeds compressed ovoid-cylindrical, 7-9 mm × 4-5 mm, with a distinct areole on each face (Jansen, 2005; Dahiya, 2016).

USES

According to Ayurveda, it contains Gunna (properties), Laghu (light), Ruksh (dry), Rasa (taste), Kashaya (astringent), Tickta (bitter), Virya (potency) and Sheet (cold). *C. auriculata* is admired as alternative medicines for its wide usage in Aryurveda, Naturopathy and Herbal therapy. The medicinal properties are due to presence of hydroxyl-anthraquinone derivatives. The plant is well renowned for its nutrients- cardiac glucoside (sennapicrin), beta pinene, limonene, terpinol, bisabolene, tannins, citral and terpenoids (Dahiya, 2016).

The bark is astringent, leaves and fruits anthelminthic, seeds used in eye troubles and root employed in skin diseases. It has been used for the treatment of ulcers, leprosy and liver disease. The dried flower bud powder is used as a substitute for tea in the case of diabetic patients and it is also supposed to improve the complexion in women. It has been widely used in Ayurvedic medicine as "Avarai Panchaga Choornam" and the main constituent of Kalpa herbal tea has come under extensive study in the light of its anti-diabetic effects. The plant is used in the traditional system of medicine for female antifertility, leprosy, worm infestation, diarrhoea, disease of pittam. The plant has been widely used as a cure for rheumatism and conjunctivitis. The various parts of the plant were reported to exert a beneficial effect to alleviate the symptoms of diabetes.

PROPAGATION OF THE SPECIES

Reproduction

C. auriculata is a cross-pollinated taxon and pollination is by lepidopteran insects. Its seeds are dispersed when the legume fruit splits open (Siva and Krishnamurthy, 2005).

Nursery Raising

The crop is raised by seeds. The seeds have hard and tough seed coat so the seeds to be soaked in hot water for 15 minutes and with 100 ppm GA_3 for 3 hours to improve germination (Ameer *et al.*, 2013). Seeds scarified with concentrated sulphuric acid also will give better germination (Begum *et al.*, 2013). Under the north Indian conditions like Rajasthan and Gujarat where the rainy season is relatively short, it is reported to be the ideal time (June-July) to spread the seeds in the land and again plough the field to cover the seeds and ensure uniform sowing as the plants put on luxuriant growth and give the maximum growth and yield as well. Heavy rains and cloudy weather during growth are harmful to the crop. An average rainfall of 25-40 cm. distributed from June to October is sufficient to produce good crop. After sowing there is some rain which motivate initial stage of growing. When the plant grows 1/2" height the entire land looks beautiful green colour. Then the farmers start removing weeds for healthy growing of the crop.

Cultivation Techniques

C. auriculata is extensively cultivated in area which is dry and warm such as Punjab, Haryana, Uttar Pradesh and West Bengal (Dahiya, 2016). It can be propagated by seed and stem cuttings. For quick germination seeds are scarified and held in running water. The seedlings are fairly resistant to desiccation. Stem cuttings are planted 5-12.5 cm apart in rows (Jansen, 2005).

Sandy and sandy loam soils are suitable for the cultivation of this crop. The land is ploughed deep and the soil is exposed to sun for 110-115 days to dry out roots of perennial weeds followed by two cross ploughing harrowing and leveling. Seeds are to be sown during June-July. After cultivation the first harvest will come after 2 months and later on every 30 days interval we can harvest leaves and pods. After harvesting leaves and pods are spread in a ventilated

room and allow it dry for around 7-10 days until it reaches 10% moisture. Sun drying is avoided to prevent the loss of sennosides.

Diseases and its Management

Usually some of the pests like aphids, leaf spot and damping off damage the plant. To prevent aphids, spraying of dimethoate 30 EC or methyl demeton 25 EC at 1ml/lit of water effectively control the pest. To control leaf spot, spray 0.50% of Carbendazim at fortnight interval basis. To control damping off, seed treatment with Carbendazim (1 g/kg of seed) is required (www.eagriculture.in). Thinning is necessary one year after sowing. Weeding and cultivation stimulate growth but are not absolutely necessary. Limed soil is reported to increase the amount of tannin. Coppiced plants regrow well (Jansen, 2005).

HARVESTING

Harvesting of *C. auriculata* starts by the third year after establishment; the twig bark can be stripped and used. Twigs that have not developed a corky bark are best. Coppiced plants can be harvested annually (Jansen, 2005).

POST HARVEST MANAGEMENT

The bark is sun dried in small pieces and stored or marketed. Unstripped twigs can be directly used to extract tanners to make a tanning extract and use of dried stripped bark is effective way to extract tan. To prepare a yellow dye, flowers (about twice the weight of the textile to be dyed) are boiled in water. Then the cloth, previously mordanted with alum, is immersed into the bath, boiling until the desired shade is obtained.

YIELD

The yield of green bark of *C. auriculata* averages 1500 kg per ha in a 4 year old plantation of about 9000 plants/ha (Jansen, 2005).

22 *Coleus forskohlii* (Willd.) Briq.

• English Name/ Trade Name :	Indian Coleus
• Common/Local Name :	Makandi, Mayani, Makandi, Patharchur, Pashan bhedi Karmelo, Gandhe jhar
• Family :	Lamiaceae
• Part Used (s) :	Tuber, Roots

INTRODUCTION

Coleus forskohlii is an important indigenous medicinal plant in India. It has been used in traditional Ayurvedic medicine for curing various disorders and recorded in Ayurvedic Materia Medica. The genus *Coleus* was first described by Loureiro in 1790 and the generic name was derived from the Greek word 'Coleos' meaning sheath. All the species of *Coleus* have four didynamous, dedinate stamens and the filaments of the stamens unite at their base to form a sheath around the style. The species name *'forskohlii'* was given to commemorate the Finnish botanist, Forskel (Alagu *et al.*, 2013). The genus 'Coleus' consists of 150 species of which species viz., *C. amboinicus, C. forskohlii, C. spicatus* and *C. malabaricus* occur naturally (Khatun, 2012).

GEOGRAPHICAL DISTRIBUTION

Coleus is a native to India and grows in the sub-tropical to temperate climates of India, Nepal, Thailand and Sri Lanka and is a popular ornamental plant (Khan *et al.*, 2012). Indian sub- continent is considered as the place of origin of *C. forskohlii*. The species grows wild in the subtropical Himalayas, distributed from the Kumaon hills to Nepal ascending upto 2000 m and in Bihar, Deccan, Peninsula and Gujarat mostly on the dry and barren hills. Apparently, it has been distributed to Egypt, Arabia, Ethiopia, tropical East Africa and Brazil. Latitudinal and altitudinal range for the occurrence of the species lies between 8° and 31° N and 600 – 800 m, respectively (Kavitha *et al.*, 2009).

BOTANICAL DESCRIPTION

C. forskohlii is an aromatic perennial, with an erect stem and tuber like roots, reaching 60 cm (Prajapati *et al.*, 2003). It has four angled stems that are branched and nodes are often hairy with tuberous roots (Lokesh *et al.*, 2018). Leaves are teardrop shaped, shimmering green framing with a bright purple center with 7.5 to 12.5 cm. length and 3 to 5 cm widths,

usually pubescent, narrowed into petioles (Khan *et al.*, 2012). Inflorescence is raceme of around 15 - 30 cm in length; flowers are stout, 2 to 2.5 cm in size, usually shows perfect and calyx is hairy from inside. Upper lip of calyx is broadly ovate. The blue or lilac corolla is bilabiate. Lower lobes are elongated and concave so that they enclose the essential organs. The ovary is four parted and stigma is two lobed and the flower is cross-pollinated by wind or insects. The root is typically golden brown, thick, fibrous and radially spreading. Roots are tuberous, fasciculated, 20 cm long and 0.5 to 2.5 cm in diameter, conical fusiform, straight, orange colored with strong aroma. *C. forskohlii* is the only species of the genus to have fasciculate tuberous roots. The entire plant has aroma (Khatun, 2012). However, the growth habit of *C. forskohlii* is strikingly variable being erect, procumbent or decumbent. Similarly, the root morphology in different populations is also fascinatingly diverse, being tuberous, semi tuberous or fibrous.

USES

C. forskohlii is widely used in different countries for various ailments. In traditional Ayurvedic systems of medicine, it has been used for treating heart diseases, abdominal colic, respiratory disorder, insomnia, convulsions, asthma, bronchitis, intestinal disorders, burning sensation, constipation, epilepsy and angina. The root portion has been traditionally used to treat colic, congestive heart failure, convulsions, eczema, hypertension, insomnia, painful urination and respiratory disorders (Khan *et al.*, 2012). It is also used as a condiment in India and the tubers are prepared as pickle.

The therapeutic properties of *C. forskohlii* is mainly due to forskolin which is the main diterpene constituent of this plant. Forskolin is used for the treatment of eczema, asthma, psoriasis, cardiovascular disorders and hypertension. Forskolin is also used in the preparation of medicines preventing hair greying and restoring grey hair to its normal colour. The presence of yellowish to reddish brown cytoplasmic vesicles in cork cells of its tubers is unique character of this plant and these vesicles store secondary metabolites including forskolin (Kavitha *et al.*, 2009).

PROPAGATION

C. forskohlii is a medium heighted, herbaceous nature plant and medium water supply is needed for this plants successful growth and development. Its violet colored flower further develops in to seeds of small size having round shape. Mature stems have potential to convert in to its new small plants similar to their parental plants. The plant is usually propagated through their seeds and by stem cutting in the presence of favorable environmental conditions. Mixed media in poly begs performed their excellent combination which supports the easy and fast development of root as well as for shoot system in grown stem cuttings of *C. forskohlii* (Patel, 2016).

It is propagated by seeds as well as vegetative propagation also achieved by terminal stem cuttings. Seed propagation is difficult and slow whereas propagation by terminal stem cutting is easy and economical. The ideal period for planting is from June to July and September to October and rooted cuttings should be planted at the interval of 60 cm. The crop responds well to organic and inorganic fertilizers. The crop gets ready for harvest after 4 to 5 months of planting. The plants are uprooted following separation of the tubers, cleaning and sun drying (Khatun, 2012).

Nursery Raising

It is propagated by 10 to 12 cm long terminal cuttings with 3 to 4 pairs of leaves in nursery beds to induce rooting (Khatun, 2012). When the cuttings are one month old and have produced sufficient roots, they can be transplanted to the main field.

Cultivation Techniques

It thrives well in red, sandy loam soils with a pH ranging from 5.5 to 7. Humid climate with relative humidity between 83% - 95% and a temperature of 10 to 25 ^{0}C is ideal for the crop. It requires an annual rainfall of 100 to 160 cm, necessarily between June-September. One month old rooted cuttings can be planted at the interval of 60 cm during June/July and September/ October. Regular care about watering, weeding and plant protection should be taken. The

crop responds well to organic and inorganic fertilizers. Organic manure is required to the level of 140 kg on 30th day and 45th day of planting. A combination of 40 kg N, 60 kg P_2O_5 and 50 kg K_2O per ha is optimum for obtaining the maximum fresh (120 t/ha) and dry (3.982 t/ha) tuber yield. Half the dose of N, the whole P and whole K may be applied as the basal dose followed by the remaining half N, 30 days after planting as top dressing. The crop is ready for harvest 4 to 5 months after planting. The plants are uprooted, the tubers separated, cleaned and sun dried *Coleus* plants raised in presence of the arbuscular mycorrhizal fungi *Glomus bagyarajii*, showed an increase in plant growth and forskolin content over those grown in the absence of AM fungi (Sailo and Bagyaraj, 2005).

Diseases and its Management

The leaf eating caterpillars, mealy bugs and root knot nematodes are the important pests that attack this crop. The wilt caused by *Fusarium chlamydosporum* is a very serious soil-borne disease but inoculation with *Trichoderma viride* and *Glomus mosseae* will give the best result in controlling the disease. The root rot caused by *Macrophomina phaseolina* affects the tuber yield up to 100% and application of bioformulation viz., *Trichoderma harzianum* and zinc sulphate exerted maximum reduction in root rot incidence.

YIELD

On an average, a yield of 800 to 1000 kg/ha of dry tubers may be obtained. Planting the crop at the spacing of 60 cm x 20 cm, harvesting at 160 DAP and nutrients application in the combination of $N_{50}P_{50}K_{50}$ was found optimum for higher tuber yield, quality and returns under irrigated condition (Mastiholi, 2008).

ECONOMICS OF THE SPECIES

Spacing of 60 cm x 20 cm produced significantly higher dry tuber (1.57 t/ha) and forskolin yield, net returns (Rs. 56,822/ha) and B: C ratio.

23 *Gloriosa superba* L.

• English Name/ Trade Name :	Glory lily, Flame lily, Gloriosa lily, Superb lily, Climbing lily
• Common/Local Name :	Agnisikha/ Ulat-chandal; Bishalanguli, Ulatchandal Vacchonag, Dudhio; Kadyanag, Bachnag, Languli, Kalihari, Siva-raktaballi, Agnisikhe, Karadikanninagadde; Kanthel, Ventoni, Malathamara, Karthikapoovu; Kalikari
• Family :	Liliaceae
• Part Used (s) :	Seeds, Tuber and Leaves

INTRODUCTION

Glory lily is used in several indigenous systems of medicine. This perennial climber which has distinctive, showy and vividly colored blooms is designated as the State flower of Tamil Nadu. Though the plant is toxic, it is an industrial medicinal crop in South India and valued for its high colchicine content. Tubers and seeds of Glory Lily are an expensive export commodity (Warrier *et al.*, 1995; Sivakumar and Krishnamurthy, 2002). Due to its over-exploitation in wild and problems associated with its cultivation, it is considered as one of the endangered species.

GEOGRAPHICAL DISTRIBUTION

Gloriosa superba is found growing naturally in many countries of topical Asia including India, Srilanka, Bangladesh, Malaysia and Myanmar (Singh, 2006). The plant grows in sandy-loam soil in the mixed deciduous forest in sunny areas. It is extensively scattered in the tropical and sub-tropical parts of the India. In India, it is spread from hotter southern parts to the milder mid hill zones of Himachal Pradesh, Jammu & Kashmir and Uttar Pradesh (Chopra *et al.*, 1956). It is mainly found in Nasik, Ratnagiri, Savanthwadi (Maharastra); Uttara Kannada, Hassan, Chikmangalur, Coorg, Mysore (Karnataka); Cannanore, Palakkad, Trivandrum (Kerala); Tamil Nadu and Goa (CES, 2004). Today, it is under cultivation in fairly large areas of India. It is also widely grown as an ornamental plant in cool temperate countries under glass or in conservatories (Neuwinger, 1994; Inchem, 2004).

BOTANICAL DESCRIPTION

G. superba is an erect perennial, tuberous, scandent or climbing herbs with tendrils formed at the tip of the sessile leaves. The plant emerges per year from the tuberous underground stem in rainy season. The leaves are spirally arranged or sub-opposite which are lanceolate, acuminate, entire, glabrous. Flowers are large, solitary at the ends of branches, greenish

at first, then yellow, passing through orange and scarlet to crimson. The flowers are actinomorphic and hermaphrodite. The stamens are 6 in number which are spreading and hypogynous. The anthers are extrose, versatile, opening by longitudinal slits; ovary superior, 3-celled; ovules numerous; style deflected at base, projecting from the flower more or less horizontally. Capsule 2-3. The fruit is oblong containing about globose red colored seeds in each valve (Neuwinger, 1994). Fl. and Fr.: September- March.

USES

The plant has been used in the Indian system of medicine since time immemorial. Different parts of the plant have wide variety of uses especially within traditional system of medicine. In Ayurveda and Yunani systems of medicine, the tuber of plant is well known due to its pungent, bitter, acrid, heating, anthelmintic, laxative, alexiteric and abortifacient nature. It is widely used in the treatment of ulcers, leprosy, piles, inflammations, abdominal pains, intestinal worms, thirst, bruises, infertility and skin problem (Gupta *et al.*, 2005). It is also used in wounds, skin related problems, fever, inflammation, piles, blood disorders, uterine contractions, general body toner, poisoning (Haroon *et al.*, 2008). Colchicine and Gloriosine are the two important phytochemicals of the plant. Tuber is used for the treatment of bruises and sprains, colic, chronic ulcers, hemorrhoids, cancer and impotence.

PROPAGATION

Gloriosa is commercially propagated from its tubers. The tubers may start bud sprouting during May. Healthy tubers treated with fungicides such as Carbendazim (0.1%) should be planted during the July-August would give better yield. The tubers are liable to break easily so proper handling of tubers is necessary. If the growing bud gets damaged, the tuber will fail to sprout. The growth, flowering and fruiting ability of the plant depends on the size of the tuber used for propagation. Plants grown from small tuber may not flower during first year of planting. The plant can also be propagated through its seeds but which takes at least four months time to germinate (Farooqi and Sreeramu 2004; http://agritech.tnau.ac.in.).

Natural Regeneration

The natural seed set is very low and the hard seeds can remain dormant for 6-9 months. Natural regeneration occurs from seeds also.

Nursery Raising

The plant can be grown by tubers and seeds but plants are best raised from tubers. Tubers are planted in the bed during rainy season, in furrows at a depth of 6-8 cm with a plant to plant spacing of 20-30 cm or 60 x 60 cm. But the closer spacing is reported to favour cross pollination and improves the fruit set.

Cultivation Techniques

The plant is more suitable for sandy-loam soil and the field should be ploughed and harrowed several times in order to bring the soil to a fine tilth. At the time of land preparation FYM or other manure may be applied. Beds are prepared into ridges and furrows. Furrows are made with 15 cm depth and a spacing of 120 cm – 150 cm between them. Tubers are planted in the bed during rainy season,

SILVICULTURAL AND MANAGEMENT PRACTICES

The plant requires little manure and fertilization but addition of compost or fertilizer dose of 60 kg N, 25 kg P_2O_5 and 40 kg K_2O/ha ensures better yield. During the initial stages of crop establishment, frequent weeding is required to avoid competition of weeds with the main crop. Weeding should be done carefully to avoid damages to the growing tip of the tubers. Irrigation at the interval of 4-7 days during initial period and later on at an interval of 15 days is recommended.

Recently, drip irrigation is receiving popularity among the plant growers of Tamil Nadu. Hand pollination of flowers during morning (7 to 10 AM) increases seed yield. *Gloriosa* is naturally a climbing plant so it requires support when the plant is 30 to 40 cm tall they should be staked or tied to wires or allowed to climb on some sort of frame. The farmers in Tamil Nadu use either wooden stick or iron rods to facilitate the plant to climb (Farooqi and Sreeramu 2004; http://agritech.tnau.ac.in.).

Gloriosa has few pests and diseases. Major pests of Gloriosa are Lily Caterpillar and Green Caterpillar and spraying of Metacid at a concentration of 0.2% at fortnightly intervals controls these pests. Major diseases are leaf blight and tuber or basal stem rotting and wilting. The leaf blight incidence is higher during cloudy weather coupled with high humidity. This disease can be controlled by spraying Dithane M-45. Another disease is tuber rot which is a soil borne disease affecting the underground rhizomes causing the death of the plant. Drenching the soil with Bavistin@ 0.2% is recommended to control the disease. Some progressive farmers apply biopesticides and bio-control agents for controlling pests and diseases (Farooqi and Sreeramu 2004; http://agritech.tnau.ac.in.).

YIELD

Gloriosa flowers during September – October and matures in 170 - 180 days after planting. A single plant produces 75 - 100 flowers and a single fruit contains 70 - 100 seeds. The right stage of harvest is when the capsule starts turning light green from dark green and skin of the fruit shows shrunken appearance and becomes light in weight. At this stage, when pressed the pod gives a cracking sound. The harvesting time is February (for crops planted in July). The fruits are harvested after 170 -180 days of planting and dried in the shade for 10 -15 days. The rhizomes, which are, buried beneath the soil again sprouts and the plant cycle continues with the advent of monsoon. The rhizomes are finally harvested after 5-6 years of plantation, cut into small pieces and dried in shade (Farooqi and Sreeramu 2004; http://agritech.tnau.ac.in.).

The yield of seed differs greatly depending on the vigour and age of the plant, which in turn depends on the size of the tuber. The yield in the initial years will be low, but gradually increases in the subsequent years. After three years from a well managed field under irrigated conditions, about 300 kg/acre of dried seeds may be harvested. About one tonne of tuberous roots is harvested after five years of the plantation (i.e. at the end of economic life of the plantation) (Farooqi and Sreeramu, 2004; http://agritech.tnau.ac.in.).

ECONOMICS OF THE SPECIES

Gloriosa is propagated from its underground rhizomes. Rhizomes can be procured from wild and cultivated sources. Seed procurement companies also supply planting material as an advance to farmers by executing MoU with farmers assuring buyback of seeds at a fixed price. The cost of cultivation of *Gloriosa* has been estimated at Rs. 1,64,000 per acre. Planting material (rhizomes) accounts for almost 65% of the cost of cultivation. The price of planting material (rhizomes) shows yearly fluctuation and it is mainly dependent on seed price (end product). If the seed price is high, tuber cost goes up and vice versa (Farooqi and Sreeramu, 2004; http://agritech.tnau.ac.in.).

24 *Phyllanthus amarus* Schum and Thonn.

• English Name :	Black catnip, Carry me seed, Child pick-a-back, Gale of wind, Gulf leaf flower, Hurricane weed, Shatterstone, Stone breaker
• Trade Name :	Bhui-amla, Bhui -aonla
• Common/Local Name :	Keezha nelli; Keezhar nelli; Nela nelli; Neala usiri; Bhumyamalaki
• Family :	Phyllanthaceae
• Part Used (s) :	Leaf, Root, Whole plant extract

INTRODUCTION

Phyllanthus amarus is a small herb which is widely used for its well known medicinal properties. The genus *Phyllanthus* comprise of about 6500 species of 300 genera, of which 200 are American, 100 African, 70 from Madagascar and the remaining Asian and Australasian (Webster, 1994). The name *'Phyllanthus'* means "leaf and flower" for the reason that the flower and the fruit, seems to become one with the leaf (Cabieses, 1993).

GEOGRAPHICAL DISTRIBUTION

P. amarus is extensively found in all tropical and subtropical regions of the world. It is native to India, China and Bahamas, (Morton, 1981; Tirimana, 1987), Philippines (Chevallier, 2000). It is a common pan-tropical weed which grows well in moist, shady and sunny places (Cabieses, 1993; Nanden, 1998). In India *P. amarus* is considered as the most widely occurring *Phyllanthus* spp., which can be commonly found to grow in Punjab, Uttar Pradesh, Maharashtra, Tamil Nadu, Sikkim, Haryana, Andhra Pradesh and Karnataka (George,1892).

BOTANICAL DESCRIPTION

P. amarus is a glabrous, erect or ascending annual herb up to 75cm tall. It is much branched with small leaves on lateral branches of the stem that give the plant the appearance of having pinnate leaves reproducing from seeds. The stem is rounded, woody at the base, horizontally branched, smooth and greenish, monoecious or rarely dioecious. The leaves are alternate, elliptic on long, 5-10 cm long and 2-4.5 mm broad, pale beneath and with short petioles. The inflorescence is axiliary and consists of one male flower and one female flower in each axil. Flowers are greenish and rather small up 1.5 mm diameter. Female flowers usually solitary in the proximal axils. The fruit is a round capsule, brownish, 1.5-2 mm across and occurs in least axils on the lower side of the lateral branches. Each capsule contains six small seeds (Akobundu and

Agyaka, 1987; Hutchinson and Dalziel, 1963).

USES

It plays an essential role in Ayurveda, an Indian system of medicine and is used to treat jaundice, gastropathy, diarrhoea, dysentery, fevers, menorrhagia, scabies, genital infections, ulcers and wounds (Patel *et al.*, 2011). Decoctions of whole plants are used for treating migraine, jaundice (Kala *et al.*,2006; Udayan *et al.*,2007; Samy *et al.*, 2008), gonorrhea and syphilis, skin disease and malaria (Chenniappan and Kadarkarai, 2010; Upadhyay *et al.*, 2010). Leaves paste or its decoction and juice of roots are used for treating jaundice (Jain *et al.*, 2005; Shanmugam *et al.*, 2009; Rajakumar and Shivanna, 2009). Chronic dysentery, menstrual problems, anorexia, urinary tract infection and diabetes are also treated by leaf extract taken orally (Mahishi *et al.*, 2005; Samy *et al.*, 2008; Shanmugam *et al.*, 2009; Samuel and Andrews, 2010). The application of *P. amarus* is gaining momentum because of its novel antiviral activity against hepatitis B virus and for several other biological activities such as kidney and gall bladder stones, for cold, flu, tuberculosis and other viral infections; liver diseases and disorders including hepatitis, jaundice and liver cancer (Unander *et al.*, 1995).

PROPAGATION

P. amarus can be propagated through seed but seed germination is poor. Micropropagation technique offers an alternative method for cloning these plants.

Artificial Propagation

The plant can be successfully regenerated through *in-vitro* techniques from shoot tips and nodal and internodal segments (Chitra *et al.,* 2009; Sen *et al.*, 2009; Xavier *et al.*, 2012).

Propagation through Seeds

Nursery Technique

Propagation Material

Seeds remain viable up to six months from the time of harvest.

Raising Propagules

Seeds are sown in raised nursery beds during June after rains and seedlings later transplanted on ridges in well laid out plots.

Seed Rate and Pretreatment: About 4 kg seed may be needed for raising seedlings for planting on one hectare of area. No specific pretreatment of seed is recommended.

Planting in the Field:

- Land Preparation and Fertilizer Application: The soil should be ploughed, harrowed and made into a fine tilth. 20 tonnes of FYM is applied during land preparation. For nursery beds, farm yard manure at the rate of 10 t/ha is mixed in the soil along with 100 gm *Azospirillum* + 100 gm *Phosphobacteria* + 100 gm *Trichoderma* as basal medium. In main field 25-30 t/ha of FYM is applied as a basal medium + 2.5 kg *Azospirillum* + 2.5 kg *Phosphobacteria* is given before transplantation.
- Transplanting and Optimum Spacing: 15-20 days old seedlings of 8-10 cm height are transplanted at 30 cm distance in rows in the field immediately after the first monsoon shower. If there is no rain; the field should be irrigated immediately after transplantation. For one hectare area about 4.0 lacs seedlings are needed at an optimum spacing of 25X25 cm

- Interculture and Maintenance Practices: The crop needs hand weeding at 30 and 60 days interval after planting
- Irrigation: Irrigation is required during dry season if monsoon rains is scanty. The frequency of irrigation depends on the moisture content of soil
- Disease and Pest Control: Powdery mildew disease occurs during rainy season. This is controlled by spraying biopesticides like *Azadirachtin, Trichoderma viridie, Pseudomonas cholotorapsis* etc.

Nursery Raising

The plants are propagated through seeds. About 1 kg of seeds are sufficient for seedlings for transplanting in one hectare of land. For raising the seedlings, the seeds should be sown in well prepared nursery beds. Well decomposed farm yard manure should be mixed with top layer of the soil while preparing the beds. Being minute, the seeds should be mixed with dry soil or sand to allow uniform distribution of seeds on the nursery bed. Later a thin layer of soil needs to be spread to cover the nursery beds. Appropriate moisture should be maintained in the beds till the seeds germinate. In north Indian plains, the month of April-May was found very good for sowing for higher rate of germination of seeds and good herb yield.

Cultivation Techniques

Approximately 15-30 days old seedlings, which are about 10 cm tall, are transplanted in the field at horizontal and vertical spacing of 15 cm each. A proper irrigation just after transplanting ensures establishment of seedlings. The crop raised by transplanting of seedlings gives improved yield of herbage. The field should be kept absolutely free from weeds for which regular hand weeding in every month is required. It is found to be well adapted to variety of soils, at soil pH ranging from alkaline to natural and acidic soil. Plants have also shown preference for calcareous well drained and light textured soils. Organic manures like, Farm Yard Manure (FYM), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds and leaves), Chitrakmool, Dhatura, Cow's urine etc. Irrigation is required in the areas where rainfall is less. Plants are harvested when the rainy season is over, when they are still green and herbaceous. Since the active constituents of *P. amarus* are concentrating more in the leaves, production of higher leaf mass is desired for the extraction. Plant in September contain highest amount of leaves and found to be suitable time for harvesting

YIELD

The application of 75% nutrients through fertilizer and 25% through FYM provided higher benefit towards crop growth, herbage and alkaloid yield and net returns as compared to application of only chemical fertilizers.

ECONOMICS OF THE SPECIES

Maximum net returns of Rs. 87,187 and benefit cost ratio of 3.74 was recorded in 75% recommended dose of fertilizers (150:60:60 NPK kg ha^{-1}) + 25% of FYM treatment. This treatment provided higher benefit towards crop growth, herbage and alkaloid yield and net returns (Aruna *et al.*, 2011). However, it may be noted that market for medicinal plants is volatile and economics may vary.

25 *Solanum nigrum* L.

• English Name/ Trade Name :	Black nightshade, Nightshade, Blackberrry Nightshade
• Common/Local Name :	Gudakamai; Makoya; Kakamachi; Kali makoy; Kage soppu
• Family :	Solanaceae
• Part Used (s) :	Leaves, Fruits, Juice of plants

Solanum nigrum

INTRODUCTION

Solanum nigrum, commonly known as "Black night shade" is an important plant in traditional medicine having good demand in the industries. Its fruits and young shoots are harvested from the wild and consumed locally as an indigenous vegetable and for medicine in many African and Asian countries (Yulianti *et al.*, 2018). It is being cultivated on a commercial scale in India. The leaves, berries as well as whole herb are economically important. The green, unripe fruits contain alkaloids such as alpha solamargine and alpha solasonine (Ridout *et al.*, 1989).

GEOGRAPHICAL DISTRIBUTION

S. nigrum is one of the largest and most variable species distributed from temperate to tropical regions and from sea level to an altitude over 3500 metres (D'Arcy, 1991). It is widely distributed in various habitats throughout the world particularly in Africa and South East Asia. In India, this plant is found growing in dry parts up to an elevation of 2,100 m (Nandhini, 2013). Its wide tolerance to habitat types and its prolific seed production contribute to the success as a widespread species (Henderson, 1974).

This species is widely spread in Asia, Africa and North America (Sarma and Sarma, 2011). In India, the species is found throughout the country as a weed in disturbed habitats, roadside areas and gardens. It is mostly found in moist habitats in

different kinds of soils and grows in dry tracts up to an elevation of 2,100 m in all temperate and tropical regions of the country (Anonymous, 1969). The black nightshade is worldwide weed of arable land, gardens, rubbish heaps and soils rich in nitrogen, in moderately light and warm situations (Grivetti, 1976).

BOTANICAL DESCRIPTION

S. nigrum is a very variable ephemeral, annual or sometimes biennial herb reproducing by seed. It has a strong white taproot, with many lateral roots being produced in moist and fertile surface soils. Stems vary from prostrate to ascending or erect, round or angular, smooth or sparsely hairy and green to purplish. Leaves are alternate, ovate and are carried on short stalks, 2–8 cm long and vary between plants from smooth-edged to shallowly lobed. They are opaque, matt and dark green both above and below and either smooth or finely hairy. The small, white, star-shaped flowers are carried in umbels on slender stalks developing directly from the stems between the leaves. Each cluster usually carries from 5–10 flowers, which open sequentially over several days. The flowers are 5-8 mm across and have prominent yellow centres. Fruits are globular and the colour of matured fruit varies from orange to black. The fruit contain many flattened, finely pitted and yellow to dark brown woody seeds approximately 1.5 mm long. Seedlings of *S. nigrum* exhibit epigeal germination (Defelice, 2003).

USES

The young leaves of *S. nigrum* are used to treat mouth ulcers. It is medicinally used in the management of several ailments, such as pneumonia, aching teeth, stomach ache, tonsillitis, wing worms, pain, inflammation, fever, tumor, as tonic, as antioxidant, as anti-inflammatory, as hepatoprotective, as diuretic and as antipyretic (Kuete, 2014). The leaves and berries are routinely consumed as food in South India after cooking with tamarind, onion and cumin seeds. The boiled extracts of leaves and berries are also used to alleviate liver-related ailments, including jaundice. The juice of the plant used to cure ulcers and other skin diseases. The fruits are used as a laxative, appetite stimulant and for treating asthma and "excessive thirst". The juice from its roots is used against asthma and whooping cough. *S. nigrum* is considered to be antitumorigenic, antioxidant, anti-inflammatory, hepatoprotective, diuretic and antipyretic activity. The decoction and juice of the berries is useful in cough, diarrohea, inflammations and skin diseases. Leaves are used for rheumatic and gouty joints, skin diseases, also used in the treatment of tuberculosis, nausea and nervous disorders. The decoction and juice of the berries is beneficial for cough, diarrohea, inflammations and skin diseases (Dilip *et al.*, 2012). This plant also possesses anti-cancerous properties (Chinthana, 2012).

PROPAGATION

The plant propogated only using seeds and it can be cultivated in tropical and subtropical agro-climatic regions by sowing the seeds during April – May in well-fertilized nursery beds. During rainy season, planting is done on ridges while during summer in furrows, at a spacing ranging from 30-90 cm depending upon the stature and spreading habit of the plant (Rajamani, 2015). Despite the propagation of these vegetables by seeds, there is a scarcity for this plant (Helen *et al.*, 2018).

Nursery Raising

The seedlings are first raised in the nursery and transplanted to the main field 30-45 days after sowing when the plants attain 8-10 cm height (Rajamani, 2015).

SILVICULTURAL AND MANAGEMENT PRACTICES

Irrigation

The transplanted seedlings should be given temporary shade for 2-4 days during summer (Rajamani, 2015). The application of FYM, vermicompost and neem cake at 20, 1.0 and 0.5 tonnes per hectare along with bio-fertilizers is

optimum for better growth, yield and realizing maximum net returns (Umesha *et al.*, 2011). The nursery beds and plantation should be irrigated periodically as and when required. One or two intercultural operations are needed to control weeds. The plants need earthing up after weeding and top dressing. Irrigation is needed at 3-4 days interval during summer and on alternate days during fruiting period. Plants need staking to avoid lodging due to heavy bearing (Rajamani, 2015).

Diseases and its Management

Shoot borers, mealy bugs, leaf webbers and miners are noted on the crop, which can be controlled by spraying mild insecticides. Root knot nematode, wilting and mosaic diseases are also noted on the crop. Field sanitation, crop rotation and burning of crop residues are recommended (Rajamani, 2015).

HARVESTING OF CROP

The crop is usually ready for harvesting after 4-6 months depending upon the climate and soil. The plants are collected and dried in shades. The yield of the plant is 12 - 20 tonnes of fresh herbage yield per hectare (Rajamani, 2015).

POST HARVEST MANAGEMENT

The shade dried herb stored in Low Density Polyethylene (500 gauge) container reported to maintain its physico-chemical properties viz. moisture, colour, brittleness and alkaloid content for a period of four-five months without much deterioration (Naz *et al.*, 2011).

YIELD

The yield of the plant is 12 - 20 tonnes of fresh herbage yield per hectare (Rajamani, 2015).

ECONOMICS OF THE SPECIES

The highest net returns of Rs. 34,000 ha^{-1} and benefit to cost (B : C) ratio of 1.80 was recorded with the application of FYM 20 tonnes + vermi-compost 1.0 tonnes + neem cake 1.0 tonnes ha-1 (Umesha *et al.*, 2011).

F RAIN FOREST RESEARCH INSTITUTE (RFRI) JORHAT

26 *Aquilaria malaccensis* Lamk.

• English Name/ Trade Name :	Agar
• Common/Local Name :	Xanchi
• Family :	Thymelaceae
• Part Used (s) :	Oleoresin, Leaves

Aquilaria malaccensis

INTRODUCTION

It is a precious floral wealth of North-East India. The tree is known to produce dark coloured resinous wood known as agarwood or eaglewood formed in the heartwood of the tree as a result of host- fungus interaction. Agarwood is valued in high class perfumery as a fixative and is much priced by European perfumer for mixing their best grade scents. Agarwood and its products are also described as aphrodisiac, alternative anodyne, antidiarrhoeal, antiasthmatic, astringent, carminative, cordial diuretic, laxative, stomachic and tonic and enter into the preparation of several pharmaceutical and cosmetic products.

DISTRIBUTION

Agar tree is native to South-East Asia and is widely distributed from the foothills of the Himalaya to the rain forests of Papua New Guinea. It occurs in Myanmar, Malaysia, Sumatra, Indonesia, Bangka, Borneo and Phillippines. The genus *Aquilaria* has 17 species, of which two species (*A. malaccensis syn. A. agallocha* and *A. khasiana*) are found in North-East India. Agar tree grows well in high humid, sub tropical climate with annual rainfall of about 1500 to 6500 mm and a mean annual maximum temperature of 22-28°C and minimum temperature of 14-21°C. The tree requires a lot of sunshine and is found in natural forest, at an altitude of a few meters to about 1000 meters amsl and it grows best around 500 meters elevation. Agar tree can be cultivated in a wide range of soil. It prefers good forest soil of acidic reaction, well drained, sandy loam to clay loam textured with high organic matter content. It can also be grown in marginal soils, shallow soil over

rocky beds in hilly slopes.

BOTANICAL DESCRIPTION

Tree is evergreen medium to large in size, which can grow up to 40 m in height and reach a diameter of 60 cm. Leaves are simple, 5-9 cm long, oblong, lanceolate, elliptic to obovate-lanceolate. Flowers are bell shaped of white or green or dirty yellow coloured, Fruit capsule, 3.5-5 cm long, obovoid, acuminate bearing 1-2 dark brown coloured seed bears a appendage that is as long as the seed, twisted from the base, tail like and covered with soft short hairs. Seeds germinate above ground.

USES OF AGARWOOD

- The essential oil is used as an ingredient in perfume.
- Agarwood essential oil is used for countless physical purposes, like it is used to alleviate some of today's common complaints such as stress and anxiety. This oil has anti-rheumatic, anti-inflammatory and analgesic properties. It can be used to help detoxify the body and clean out any excess salt and uric acid that can lead to a number of complaints and also to treat a number of digestive issues.
- Cosmetics and cosmeceuticals, toiletries, flavourings, fragrances, incenses, candles are some valuable products from agarwood.
- Agar Tea, one of the most important products from Agar tree, which is a natural detoxifier. It also helps in stabilization of blood sugar, promotes healthy and clear skin.
- Other uses: Ornamentation, bead strings, carvings, wines, burial and cremation (grave-clothes, libation ingredients in funeral pyre), prayer rugs.

Agar leaves used as tea

Agarwood incense sticks

Agarwood oil

Raw Agarwood oil

Perfume

PROPAGATION

Seed Collection

Agar is propagated by seeds. The matured but still green fruits are harvested for seed collection during rainy seasons (June to August month). The fruits are dried in the shade for two days, then bursting fruits release seeds. The germination of mature seed takes places in the plants itself. Seeds remain viable for a very short period and therefore should immediately be sown in sand beds.

Nursery Technique

Seeds are first germinated in sand beds and then transferred to poly bags. Germination starts after 5-10 days and normally completes within one month. When the seedlings are 3- 5 cm tall (after 40- 45 days), they are picked out in to polythene bags, arranged under temporary shade. 10- 12 months old seedlings can be transplanted to the main field when they become 30- 35 cm tall. Light watering is essential. Seeds can also be shown in the root trainer. The soil, sand and well decayed cow dung mixture (at 1:1:1 ratio) can be used in the root trainer. Seeds are shown at a depth of about 1- 1.5 cm, followed by watering along with proper shading and other normal management practices.

Transplanting and Planting Density

The best time for planting is during the rainy season (May- September). Under average condition, spacing ranges between 2.5-3.5 m, (initially accommodating about 1700 plants per hectare) which at later stages i.e., after 8-10 years of growth maintained at 4-5 m by harvesting in phase manner. Planting of the samplings is done in well-prepared pits of size 50 × 50 × 50 cm made in advance. Well rotten cowdung or FYM may be applied @ 10- 15 kg per pit and mixed properly prior to planting, to ensure better micro climate in the soil. Planting should be done preferably in the evening time or during the cloudy weather and soil around the plant should be firmly consolidated and watering should be done until the establishment of the saplings. Dead seedlings should be replaced preferably within the same planting season.

After planting, staking should be done to keep the seedling in upright position and the soil around the plant should be firmly consolidated. Immediately after planting, watering is necessary. In the open and in public places the newly planted seedlings are to be protected in cages till they grow fairly large. For better and faster growth of the plant, the pits should be weeded and hoed to keep the soil loose and free from weeds. About 40% selected trees may be harvested after 8- 10 years to thin out the plantation (4- 5 m spacing) for better growth and development of the trees.

Agar seed

Seedlings in nursery beds

Seedlings transferred to poly-bags

Disease Management

Heortia vitessoides, a leaf-eating caterpillar is the most destructive pest for agar plantation. It causes menace to the plantations twice in a year i.e. first in May- June and second in August- September, by complete defoliation of agar

trees. The intensity of attack during the months of March- April (drier season) is more as compared to the months of July- August (rainy season). Agar trees grown in open condition are more prone to this pest as compared to the trees under shade.

Control Measures

- Hand collection and destruction of caterpillars while in clusters.
- Severe infected site should be treated with an extra dose of nitrogenous fertilizer to boost up the growth of the infected trees.
- Bio-pesticides such as Neem extract can be sprayed in 7- 14 days interval. Besides, the natural enemies such as birds, frogs etc. should be encouraged to control this pest.

Diseases

- Branch Drying

  Symptoms appear as rotting of the stem base and roots. Branches are easily breakable. Trees get shriveled and resulting in death of the trees.

- Causal Organism

  The primary cause of the disease is nematode i.e. *Pratylenchus* sp. and fungus i.e. *Fusarium solani* makes entry through the injury in the roots caused by nematodes and resulting in rotting of roots and ultimately death of the trees.

Control Measure

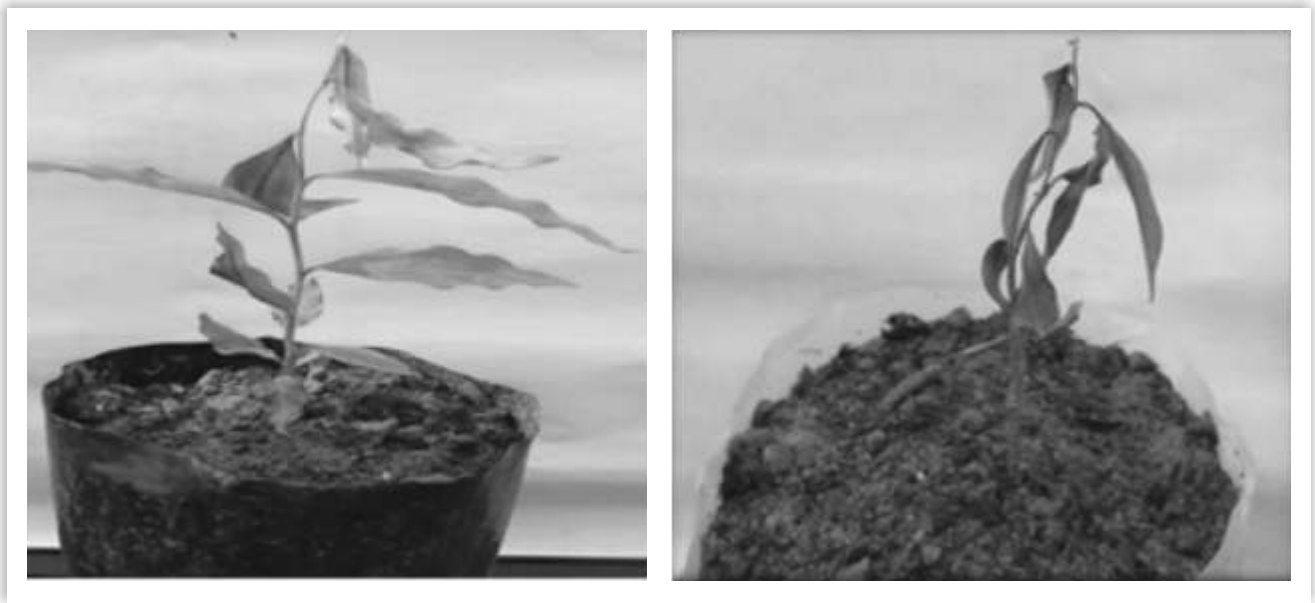
Application of Furadon 3G at the base of the tree.

Damping Off

In early stage, seedlings show stunted growth with typical discoloration on the collar region and formed small lesions on roots near to soil level and grey to brown spots on leaves. The spots coalesce together which in turn cover the whole leaf surface. In severe infection, the entire root was found to be rotted and mortality of the seedlings occurred.

- Causal Organism

  Rhizoctonia solani.



Control Measure

Seed treatment with Bavistin (0.1%) is found to be effective.

Leaf Spot

The characteristic symptoms initially appear on the upper surface of leaf as spindle shaped spot with yellow halo and pin head reddish brown dot at the centre. Later on, the spots increase in size up to 2-3 mm. the diseased spots scatter as dark brown to black in colour, angular to oval and irregular shape, produced large numbers on the surface of leaves. Initially, symptoms are noticed on the younger leaves and later on infections spread to all the leaves of agar seedlings.

- Causal Organism

  The fungi *Corynespora cassiicola.*

Control Measure

Spraying of Mancozeb @ 2.5 gm/lit or Carbendazim @ 1gm/lit of water at 10-12 days interval is found to be effective.

KEYS FOR IDENTIFICATION OF INFECTED AGAR TREES

The external symptoms for identifications of initiation or formation of agarwood in agar tree are described below:

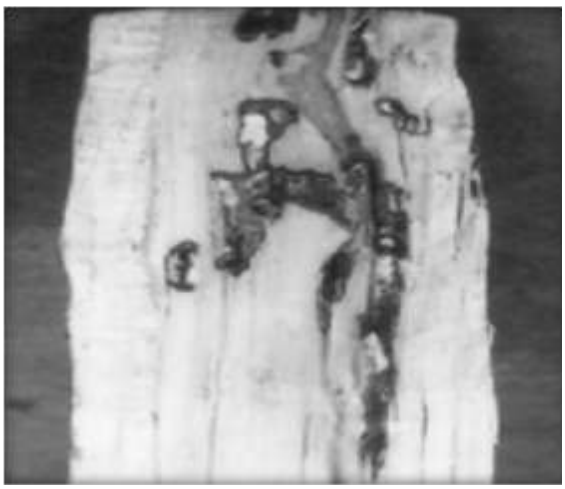
- Appearance of borer hole
- Oozing out of watery substances from fresh borer hole
- Accumulation of frass at the base of the tree
- Closing of borer hole by the growth of host tissue leaving a small spindle shaped mark
- Longitudinal cracks on the trunk/ bole
- A poor unhealthy crown with small and yellow leaves
- Swelling or depression and sometime canker formation on the bole/tree
- Appearance of hordes of ants in the tissue and formation of ant's nests
- Leaves become smaller and yellowish colour
- Overall abnormality and ill health of plant distinct from a healthy looking plant
- Formation of hollow sound when hammered on the trunk

AGARWOOD FORMATION

Agarwood formation is the resinification of accumulated oleoresins due to the action of microorganisms. The infection of fungus occurs when stem injured or is bored by larvae of a stem borer (*Zeuzera conferta*). The borer makes tunnels inside the tree trunks. Fungus enters the plant through this vertical hollow sometimes-zigzag tunnel inside the stem, which serves the initial sites of infections. From these, infection gradually spreads up and oleoresins are accumulated in the infected areas. Raising of agar plantation is a long time investment as agar generally starts yielding after 20 years. Besides, all agar trees do not form agar wood and it is found invariably in some defective and

diseased trees only. So, even if agar is planted on a massive scale, there is no guarantee that agarwood can be harvested on a commercial quantity. The fungal infection takes long time to mature and trees about 50 years old have the highest concentration (2.5-5.0 kg/tree).

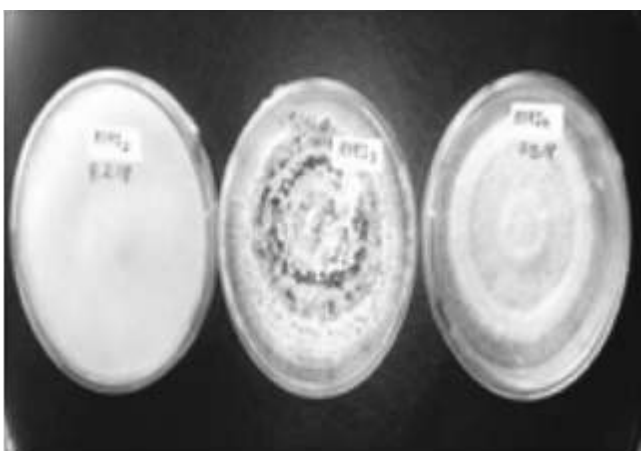
Zeuzera conferta Walker

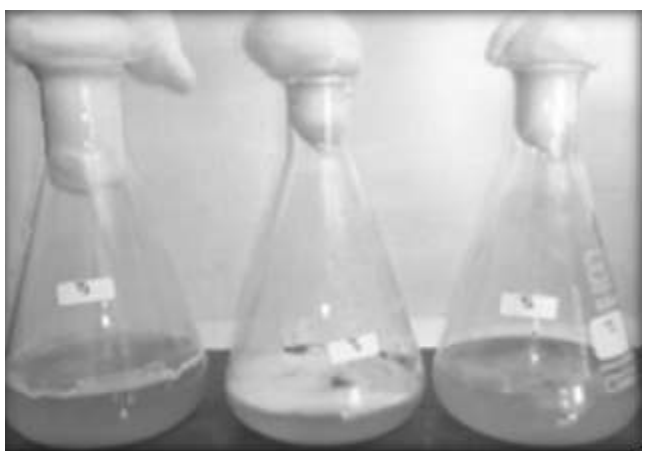


Formation of natural agarwood at the site of borer

Technology for artificial induction of agarwood in *Aquilaria malaccensis* by RFRI

Of late, Rain Forest Research Institute, Jorhat, Assam has successfully induced agarwood with artificial inoculation of fungi in healthy agar trees (*Aquilaria malaccensis*) of 6-7 years old. Trees can be inoculated by making holes of 2 cm diameter in a zig-zag manner along the trunk using an electric drill upto a depth of 5-6 cm. The first hole is to be made 1 m above the ground and the remaining holes are made at 30 cm apart. Minimum, 10 holes are to be made on the tree with girth of 35-40 cm and height of about 15-20 m. Fungal broth (10 ml) is to be injected into the drilled hole using a hypodermic syringe and the holes are closed with a thin layer of non-absorbent cotton. Formation of agarwood can be observed after 1 month of inoculation from the discolouration of wood surrounding the inoculated holes by removing the bark near the hole. After 5-6 months, discolouration zone of the holes will coalesce and thus resulting in formation of agarwood throughout the tree. Two years after inoculation, trees are ready for harvest.





Fungal cultures on PDA and Broth

Making Hole

Artificial Inoculation Techniques

Infected agar tree after two years of inoculation

Agarwood from artificially inoculated agar trees at Rowta

YIELD

With intensive management practices, a 10 years old infected agar tree may yield up to 30-40 kg agarwood for oil extraction. Harvested wood chips are steam-distilled (may be continued for 5-10 days) for agar oil extraction in a special type distillation unit. However, yield of commercial products of agar tree is not uniform and is almost unpredictable.

ECONOMICS

Three grades of oil are being extracted from the agar namely Boya, Boha and Khara. The rate also varies from Rs. 500/- to 12000/- per tola (11.62 g) and Rs. 2.50 lakhs per kg of agarwood in the North-East India. In the International Market, whereas one liter of essential oil extracted form agarwood fetches a few US $ to 50,000 US$ depending on the quality.

ECONOMICS OF AGARWOOD PRODUCTION PER HECTARE

Heads of expenditure	1st year (Rs.)	2nd year (Rs.)	3rd year (Rs.)	4th year (Rs.)	5th year (Rs.)	6th-8th year (Rs.)	9th-15th year (Rs.)
Cost of fencing and repair	16000	3000	5000	18000	5000	5000	-
Land preparation Pit (30×30×30 cm) making 1700×Rs.5/ pit	8500	-	-	-	-	-	-
Cost of saplings 1700×Rs.10.00	17000	-	-	-	-	-	-
Planting cost @ Rs.3.00/plant	5100	-	-	-	-	-	-
Compost	10000	10000	9000	10000	10000	-	-
Fertilizers	-	7000	7000	8000	8000	-	-
Application cost Rs.3.00/plant	5100	5100	5100	5100	5100	-	-
After care/year	1,25,000	1,25,000	1,25,000	1,25,000	1,25,000	3,75,000	8,75,000
Inoculation	-	-	-	-	-	4,76,000	4,76,000
Miscellaneous expenditure	20000	2500	2000	3000	2000	5000	8000
Total	2,06,700	1,52,600	1,53,100	1,69,100	1,55,100	8,61,000	13,59,000

TOTAL EXPENDITURE = Rs. 30,56,600/-

RETURN

1. At 7-8th years Boya (250 trees X 25 Kg X @ Rs. 10/Kg) = Rs. 62,500.00
2. Dum low quality product (550 trees X 40Kg X @ Rs. 100/Kg) = Rs. 22,00,000.00
3. Dum high quality product (400 trees X 50Kg X @ Rs. 1000/Kg) = Rs. 20,000,000.00
4. Botali mal (500 trees X 0.5 Kg X @ Rs. 5000/Kg) = Rs. 12,50,000.00

Total Gross Return: Rs. 2,35,12,500.00

Net Return: Rs. (2,35,12,500.00 – 30,56,600.00) = Rs. 2,04,55,900.00

Net Return Per Year: Rs. 13,63,727.00

27 BAMBOO

• English Name/ Trade Name :	Bamboo
• Common/Local Name :	Assamese (Assam) – Banh Hindi - Baans
• Family :	Poaceae
• Sub Family :	Bambusoideae
• Part Used (s) :	Rhizomes, Shoots, Culms, leaves

INTRODUCTION

Bamboo is a tall, woody perennial and evergreen plant belonging to the grass family, Poaceae under the sub-family Bambusoideae. There are about 1250 species of bamboos from 75 genera existing all over the world. In terms of bamboo production, India stands 2nd position next to China, occurring over an area of 10.05 million hectare. Total 136 species belonging to 23 genera are reported from the country. The northeast region of the country possesses the largest diversity of bamboo. Around 90 species comprising 44% of total bamboo species of the country is widely distributed in this region. Even then, bamboo resources in their natural habitat are dwindling, due to over exploitation, shifting cultivation practices and extensive forest fires, gregarious flowering etc. As reported, demand of bamboos in the country from different sectors is of about 27 million metric tonnes approximately against the total annual production of 13.47 million tonnes only (Bhuyan, 2009). In order to bridge the increasing gap between demand and supply, cultivation of bamboos on commercial basis, afforestation in hill areas, degraded land etc. are very essential on today's date. To support the growth of the bamboo sector, Government of India has restructured the National Bamboo Mission (NBM) under Ministry of Agriculture and also established Cane and Bamboo technology Centre under the aegis of North East Council, to design projects for the sustainable development of the bamboo industries in the north east India.

GEOGRAPHICAL DISTRIBUTION

Most bamboo species grows well in hot to warm and moist tropical and warm temperate regions of the world with an uneven distribution based on annual precipitation, altitude, soil conditions and temperature. Large patches of natural forests occur in tropical Asian countries including India, Myanmar, Thiland and China. In India, they are found growing naturally in almost all parts of the country except Kashmir.

However, bamboo does not prefer temperatures under 15° Celsius in summer. Annual rainfall ranging from 1270 - 4050

mm is good for its luxuriant growth. Well drained sandy loam soil to loamy clay soil, having pH range of 4.5 to 6 is considered as the best for cultivation of bamboo. Rock-strewn soil is never preferred for bamboo plantation.

BOTANICAL DESCRIPTION

Structurally, bamboo is unique from the other plants and trees. The inter-nodal portions of the bamboo are usually hollow. The components of a bamboo plant include rhizomes, roots, culms, branches, leaves and flowers.

Rhizome

The rhizome is the underground part of the plant bearing roots. Bamboo rhizomes are of two types namely sympodial and monopodial. Rhizome is one of the main propagule for vegetative propagation of bamboo.

Roots

The primary function of roots in bamboo is to anchor the culm to the ground. In case of bamboo, roots are typically symmetrical in size and shape. They form at the base of the culm from the rhizome nodes and generally go no deeper than one foot below the surface.

Culms

The culms are the most useful part of bamboo. Culms may vary in size, shape, colour and even in smell. For most of the bamboo species, vegetative propagation can be done easily through culm cuttings for mass production.

Branches

The majority of bamboo species will grow multiple branches from a single bud, located at the node. These branches can be also used as propagules for vegetative propagation.

Leaves

Appearance of leaves plays an important role in the identification of bamboo. New leaves emerge during the spring season to gently push off old foliage. Bamboo leaves are high in fiber, protein and silica, resulting in many uses such as bamboo tea, bamboo beer, medicinal aids, aroma therapy, essential oils, etc.

Flowers

Flowering in bamboo is a botanical enigma. Flowering cycle varies depending on the species, but in general, bamboo flowering intervals can be as long as 20-120 years. Three types of flowering may occur i) that flower annually, ii) those that flower gregariously and , iii) those that flower sporadically. It is generally believed that flowering in bamboo results in death of the bamboo. But it is found that the mortality behavior is different from species to species. (Pattanaik *et al.*, 2002).

USES

The use of bamboo is now getting diversified day by day. It is because, bamboo is a versatile, strong, renewable and environment-friendly plant that can be utilized in all levels of industrial activity from small craft based industries to modern highly integrated Plants. There are more than 1500 documented uses of bamboos. It is mainly used as construction material, furniture, pulp and plywood. Bamboo is regarded as substitute of wood due to its physical and mechanical properties. Moreover, the bamboo shoots are consumed as food and are considered good source of nutrition. In India, especially in north eastern region, bamboo is an integral component of rural livelihood. Millions of tonnes of bamboos are utilized in different types of cottage industries such as agarbatti, kite and cracker industry, ice cream industry, matchbox industries etc. Hence, it plays an important role in the development of socio – economic status of the local people of that

region. As, bamboo provide considerable environmental benefits, in many countries, it is used for ecological purposes such as soil stabilization and erosion prevention on hill slopes.

PROPAGATION

Bamboo can be propagated either through seeds or vegetative means. Normally, vegetative propagation is done through rhizomes / offset, culm cuttings and branch cuttings.

Propagation through Seeds

- When bamboo flowers, fresh seeds should be collected as much as possible.
- Soak the seeds for overnight (12 hours) in tap water then sow the seeds in germination bed. Cover the seeds with thin layer of mixture of soil, sand and FYM. For first few days watering should be done twice in a day to keep the germination beds in moist condition
- Germination starts after 10 – 15 days of sowing. When the seedlings attain a height of about 8 -10 cm, get ready for transplantation. Bamboo seedlings are raised in nursery beds for a year maintaining a spacing 20 cm row to row and 20 cm from plant to plant. Later, seedlings are transferred into the main field. Sometimes, seedlings are raised in polybag also. After a period of four months, the seedlings become ready for macroproliferation
- Provide overhead shade to protect the newly germinated seedlings from direct sun light

Propagation of bamboo through seed is very easy but, getting seed is a major problem due to rare and irregular flowering of bamboo. It is found that some species like *Bambusa balcooa, B. vulgaris* do not produce seed and there are some other species like *Bambusa bambos, B. polymorpha, Dendrocalamus strictus, Melocanna baccifera* and *Phyllostachys* sp. which often flower at long intervals varying from 30 to 70 years. Therefore, alternative propagation method is to be adopted i.e. through vegetative means.

Propagation through Vegetative Means

Vegetative propagation of bamboos is normally done through the rhizomes / offsets, culm cuttings and branch cutting.

Propagation through Rhizomes / Offsets

An offset is the lower part of a single culm usually with 3-5 nodes (i.e. about 1 to 1.5m) with the rhizome basal and roots attached. The rhizome is the underground part of a bamboo stem (culm). However, rhizomes are not roots, as roots grow under the rhizome and culms comes on top of the rhizome.

Propagation of bamboo through rhizome and offset is a traditional method that the most of the village people always use. People just dig out the rhizome or offset from the mother clump and plant directly in the pit. Due to lack of basic knowledge on scientific way of planting, it shows a high mortality percentage. To ensure high survival rate, the scientific method of rhizome and offset planting should be followed, as described below.

- Select a healthy clump and choose 1.5 -2 year old culms

Rhizome for propagation

- Cut the culms leaving two nodes on the offset with a sharp instrument. Cut off the top portion at about 1 to 1.5 m height (3 to 5 nodes from ground level bearing viable branch buds). The period from February to May is the best time for rhizome and offset plantation. In tropical to sub tropical regions, rhizomes are transplanted just before rainy season
- Dig around the rhizome portion and detach it from the mother culm at the neck portion carefully so that the rhizome and the attached roots are not damaged
- Wrap the roots and rhizome with gunny bag and cover the cut portion with plastic strip or paint or mixture of soil and cow dung to prevent desiccation

Rhizome planted in field

- In the field, planting pit should be prepared before or in the same time of collection of rhizome, so that it can be planted immediately. Generally pits of size 50X50X50 cm are made. Fortify the dug out soil with farm yard manure and other fertilizers such as Urea, Single Super Phosphate and Murate of Potas.
- Dip the rhizome portion in Bavistin solution (1gm in 1 litre) just before planting to avoid any fungal attack. Always plant the rhizome / offset vertically
- Watering is very essential for first few weeks. Any prevailing drought has to be avoided by watering

Propagation through Culm Cuttings

Single bamboo in a clump is called culm. The culm is the above ground stem which grows from the underground rhizomes. Propagation through culm cutting is a very useful method for mass production of bamboos. The method is described below

- The propagation material consists of culm cuttings with two nodes and sometimes with single node
- The cuttings should be collected from disease free, healthy culms having age 1.5 to 2 years
- February to May is the best time period for collection of the culm cuttings
- Cut the culm with a sharp instrument leaving two nodes at the base. Discard the top thin portion of the culm and cut the whole culm into either two noded or single noded segments depending on wall thickness of the bamboo. Generally, for thick walled bamboos like *Bambusa bambos, Dendrocalamus strictus, B. balcooa* (basal portion), single noded culm cuttings are preferred and in case of bamboos like *B. tulda, B. nutans, B. cacharensis,* two noded culm cuttings are

Two noded culm cuttings

considered. Trim the branches leaving two nodes. Cut portion should be oblique to expose maximum area

- Make two holes at the centre of the two noded culm cuttings with the help of a hand drill machine
- Hormone plays an important role in development of roots in the cuttings. In order to prepare hormone solution take 2 gm of Indole -3 Butyric Acid (IBA). Dissolve it in 10-20 ml of ethyl alcohol and then make up the volume up to 10 litres of water. Take only 200 ml hormone solution and inject it into the cuttings with a syringe. Wrap the holes with polythene strip so that no solution will come out during transfer to the main field. In case of single noded cuttings dip the cuttings in the hormone solution for 24 hours.

Injecting hormone solution

Sealing the holes with polythene strip

Planting of cuttings in the nursery bed

Emergence of new shoots

Development of roots in culm cutting

- Dip the cut portion along with the nodes in Bavistin solution (1gm in 1 litre water) just before planting to avoid any fungal attack.
- Plant the cuttings in raised bed in horizontal manner. The beds are filled up with mixture of soil, sand FYM. Cover the cuttings with a thin layer of mixture of soil, sand and FYM
- Watering is very important at least for first 15 -20 days
- Sprouting will be observed after 10 – 15 days of planting. After 1-1.5 months, slender root development will take place and after 4-5 months, new shoots will emerge out. Complete leaf development in the new shoots indicates to go for macroproliferation

Propagation through Branch Cuttings

- In thick walled bamboos like *Bambusa balcooa, B. bambos, Dendrocalamus hamiltonii* there are some prominent primary branches. These branches can be used as the ideal planting material
- Cut the branches from the culms having age 1.5 to 2 years old with a sharp hacksaw. The branches should have a rhizomatous swelling portion with some roots
- Discard the top portion leaving only two nodes and the basal swell
- Dip the cuttings in hormone solution (200 ppm IBA) for 24 hours
- Seal the upper cut end with molten wax to minimise water loss through cut ends
- Dip the cuttings in Bavistin solution (1gm in 1 in litre of water) just before planting
- Cuttings may be raised either in polybags or in nursery bed
- Potting media should contain equal parts of soil, sand and FYM
- Watering is essential and also provides overhead shade
- After six months the plants will be ready either for planting in the main field or macro-proliferation

Branch Cuttings

B.balcooa

D. hamiltonii

Emergence of New Shoot

Macro-Proliferation

Macro-proliferation is the technique in which regular separation of new shoots at 3-6 months interval is done in such a way that each shoot contains a rhizome portion and few roots. Bamboo itself possesses inherent property of proliferation. So, the new shoots can be easily separated for production of quality planting stock. It is an easy and low cost technique that farmers can adopt for large scale production as well as plantation programme. Method of macro-proliferation is described below:

- When the seedlings / rooted culm cuttings / branch cuttings reach 3-4 shoot stage, dig out from the nursery bed

- Separate the individual shoots at the rhizome neck portion with the help of sharp secateurs.
- Discard the upper portion leaving only two nodes
- Seal the upper cut portion with wax and dip the rhizome in Bavistin solution (1 gm bavistin in 1litre water) just before planting in the field or in polybags

Different steps of macro-proliferation technique

Macroproliferated Bamboo Plants of different species

Guadua angustifolia

Bambu sanutans

B. vulgaris var. striata

SILVICULTURAL AND MANAGEMENT PRACTICES

Land Preparation

In case of grass growing land, first cut off the grass and laid them on ground and then clear the ground by burning after they get dried. Sometimes, slashing and burning method can also be applied for clearing the land. Unwanted vegetation should be cut from the area. Fencing should be provided in all sides of the planting area.

Pit digging, Spacing and Planting

Digging of pits should be done before the planting season. Generally for rhizome planting, pit size of 50 cm X 50 cm X 50 cm and for seedling / rooted cuttings (macroproliferated plants) of 30 cm X 30 cm X 30 cm are to be prepared. Before planting, fortify the dugout soil with FYM and chemical fertilizers. In commercial cultivation of bamboo, a standard spacing should be maintained between two clumps. For *Bambusa* spp. generally 5 m X 5 m – 7 m X 7 m spacing is required. But in case of *Dendrocalamus* spp. it should be of 10 m X 10 m. The rhizome / offset / rooted cutting / seedlings should be planted vertically in the pit and cover it with soil up to the first node. Mulching is also beneficial as it prevents water loss.

Manuring and Fertilization

Manuring and fertilization to the bamboo clumps are very important factors for high quality and best yield. As the bamboo plants are heavy feeders so, fertilizers should be applied on them. Fertilization may be done every year after harvesting and provision to irrigating the plants. Potassium and Nitrogen are vital components of the fertilizer for well growth of bamboos. So, the mixture of Urea, Single Super phosphate and Muriate of Potash in 2:2:1 ratio along with organic manure must be applied around the clump.

Weeding, Soil Loosening

Weeding and soil loosening around the clumps of the bamboo planting area should be done for 1-2 times every year. Soil loosening is necessary so that the tender shoots easily emerge out of the soil.

HARVESTING

Bamboo is considered as the fastest growing plant in the world. It attains the maximum height at the age of 1-1.5 years but, takes 4-7 years to become full size culms. Of course, it depends on the species, soil, humidity and position of the culm in the clump. The harvesting can be started from the fifth year onwards. Harvesting mature culms is important for optimum quality. For ascertaining culm maturity in the field while harvesting, besides morphological features, the colour of the culm can also be taken as a reliable indicator for accuracy. Since, in case of matured bamboo, the clear and shiny green colour of the stem turns into a gray and dark green colour. Moreover, emergence of new shoots for most of the bamboo species generally takes place during May to October, So, during this period, harvesting should not be taken up. Most recommended time to harvest bamboo is at the end of rainy season to beginning of the emergence of new sprout.

There are some special techniques for harvesting congested culms from the natural forest as well as from homestead gardens where no such management practices followed earlier. These are 1) Perpendicular tunnel method and 2) Horse shoe method. In the first method, two perpendicular tunnels are to be made so that matured bamboos could be cut out from the congested part of the clumps. In the second method, the whole clump is converted into a horseshoe shape by thinning the culms from the inner side.

POST HARVEST MANAGEMENT

Post harvest management of bamboo culms is very important for enhancement of its service life because, bamboos are susceptible to biodegradation which reduce its durability after 3-4 years from harvesting. For effective post harvest

protection of bamboos, the following integrated pest management strategy may be adopted:

- Bamboo should be cut at the season during which the starch content is less. Best time to harvest bamboo is at the end of rainy season to beginning of the emergence of new sprout
- The traditional methods of preservation like water soaking, curing and smoking may be adopted (Singha and Borah, 2017)
- Bamboo can be preserved by treating with chemicals to prolong their durability. Generally, Copper Chrome Arsenic (CCA), Copper Chrome Boron (CCB) and Boric Acid Boraxare used for bamboo treatment. Boric Acid Borax is most commonly used preservative. It is a nontoxic chemical and can be used for treating bamboo products like baskets, dry containers, etc. which come in contact with food products. Copper Chrome Arsenic (CCA)is a very effective chemical preservative patented as AsCu. However, this preservative is highly toxic and not eco-friendly due to presence of Arsenic so, instead of it, Copper Chrome Boron (CCB) is used as a good alternative to CCA
- For different chemical methods of bamboo preservation like steeping, sap displacement, diffusion process, 10% aqueous solutions of water–borne wood preservatives is recommended (Negi and Gurung, 2009)

YIELD

The yield of bamboo always depends on management objectives and intended products. If the management objective is production of shoot, the density of shoot producing bamboo is 2100-3300 / ha and the production of shoots may be 18 t / ha. If the management objectives is production of culm, the density of culm is 3600 -4500 individual bamboo / ha and the output of the culms is more than 20 t. If the management objectives is both shoot and culm, the density of shoot and culm producing bamboo is 2700-3000 / ha and the output of the culms is 40-50 Kg and the output of the shoots is 12 -15 t (Bhuyan, 2009).

ECONOMICS OF BAMBOO

In India, 8.6 million people depend on bamboo for livelihoods. Indian bamboo is currently estimated to create value equal to $4.4 billion. (INBAR). One can cultivate bamboo with a very low investment as bamboo grows itself in natural condition. Planting of bamboo is easy to payback as every part of bamboo like shoots, culms, leaves, rhizomes have economic value. After 4-5 yrs. of plantation:

No. of individual bamboo harvested from one clump	=	5-6 nos./yr.
Total No. of individual bamboos from one hectare of land	=	2500 nos./yr.
If the cost of one bamboo	=	Rs. 50/-
Cost of 2500 nos. of bamboos = 2500 x Rs.50/-	=	Rs. 1,25,000/- per year
Expenditure: Cost of land preparation + cost of FYM and fertilizer + cost of fencing + cost of labour charge etc.	=	Rs. 25,000/ to Rs. 30,000/-
Net profit	=	Rs. 1,00,000/- to Rs. 95,000/- per year /ha

Thus, bamboo cultivation is a very good source of income generation for the rural people and thereby plays an important role in development of socio economic status of the poor people. Various funding agencies like NBM, NABARD, NEDFI are providing financial support for bamboo cultivation. The unemployed youths should take up this opportunity and cultivate bamboo to contribute to the country's green economy.

28 Canes (Rattan)

• English Name/ Trade Name :	Rattan
• Common/Local Name :	Assamese : Bat
• Family :	Palmae
• Part Used (s) :	Root, Stem

C. khasianus in natural habitat

INTRODUCTION

Rattans (Canes) belong to a group of spiny palms of the sub-family Calamoideae under Arecaceae, characterized by fruit bearing scales. The word 'rattan' is derived from Malayan word 'rotan' which is the collective name of a big group of Lepidocaryoid palms. It is a large and diverse group of climbing and non climbing palms, comprising an important group of non timber forest products that are extensively collected for household uses and cash income in the humid tropics. Worldwide, 14 genera of rattans comprising 600 species have been reported which are naturally distributed in the South East Asia from Fiji Island to Africa and from southern China to Queensland (Australia) with the greatest concentration in the Dipterocarp rain forests of the Malaysian Archipelago.

It has increasingly been recognized worldwide for its economic and social potentialities especially of furniture products. In recent decades as furniture products of rattan are drawing attention in the global market, rattan based industries are increasing in local, national and international level.

GEPGRAPHICAL DISTRIBUTION

In India, 60 species of rattan representing 5 genera is distributed in 3 major ecological regions viz. Peninsular India, Eastern and Northeast India and Andaman and Nicobar Island. In the North-eastern region of India, more than 20 species and 3 varieties under 4 genera have been reported. Among these, *Calamus* accounts for 14, *Plectocomia* for 4 and Daemonorops and Salaca for 1 species each. The species are distributed in the evergreen, semi-evergreen to deciduous forests of the region. Out of these 20 species and 3 varieties, twelve species are endemic to this region.

Priority species of Rattan for Northeastern Region

Rattans are usually used for preparation of diverse traditional and cultural items and to make furniture. The species for their stem characteristics i.e. elasticity, strength, good splitting and stem diameter - small (<10mm), medium

(>10<20mm,) large >20 mm etc are given priority for furniture and domestic use. Fruit pulp and tender shoots of some species are edible.

Table 1. *Priority species for furniture and domestic use:*

S.No	Species	Vern Name	Stem Category	Use
1	*Calamus tenuis*	Jati bet (Ass.); Panibet (Karbi);Chang –dam (Mizo); Yai-ree (Meitei); Taiting (Kuki)	Medium	The tender shoots are used as vegetable, fruit pulp is edible. A most important rattan, having good splitting characteristic. Cane sheets are used for stitching of furniture back, binding purpose, for preparation of traditional fishing tools etc. Canes are used as rope in traditional ploughing tools.
2	*C. flagellum*	Raidang bet (Ass.); Tor (Karbi.), Hrui-pui (Mizo); Ramang (Adi), Thou (Nishi); Lee-khet (Meitei)	Medium	The tender shoots are used as vegetable, fruit pulp edible; canes are used for preparation of sofa's frame. Leaves are used for thatching purpose.
3	*C. latifolius*	Houka bet (Ass.); Preshek (Karbi); Hnah-bawr (Mizo); Takat (Nishi); Lee-ren (Meitei), Rudai (Naga); Tingpi (Kuki)	Medium	Good splitting characteristic, the sheet used for knitting of cane hat, different type of decorative household items by blending with bamboos
4	*C. nambareinsis*	Houka bet (Ass.); Teng-yar (Karbi); Hnah-bawr (Mizo); Takat (Nishi)	Medium	A most popular rattan of northeastern region with good splitting characteristic, most preferred by furniture industry. Whole stem is used for furniture frame; sheets used in preparation of diverse household items. The cane is high quality and a most preferred species.
5	*C. gracilis*	Oahing bet, Chuli bet (Ass.), Prelude (Karbi); Kawr-tai (Mizo)	Small	The canes are used for preparation of chair/sofa's side /bottom
6	*C. khasianus*	Raidang (Karbi), Mawt (Mizo); Takat (Nishi)	Large	Fruit pulp edible; Whole stem (cane) is used for furniture frame
7	*C. inermis*	Raidang (Karbi), Mawt (Mizo); Takat (Adi, Nishi); Lee-nan(Meitei);	Large	Whole stem (cane) is used for furniture frame

8	*C. viminalis*	Hill Jati (Karbi);	Medium	Shoots are used as vegetable, fruit pulp is edible; cane sheets are used for making Sofa's back and side
9	*C. acanthospathus*	Paharia Jati (Ass.); Mit perh (Mizo); Esong (Adi); Thatchu (Naga); Lee-tingkhang-panbi (Meitei)	Medium	A strong rattan. Cane sheets are used for preparation of traditional hat, binding and knitting of Sofa's back
10	*Daemonorops jenkinsiana*	Gola (Ass.); Tor (Karbi.); Rai-chhawk (Mizo); Lee-phop(Meitei); Songrui(Naga); Umpong(Kuki)	Large	Canes are used for furniture frame; cane sheets are used for knitting of Sofa's back
11	*Plectocomia assamica*	Hati bet (Ass.)	Large	The biggest rattan in the Northeast India, used as pole by communities
12	*P. himalayana*	Mawt (Mizo); Lee-phop (Meitei)	Large	Cane sheets are used for preparation of indigenous cap/hat

Vernacular name(s)- Assamese (Ass.), Karbi-Anglong (Karbi.), Mizoram (Mizo.), Adi-tribe of Arunachal Pradesh (Adi), Naga (Nagaland), Kuki (Kuki Naga) of Manipur, Meitei (Manipuri), Nishi tribe of Arunachal Pradesh (Nishi)

Important rattan species for furniture and domestic use

Calamus khasianus

C. flagellum

Important rattan species for furniture and domestic use

C. gracilis

Daemonorops jenkinsianus

PROPAGATION

The most common propagation method of rattan is by seed. In addition, rattan can be propagated by suckers, rhizomes and wildlings. Suckers are good propagules in clump forming species. Suckers intact with roots are best to survive. *Calamus tenuis* is well raised by suckers. The rhizome network developed in the ground is taken out wholly for planting. This traditional method is still prevalent in rural areas and very effective. Besides, tissue culture is also practiced for mass multiplication of rattan.

Climate

The mean annual temperature for rattan should be in between 25-27 °C and well-distributed rainfall of over 2,000 mm and a high relative humidity.

Soil

Rattans prefer strongly acidic soils rich in organic carbon and with high water holding capacity, rich humus layer (1.2 - 4.9%), medium loam, light clay and sandy loam soils and a low pH of about 4.5 to 6.0.

Development of Nursery

Different steps for development of seedlings as well as nursery of rattans are summarized below:

Fruit Collection

Rattan seeds generally mature during April to May, which may vary according to species. Fruits are usually collected from more than 6 m high mother plant. Generally seeds become mature when its colour turns yellowish white and the outer pericarp more or less ruptured. At this stage the fruits can be fallen down to the ground by slight shaking of the mother plant. The naturally fallen down seeds before damaged also can be collected which yield better germination percentage.

Fruit Processing

Immediately after collection, scaly pericarp and fleshy sarcotesta of fruit are removed carefully by placing the fruits in water and washing them by hand. It is important to remove the sarcotesta completely, because it is believed to contain substances that inhibit germination. Seed still embedded in sarcotesta will eventually germinate when the sarcotesta is decomposed. After wards the seeds are rinsed, dried briefly in the shade. The seeds should not be

dried out completely before showing. Generally rattan seeds are viable only for one or two weeks. To have better germination, collected seeds need to be sown within this period. When seeds are kept under very warm and dry conditions, they lose their viability completely within one or two weeks. It is possible to store clean seeds for up to four months in a closed container with moisture content of 45-60% at 16° C without any noticeable declining in germinating ability.

Mature Seeds

Calamus gracilis

C. khasianus

Germinant Development and Transplantation:

After thorough cleaning of the pericarp and sarcotesta, seeds are sown in shaded seed bed, with mixture of coarse sand, forest top soil and farmyard manure (1:1:1). Seeds should be treated with 0.5% solution of fungicide before sowing. After sowing, the seed beds are covered with decomposed grass/leaves and watered regularly. Seeds starts germinate within 20-30 days which may vary from species to species. Some species require relatively long time, 3-6 months for germination.

As soon as the plumule and radicle developed, the germinant are carefully transplanted to polythene bags having 1:1 proportion of soil (forest top soil) and farmyard manure. After transplantation to polythene bags, the seedlings are kept in 50-75% shade for their initial growth. Wooden or bamboo slates, palm leaves, thatch etc as natural shade are more suitable. In the initial stage, seedlings grow slowly and need 12-18 months before they have attained a height of approximately 30-50 cm to cope with field conditions and at this stage, the seedlings become ready for plantation in field.

Seedlings of endemic and threatened rattans

Calamus nambareinsis

C. khasianus

Collection of Wildlings

The seedling grown in wild are called wildlings. In North east India, particularly in Assam, there are difficulties in seed collection during the seed maturing time because during this period, cane brakes normally remain submerged under water or are in inaccessible plots. It starts drying up in September-October when the wildlings are coming out. The healthy wildlings can be picked up and transplanted to polythene bags. Wildlings collected with small ball of soil containing its roots enhance the survival rate and can be planted directly under shade.

Planting System

The planting space depends on the habit of canes. Clump forming species require 5 m and more space while single stemmed require 2-5 m spacing. To carry out plantation in secondary forest, planting lines are prepared by clearing 1-1.5 m wide grooves at a distance of 5 m interval and 30X30X30 cm pits are dug out at 5 m interval in the planting lines and 12-18 months old seedlings are planted out in the pits before the monsoon starts i.e. during March-April. *Daemonorops* species form dense clusters, for its suitable growth required spacing is 5 x 5 m or 6 x 6 m. In natural forests, *Calamus tenuis* seedlings can be planted out in 5m x 5m spacing. The seedlings are planted after removing the polythene bag containers without disturbing the soil around the roots in such a manner that the root collar is at level with the ground. Once the plants are established, very little attention is required beyond occasional loosening of the soil around the clumps. Mulching with humus may be done to boost the development of new shoots.

The supporting trees have important role for yielding performances and quality of cane. If the canes have trees to climb up, its pliability quality is affected. The supporting trees should be strong enough to bear the considerable weight of cane palms and should not break when the shoots are pulled down. The supporting trees should not have too large and dense crowns.

RATTAN DISEASE AND MANAGEMENT

Colletotrichium Leaf Spot

Colletotrichium gloeosporiodes causes leaf spot. The diseases symptoms first appear as a small pin head grayish brown water soaked lesions, which under favorable environmental condition, coalesce and form a large angular to irregular necrotic areas. Several such lesions coalesce and cause necrosis of the leaf. The disease is more severe in *Calamus tenuis.* The diseases have been recorded in nurseries, plantations and in natural stands as well in Mizoram and Tripura, North East India.

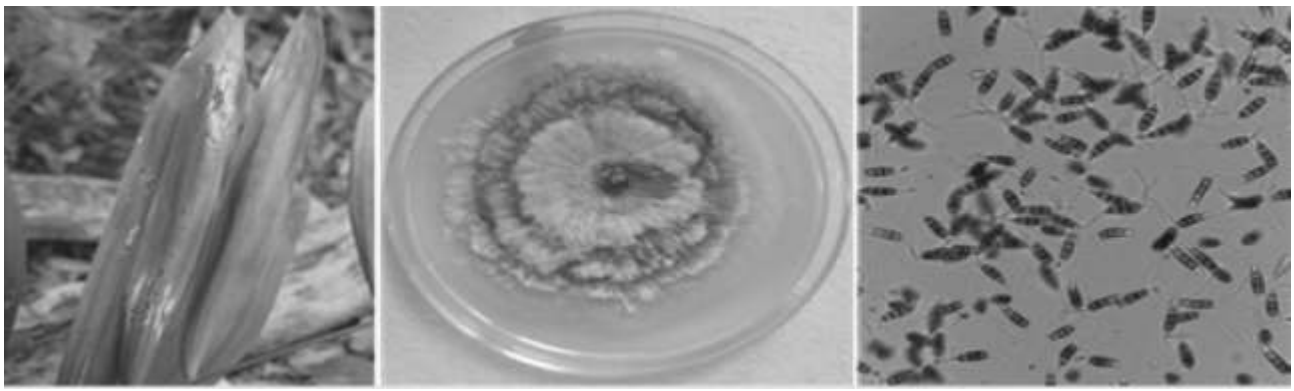
Pestalotiopsis Leaf Spot

It is caused by *Pestalotiopsis calami*. The symptoms of infection manifest as pale brown angular lesions on the lower side of the mature leaves of almost all the species of rattan under study. The lesions spread and coalesce to form irregular dark brown necrotic areas on infected leaves. Under favorable environmental condition the fungus sporulates on the upper surface of the necrotic lesions or areas. The diseases have been recorded in nurseries, plantations and in natural stands as well in Mizoram and Tripura.

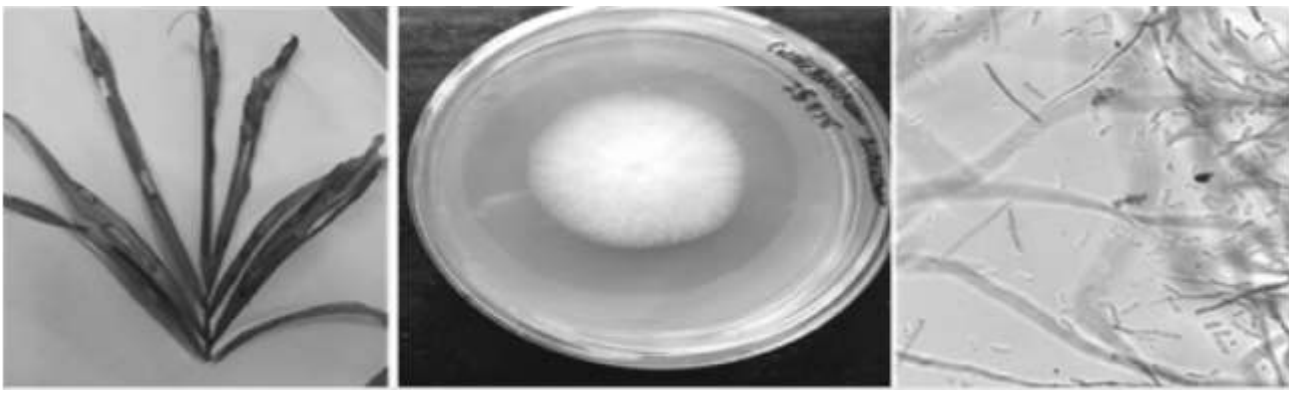
Leaf Blight

Fusarium oxysporum is responsible for leaf blight. The symptoms first appear as yellowish brown small lesions at the leaf margins and tips which under favorable condition coalesce to form a large dark brown necrotic areas. Under severe infection, the lesions spread over the whole leaf and lead to leaf blight and withering of infected leaves. *Calamus tenuis* is found to be severely affected by the disease especially under nursery stage.

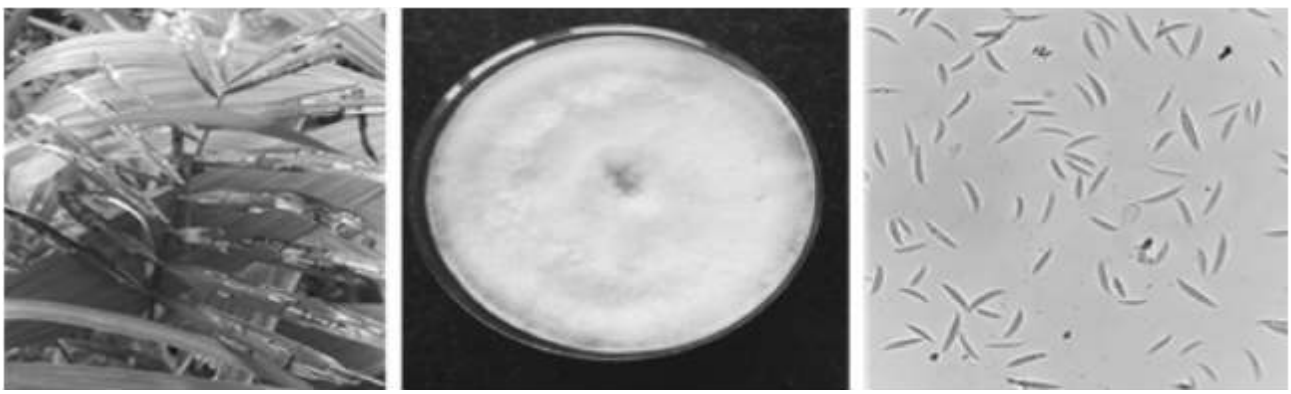
Two sprays of Hexaconazole (0.05%), tebuconazole (0.025%) and difenconazole (0.025%) and Mancozeb (0.35%) at 21 days intervals are recommended to control the diseases in nurseries, plantations and natural stands.



Diseases Symptom, pure culture and conidia of *Pestalotiopsis calami*



Diseases Symptom, pure culture and conidia of *Colletotrichium gloeosporiodes*



Diseases Symptom, pure culture and conidia of *Fusarium oxysporum*

HARVESTING

Indiscriminate and unscientific harvesting is one of the major causes of dwindling rattan resources in the region. Due to lack of strictness in harvesting rules, the yield of cane is reducing drastically and it is necessary to maintain norms to harvest the clumps to ensure sustained yield for longer period of time.

Generally, mature culms (not less than five meter height) are harvested by cutting them at 25-30 cm above the ground level from the base and then dragging them away from their support trees. Canes take 7-10 years to reach maturity and at this stage, the leaf sheath of the lowest portion dries out, loosens up and falls off exposing the stem. Only mature canes

should be removed from the clumps without damaging or hampering the immature or tender ones. Immature culms should not be harvested otherwise the plant may die and the canes obtained will be of very poor quality. Uprooting and extraction with rhizomes is not allowed. Up to the 10 % of the matured canes can be harvested at a rotation of 3 years from clumps of 7-10 years old. The best season for harvesting is October/ November when the growth of clumps is arrested for winter and weather become dry. Clumps consisting of less than six culms are not selected for harvesting. After harvest, the spiny leaf sheaths are removed on the spot. The top 1- 2 m of shoot is discarded, as it is soft and tender and unfit for use. The remaining portion is cut into 5-6 m pieces, folded over at the middle and bound into bundles. Very slender canes are coiled. The harvested rattans are immediately shifted to the processing centres to prevent deterioration.

Grading of Rattans

Rattans are qualitatively graded in the Northeast India. Following criteria are used for grading large-medium-small diameter of rattans as detailed in table 2 and 3.

Table 2. *Qualitative grading of large (>18mm)-medium (>10<18mm) diameter rattan*

Grade	Criteria
1	Mature stem, long internode, nodal ring not swelling, ivory to brownish yellow in colour, no surface defects, no cracks or borer hole
2	Mature stem, creamy in colour, upto 5% allowable surface defects
3	Mature stem reddish black in colour, 6-10% allowable surface defects

Table 3. *Qualitative grading of small (<10 mm) diameter rattan*

Grade	Criteria
1	Mature stem, long internode, smooth nodal ring, no surface defects, no cracks or borer hole
2	Mature stem, a few defects in epidermis
3	Mature stem, more effects of surface/epidermis

Curing and Drying

Curing improves durability and is also important to maintain the density and strength of natural rattans and for improving the stem colour. It also improves the appearance and aesthetic value of rattans. Whitish, yellowish or cream coloured rattans are more priced than the brown ones. Rattans with bright and glossy surface are superior to those with dull and non-lustrous surface. If rattans are not cured and dried properly after harvesting, they get attacked by fungi and insects resulting in quality deterioration. The conventional method of curing is by sun drying. The harvested material is air dried in the sun by staking vertically for 15-20 days. Under circumstances where this is not possible, drying over fire is resorted to. If the weather is dry, canes can be dried in about two weeks in the open. After thorough air-drying, rattans are horizontally stacked and stored in godowns.

Cane is also treated with kerosene oil to impart ivory white colour. The freshly harvested rattans are immersed in hot kerosene oil at a temperature of 100° - 105° C for varying lengths of time depending on diameter. The curing time

recommended is 20 minutes for small diameter (< 10 mm), 30 minutes for medium (10-18 mm) and 45 minutes for large diameter (> 18 mm) rattans. In this technique the cost of curing was found to be very marginal amounting to 40-50 paise per piece of 12-18 feet. Other hot oil mediums using mixture of diesel and coconut oil, diesel and palm oil as well as diesel and kerosene can be used for curing of canes.

YIELD

The yield of rattan plants ranges from a first harvest of less than 0.4 t/ha/year to 1.905 t/ha/year from 12th year onwards.

ECONOMICS

Majority rattan industries are cottage based and still unorganized, so, information on economy and people involved in rattan industry is less known. In flood prone areas of Sibsagar district, Assam, a good rattan resources of *Calamus tenuis* provide income of Rs. 25000- 30000 per ha/per year to land owners. It was recorded that a rattan based artisan can earn Rs. 3500-4500/ per month by selling rattan product subject to availability of raw rattan. It is estimated that the Indian Cane furniture industry produces goods worth Rs. 50 million. About 20000 people are employed in furniture manufacturing industries situated in different parts of India. Many more are employed for extraction, processing, transportation etc.

29 *Thysanolaena maxima* (Roxb. ex Hornem.) Honda.

• English Name/ Trade Name :	Broom grass
• Common/Local Name :	Tiger grass, Broom grass and Bouquet grass
• Family :	Poaceae
• Part Used (s) :	Leaves, Inflorescence and Roots

Thysanolaena maxima

INTRODUCTION

Broom grass or tiger grass is a tall perennial grass. These grasses grow naturally in the hilly terrains of the North eastern region. Inflorescences of these plants are used for making brooms which is called grass broom.

DISTRIBUTION

It is endemic to tropical Asia. In India it is distributed especially in Meghalaya, Assam, Arunachal, Mizoram, Nicobar islands, West Bengal (Darjeeling),Tripura; Bangladesh, Combodia, China, Indonesia, Japan, Laos, Malaysia, Myanmar, New Guinea, Nepal, Sri Lanka, Thailand, Vietnam and Philippines. It grows up to an elevation of 1600 m.

BOTANICAL DESCRIPTION

Evergreen, tall, rhizomatous, tufted perennial grass; has solid, smooth and rounded culms; wild but suitable for cultivation too. Grass clump is in tussock (bunch form). Culms arise centrifugally, green when young, brownish green at maturity.

USES

It is a multipurpose NTFP produce. It is used as soft brooms, handicraft, organic paintbrush (panicles); palatable fodder (leaves); bio-fencing, harvested broom sticks in fencing, fuel, wall building materials; checking soil erosion (fibrous roots), pulp and paper. In medicine- roots are used in bronchitis, skin boils, anthaelmintic, anti-microbial, flatulence, flowers in rheumatic pain and skin swelling; weed suppressor, landscape and ornamental purposes; mulching, roofing materials and wrapper for steamed foods; substrate for the cultivation of oyster mushroom; dyed panicles in carnival customs and decorative extenders.

PROPAGATION

Natural Regeneration

Broom grass is naturally regenerated through seeds in wild habitat. The seeds mature during February to March and disseminated by wind or water to long distance due to their light weight. The seedling establishment and growth are good on loose soils in exposed areas like landslides and freshly disturbed soil specially near road construction sites where light is naturally available.

Artificial propagation

Broom grass can be propagated artificially through seeds and rhizomes. The seeds can be collected from the matured inflorescence during February- March. Seeds cannot be sown directly in the main field. Seedlings are to be produced from seeds in nursery beds. Generally 10 g seeds are broadcasted in nursery beds of size 2 m x1 m. Seeds should be covered with thin layer of sand and watering is done to keep the seed bed moist. After 6 weeks, the seedlings are either transplanted into a second seed bed or raised in polythene bags which were filled with a mixture of soil, sand and farmyard manure. The raised seedlings are to be planted in the main field with the onset of rainy season. Broom grass can be planted through seed and rhizomes, but planting through rhizomes are easy and more successful method. The rhizomes are easy to transport to long distances for propagation. The rhizomes (roots alongwith culms) are collected by digging of roots from wild or cultivated broom grass plants after harvesting of brooms. A small clump of rhizome having 2-3 culms with 4-5 nodes is good for planting and gives cent per cent result. The sprouted seedlings/ rhizomes are ready within two months for transplanting.

Cultivation

Broom grass can be cultivated easily on marginal lands, wastelands and Jhum fallow land. It prefers sandy loam to clay loam soil. Field is prepared before March. Pits of diameter 30-50 cm are dug in the field and left for one month for weathering. The seedlings planted at a spacing of 2 m x 2 m in comparatively dry and plain land, 2.5 m x 2.5 m in fertile hill slopes, jhum lands, riverine and damp steps. Sprouted rhizomes from the nursery are transplanted within three months and plantation is done with onset of monsoon during April-June when soil has sufficient moisture. 1600 to 2500 seedlings are required for planting one hectare area. FYM (2kg per pit) is mixed in each pit soil before planting. FYM can be applied in soil during the second year also to get a better yield.

Cultivation of broom grass in Meghalaya

PLANT PROTECTION

Cut portion of the rhizome should be dipped in Carbendazim solution @ 0.1g/L as a prophylactic measure to control fungal attack. Fencing of the field is essential to prevent damage of seedlings from grazers. Two to three weeding are necessary in the first year and after that minimum care is required. Similar operations in subsequent years are necessary for obtaining better returns.

HARVESTING

The panicles from the grass are harvested from December to March when the panicles become tough and its colour changes to light green or red or brown. Harvesting is done carefully just before maturity without damaging the newly

sprouted shoots by cutting above the ground or hand pulled. The panicles are disjointed from culms and dried under direct sunlight for a few days. Burning of the field is necessary to boost up the sprouting of new shoots after harvesting. Yield varies with site; however, maximum yield is generally obtained from third year onwards. The ratoon of this grass can be taken up to the 5th year of planting. It is better to replant after 6th year for better economic returns.

YIELD

Broom grass is a perennial crop. A main crop can be followed by 4-5 ratoon crops. Broom yield is lower in the first year crop and it goes on increasing upto 3rd year again it goes on decreasing in 4th and 5th year crop. Therefore after 5th year whole plantation should be dug out and new plantation should be done. The yield varies between 300 and 500 kg of broom material per hectare, depending upon the quality of planting, materials, spacing, fertility of the land and the cultural practices adopted for maintenance. The highest yield of inflorescence is obtained from three and four year old plants, about 2 kg per plant.

ECONOMICS

As per current market trend, a bundle of 1 kg of broomsticks containing about 3-4 sticks is sold around Rs. 20-25 while the same may fetch Rs. 30-50 in the off season. An analysis of the market trend of broom grass in recent years exhibits it to be a stable commodity devoid of major market fluctuations. Average broom grass price at present is around Rs. 55,000 per metric ton while top grade material can reap as high as Rs. 80,000 per metric ton. Average annual cost and average annual income for first year of broom grass cultivation are Rs. 32,000/- and Rs. 44,000/- per ha. respectively, whereas, average annual cost and income for the 2nd year of broom grass cultivation are Rs10,000/- and 1,50,000/-respectively. Meghalaya has now emerged as one of the largest producers and exporters of broom grass in the country. Ninety per cent of the brooms produced are exported outside the state. Mawsynram alone is producing one lakh tons of broomsticks in a year with a turnover generated to the tune of Rs. 2.5 crore.

30 *Parkia timoriana* (DC.) Merr Syn: *Parkia roxburghii*

• English Name/ Trade Name :	Tree Bean
• Common/Local Name :	Yongchak in Manipur and Zawngtah in Mizoram
• Family :	Leguminosae
• Part Used (s) :	Tender Pods, Seeds and Flowers

Parkia timoriana

INTRODUCTION

Tree Bean is one of the most popular multipurpose tree species in the hill states of North-East of India. It is popularly known as Yongchak in Manipur and Zawngtah in Mizoram.

DISTRIBUTION

It is an important tree vegetable of South East Asia, especially North Eastern India. It is distributed in India, Bangladesh, Myanmar, Java, Thailand, Egypt and the Malaysian region. In North East India, tree bean is found in Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Green Pod

BOTANICAL DESCRIPTION

It is a large tree (up to 25 m height) with spreading branches, generally found in lowland rainforests and often along streams. The inflorescence head or capitulum arises terminally with clusters of yellowish-white tiny flowers, hanging at the top of long stalks from the branches. The fruits in early stages are soft, tender and bright green in colour. They turn blackish when fully mature in March-April. Pods are formed in clusters of 10-15, each measuring 25-40 cm in length and 2-4 cm in breadth. At the age of 6 years, the plant starts its production; however, full bearing stage is only after 10 years. It is mostly grown in the home garden, *Jhum lands* and also found in the forests throughout the North Eastern states of India.

USES

The immature tender pods are consumed during its developmental stages and are one of the favourite foods among the people of Manipur as well as the neighbouring North Eastern states for its unique taste and flavour. Tree bean is having a variety of uses, *viz.* human food, medicine, insecticide, pesticide, antibacterial, tanning, face wash, shampoo, firewood and paper pulp (Firake *et al.*, 2013). Flowers, tender pods and seeds of this plant are edible and are a good source of proteins, fats, carbohydrates, vitamins and minerals compared to other legume. The flowers and pods are used in the preparation of salads (*Singju*), curries, chutnies or in frying items and sometimes they may be mixed with fish and in preparation of local delicacy *Iromba*. The seeds are used as flavouring and nutritive additives to soups/stews.

Pods and seeds are widely utilized, especially in the villages for curing toothache and diarrhoea. The seeds as well as the tender pods are known to cure stomach disorder, abdominal colic, bleeding piles and regulate liver function. The bark and leaves of Parkia are used in lotions for skin diseases, eczema and ulcers. The leaves and roots are also used in preparing lotion for sore eyes.

The ether extracts of *Parkia timoriana* seeds are highly poisonous to the aphids and as little as 2% of the crude extract can kill all the aphid population within two days. The seed extract has also been found effective against termite *species*.

PROPAGATION

Nursery Techniques

Tree bean is commonly propagated by seed. Mature pods should be collected from healthy, productive and disease free mother plants during March-April. Mature seeds are extracted from the pods, dried for 10 days and soaked in water for 48 hours and treated with fungicide (Carbendazim 12% + Mancozeb 63%) @ 2 g/lit of water for 2 minutes. After that seeds are dried in open areas under shade for 15 minutes. Sand, soil and FYM (1:1:1) are mixed together and this mixture is treated with Carbendazim @1 g/10 kg of mixture. The polybags are filled with this media and seeds are sown in polybags. After sowing, the polybags are arranged in a block (100- 200 polybags/block) and covered with moist gunny bag for 3-4 days under poly-house. Nursery may also be raised under the open field condition with provision of semi shade. The ideal sowing time is from last week of April to first week of June. Seed germination takes about a month after sowing. One month old seedlings should be transferred to a naturally ventilated polyhouse for about 6 months for hardening.

Planting in the field

Site should be selected where there is proper sunshine in the hills. Water logged and marshy areas should be avoided. Tree bean is usually planted in the backyard of the houses and along the boundary as a mark of demarcation of the house. The soil should not have any hard pan within 1 m depth. The site should be cleaned from weeds and stones. On sloppy land, a barrier strip of perennial grasses can be made to check the soil erosion.

Germination of seed in root-trainer

Pit Preparation and Planting

The size of the pit should be 60x 60 x 60 cm and it should be prepared at a spacing of 7-9 X 7-9 m. The pit should be kept exposed for 10-15 days before planting. The pits are filled with top soil thoroughly mixed with FYM (1:1). Before

plating, 30 g Lindane 5% dust+5 mL Chlorpyriphos 20 EC+1.5 Mancozeb +Carbendazim per pit should be mixed with soil and applied in to the pit. Planting can be done after receipt of pre-monsoon shower (March-April)or during monsoon (June) or post monsoon period(September) if sufficient soil moisture is available. A light watering is required after planting.

Seedlings in polybags

Nutrient and Water Management

The manures and fertilizers should be applied in a circular trench (8 inch wide and 6 inch deep) around the tree in three splits i.e. February, May-June and September- October. Though tree bean is commonly grown as rain-fed crop, watering should be done after application of nutrients and during the lean period.

After Care

Regular weeding should be done especially during initial stage of plantation, as weeds compete for water and nutrients resulting in poor growth of the plant. Intercropping with vegetables or small fruit crops should be practiced. As tree bean takes about 6-8 years to bear fruits, additional income can be generated from intercrops during the gestation period. For full grown plantation, shade loving crops should be selected as intercrop. The basal area should be mulched with paddy straw, dry leaves or black polythene (100 micron) during the lean period. Pruning is not recommended for tree bean except the dry, diseased or any unwanted branches. But training is considered as an important operation; because the junction, from where primary branches come up from the main stem, is the most preferred area for stem boring insects to enter in to the stem. Hence, a single trunk needs to be maintained up to 2 m height from the ground and thereafter the 2-3 primary branches are allowed to grow. Spraying Gibberellic acid @ 20 mg/lit of water at full bloom stage also helps in enhancing the yield.

PLANT PROTECTION

Plant protection is the most important aspect for management of tree bean. In entire North Eastern region in general and particularly in Manipur, a large scale dieback of tree bean has been observed during the last 6-7 years. Tree bean decline has emerged as a major threat to its cultivation in the last decade. A large number of trees have been wiped out due to the problem of decline in Manipur and other NE states.

Disease and Pest

Despite a variety of uses, unfortunately the tree bean plants are under threat and there is vast decline in their population in some parts of NE India particularly in Manipur, Mizoram and Nagaland. The disease symptoms are first noticed as yellowing of leaves and die back of twigs. Dark necrotic lesions are noticed all over the main stems and branches. Subsequently, tree exhibited symptoms of blister bark. It is also noticed that affected trees developed vertical cracks and splits in the main stem. The adult beetle of *Coptops aedifecator* (long horned beetle) was found infesting heavily on the Parkia trees. Shot hole borers were also noticed. The pests made the holes in the stem/branches of the tree like the shot of a gun on any surface. Parkia trees growing in the water logged areas exhibited symptoms of root decay and the fungus *Fusarium oxysporum* was frequently isolated from the decayed root.

Yellowing of leaves

Die back of twigs

Blisters on the bark of parkia

Die back and Blisters of Parkia

Indarbela quadrinotata was also found in infected twigs. It is a bark feeding insect. Presence of webby mass of chewed wood particle and excreta of larvae plastered on the tree trunks was observed.

Indarbela quadrinotata

Coptops aedificator and insect infestation in Parkia tree

Painting of mixture of Malathion 50% EC: lime powder (1:10) on the base of the affected trees followed by soil drenching with 0.1% Bavistin is found to check the further spread of the disease.

HARVESTING

For long term storage, the pods should be harvested along with stalk. The pods are washed thoroughly to remove dirt and other external material and kept in airy place under shade to remove excess water. The pods should be wrapped in paper bag or polyethylene bag and stored at 4-5^{o}C temperature and 90-95% RH.

ECONOMICS

During favourable season, a full-grown plant bears 10,000– 15,000 pods. A single pod fetches upto Rs.50/- in local market. Thus, on an average, one can earn Rs 30,000 to 40,000 per annum from a single plant. At an average, about 1,70,000 bean sticks of yongchak are sold at Moreh market. It is estimated that Manipur spent about Rs 12 lakh daily in buying yongchak from Myanmer traders (Singh and Singh, 2017).

G HIMALAYAN FOREST RESEARCH INSTITUTE (HFRI) SHIMLA

31 *Angelica glauca* Edgew

• English Name/ Trade Name :	Chora
• Common/Local Name :	Chora; Cheura
• Family :	Apiaceae
• Part Used (s) :	Roots, Rhizomes

Angelica glauca

INTRODUCTION

Chora is an important high temperate medicinal plant of Himalayan region. Roots of the plant contain essential oil, valerianic acid, angelic acid and angelicin resin. Due to unsustainable harvesting, heavy biotic pressure, habitat loss and fragmentation, population of this species is dwindling in its natural habitat (Mamgain *et al.*, 1998; Mishra and Rawat, 1998). As a result of this, species has become Critically Endangered in Himalayan region (CAMP, 2003).

GEOGRAPHICAL DISTRIBUTION

This plant is found in areas ranging from East Asia to the Western Himalayas. In India, it is found in areas of high altitude ranging from 1800-3500m in Kashmir, Himachal Pradesh and Uttarakhand in shady and moist conditions. In Himachal Pradesh, it is mainly found in Mandi district (Shikari Devi, Nagru Pashuvihar), Kangra (areas of Dhauladhar, Bara Bhangal, Chhota Bhangal), Chamba (Kala Top, Sartrundi, Sural Batori), Kullu (Seraj, Thatch, Basherudhar, Hamta, Chhatru and GHNP), Lahaul Spiti (Rohtang Pass, Koksar, Pin Valley etc.), Shimla (Hatu, Shilaru, Narkanda, Kashapat, Chansal, Darkali, Panju, Churdhar and Dhaulabagi) and Kinnaur District (Rakkcham-Chitakul Wildlife Sanctuary, Rupi-Bhawa Wild Sanctuary, Nichar Bari Kanda, Lippa-Aasrang Wildlife Sanctuary and elevated areas of Pooh tehsil, Kinnaur (Chauhan, 1999).

BOTANICAL DESCRIPTION

It is a perennial, tall, erect, aromatic herb. The stem is straight and hollow from inside and is 1-2-meter-tall with thick, stout perennial rootstock (Chauhan, 1999). Leaves are pinnately divided, having upper green surface and lower glaucous. Its flowers are white-colored, in long stalked compound umbells. Its seeds are numerous, aromatic and flat. The color of the seeds is brown. Its roots are brownish, long (about 30 cms), fleshy, annulate, fusiform, resinous and pungently aromatic.

PHENOLOGY

It is a perennial plant which is not affected by frost and pollinated by insect. New leaves emerge in the month of April. Flowering season is from July to August (Chauhan, 1999). Its fruits are formed from August to October. Seeds mature in the month of September to October.

USES

Its roots are used in indigestion, constipation, vomiting and urinary diseases. Its roots are also used as aromatic spices and condiments. The powder of roots is mixed with warm water to remove the stomachache of the children. It is also beneficial in vomiting. Europeans use angelica oil for making sweets, sweetening of wine and in the perfume industry.

PROPAGATION

Natural Regeneration

In nature species regenerate mainly through seeds and roots. However, due to over exploitation of the species from its natural habitat, natural regeneration is less. Seeds remain dormant during the winter and germination starts in following spring after the melting of the snow.

Artificial Propagation

Chora can be raised by both sexual and vegetative methods. In the sexual method, it is raised by seeds. It can be vegetatively propagated from the nodes of the roots. Seeds are the best method for raising Chora plant. Fresh and mature seeds have very good germination capacity which gradually decreases during storage.

Cultivation

For its cultivation, the maximum temperature in summer may be 25°C to 30 °C and the minimum temperature in winter is from 1°C to 5 °C. This crop can be grown in those areas where the amount of rainfall is 1,500 mm to 2,000 mm. It is difficult to cultivate in low moisture conditions. But, it can be easily grown in soil having abundance of humus / organic carbon. It needs shady, moist sandy loamy soil. Water-logging conditions should be avoided for its cultivation. Loam soil is considered to be the best. Due to suitable climatic conditions in Himachal Pradesh, it has great potential for cultivation and farmers can easily grow this important medicinal and aromatic plant in their farms or orchards.

For cultivation of Chora, fields/beds should be well ploughed for making the soil finer. After that, manure should be mixed in the soil properly by again ploughing the fields. Bed size of 5-10 m^2, raised 15 cm from ground should be prepared with proper drainage system Excess moisture also damages Chora crop.

Propagation through Seeds

Seeds are collected in the month of September-October. Sowing should be done in the month of November-December. The seeds sown in the month of spring have least germination capacity. For sowing, 4 gram of seeds is

required per square meter. Its seeds are very fine and therefore should be sown in lines at a depth of 1 cm. After the sowing, they start germinating in the month of April and gradually grow up to 2-4 leaves stage with in a month (Sharma and Singh, 2014). Plant should be kept under shade conditions in the months of May-June. 35% or 50% shade is required in low-altitude as per aspect and orientation of the Sun.

Vegetative Propagation

Plants can also be prepared from nodes of the nodular roots. It is more convenient to plant by the roots. Also this method has more survival success than seed germination. It takes at least three years to produce the good roots in the seed-grown plant, while it takes two years for same in plants grown by vegetative methods. The time of planting this species through vegetative methods is July-August (i.e. rainy season). To grow the plant by roots, root pieces of the length of 6 cm are cut, which must contain one or two buds. These root sections, containing eye-buds should be covered by the mixture of soil and sand. These roots can be planted in the month of April to September. Nursery grown plants can be transplanted in the rainy season. For this, 9 plants per m^2 can be planted in plantation area. Proper shade arrangement should be provided to the plants for the first year. Survival success can be enhanced by covering the nursery beds of Chora by Agro-Shade nets providing 35% shade.

SILVICUTURAL AND MANAGEMENT PRACTICES

Compost and Fertilizer

The medicinal plant should be grown without the use of chemical fertilizers, because such fertilizers can alter their medicinal quality. Use manure of cow-dung or leaves for 15-20 tons per hectare. Accordingly, vermi-compost, green manure, neem cake, etc. can also be used (Sharma and Singh, 2014).

Irrigation

Often, Chora plants are found in places near water or moist areas. Therefore, it is necessary to have moisture in the soil for the proper growth of this plant. It requires proper irrigation facility. It is necessary to water at least once a day in the summer season and irrigate once or twice a week in the winter. For maintaining moisture in open spaces, mulching has also been found to be beneficial for the growth and development of this species.

Weeding and Hoeing

Weeding and hoeing works are very important in the nursery and field. It is very important with respect to establishment and development of new plant. It helps in establishment of roots. By removing the weed, nutrients present in the soil are readily available to the crop. Weeding and hoeing works should be done carefully during early months of growth so that their roots are not damaged.

Insect-Pest and Disease

Chora plants are often free from insect pest and diseases. In the hilly regions, the plants are usually disease free, but in the lower parts due to over irrigation and water logging or excess rainfall, roots of the plants may get fungal infestation. Therefore, there should be proper drainage system in the fields to prevent such conditions. In case of severe fungal infestation, biological control measures should be preferred.

Inter-Cropping

Himachal Pradesh is a horticulture state and this plant can be raised through intercropping practices. There are orchards of apple, pear, cherry, stone fruits, etc. all over the state. The part of land in the interspaces of fruit trees in the

orchard is mostly under-utilized. To make proper use of that land, Chora can be planted as inter-crop. It will fetch additional income to the farmers. But it is important that wherever Chora planted as inter-cultivation crop, it is advisable to practice organic farming so that the medicinal properties of chora remain intact. In these conditions, 9 plants can be planted per square meter in the orchards (Sharma and Singh, 2014).

HARVESTING AND POST HARVEST MANAGEMENT

Roots of the chora plant are harvested in the months of September-October as their productivity is high at this time. After harvesting, roots are thoroughly washed with water and dried in the shade. Dried roots should have moisture content up to 8-10 percent. Powder can also be made by grinding roots. The roots and seeds should be stored in dry and freezing temperatures (< 5 °C) so as to conserve their medicinal properties and survival success.

Production

By growing Chora, 7-9 q/acre yield can be achieved. The crop grown by the vegetative methods can be harvested after two years. When the crop is ready for harvesting, whole plant should be taken out and the roots attached with main stem, disc can be separated and planted again. By this method the cop of Chora can be harvested continuously. The market value of roots ranges from Rs 60 to 100 per kg (Sharma and Singh, 2014).

32 *Aconitum heterophyllum* Wall. ex Royle

• English Name/ Trade Name :	Aconite, Atish
• Common/Local Name :	Hindi (HP): Atis; Patish, Kadvi, Ativish, Visha. Atish in Uttaranchal : Ativisha in Sanskrit
• Family :	Ranunculaceae
• Part Used (s) :	Roots, Rhizomes

Aconitium hetreophyllum

INTRODUCTION

Atish/Patish is as an endangered medicinal herb endemic to north western Himalaya and grows only in localized restricted ecological niches (Dhar and Kachroo, 1983). Due to poor seed germination and low seedling survival natural regeneration in this plant is quite poor (Nautiyal and Dhyani 1994). Owing to overexploitation from wild and excessive demand by the pharmaceutical industry this species is on the verge of extinction. Thus specific cultivation and conservation practices are the need of the hour to conserve this important high valued temperate medicinal herb.

GEOGRAPHICAL DISTRIBUTION

Atish is distributed from 2500 meters to 3600 meters in the highlands of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Sikkim. In Himachal Pradesh, this plant is found in Mandi District (Shikari Devi, Nargu, Pashuvihar), Kangra (Bara Bhangal, Chhota Bhangal), Chamba (Mani Mahesh, Sartrundi, Sural Batori), Kullu (Seraj, Thatch, Basherudhar, Hamta, Chhatru and G.H.N.P.), Shimla (Shillaru, Narkanda, Kashapat, Chansal, Darkali, Chunrdrhar etc.), Lahaul & Spiti (Rohtang Pass, Koksar, Pin Valley etc) and Kinnaur District (Rakkcham-Chitkul Forest Reserve, Rupi Bhawa Wildlife Sanctuary, Lippa Aasrang Wildlife Sanctuary, Bari Kada and Highlands of Puh Tehsil (Chauhan, 1999).

BOTANICAL DESCRIPTION

This is a biennial herb having erect stem and paired tuberous roots. The plant height is up to 1-3 feet, leaves are broad, ovate or orbicular and lobed. The older leaves are long petioled while cauline leaves are sessile and amplexicaule. The flowers are bright blue to yellow green and fruit is five celled capsule. Seeds are flat and dark. Roots are brown coloured which are very bitter in taste (Chauhan, 1999).

Phenology

New leaves in Atish emerge in the month of April. By the end of May, the leaves sprout in 5-8 clusters in the lower part of the plant. It flowers in the month of July-August. Fruiting occurs during month of August to September and simultaneously the seeds mature and at the same time need to be harvested from the plant and stored. The plant produced from tuber cutting completes its vegetative and sexual phases within 3 years and can be harvested after 3 years.

USES

Atish is an important medicinal plant which is used widely in Ayurvedic, Unani and Homeopathic medicine. Different parts of this plant are reported to contain alkaloids, carbohydrates, proteins, amino acids, saponins, glycosides, flavanoides and terpenoids. Its tubers and roots are mainly used in preparation of various medicines. The roots of this important species are mainly used to treat patients with reproductive disorders and shown to have hepato-protective, antipyretic and analgesic, antioxidant, alexipharmic, anodyne, anti-atrabilious, anti-flatulent, anti-periodic, anti-phlegmaticand carminative properties. The alkaloids called 'Atisin', is found in the roots and tubers, due to which it tastes very bitter. It is considered as Medicine when consumed in small quantity, while when consumed in large quantity it becomes toxic. Therefore, it should be used only after proper consultation with physician/Vaidya etc.

PROPAGATION

Natural Regeneration

In nature, species regenerate mainly through seeds and roots. However, due to over exploitation of species from its natural habitat, natural regeneration of species is less. Seeds remain dormant during the winter and germination starts in following spring after the melting of snow.

Artificial Propagation

It can be grown easily in the temperate regions of the Himalaya. Its crop can be grown easily in areas at an altitude of 2200-3500 meters. For its cultivation, the maximum optimum temperature in summer should be 20 to 25 °C and in winter the minimum temperature can be sub zero. This crop can also be grown in areas where the amount of rainfall is 1500 mm to 2000 mm. It is difficult to cultivate in low moist soil. Sandy loam and acidic soils are most suitable for its cultivation. In this type of soil, its survival percentage, plant growth and tubers production is highest. Generally, areas with altitude above 2200m, having sandy loam soil are suitable for cultivation of this species. This is a moisture loving plant, so it needs more water for growth. Land having direct sunlight or improper drainage facility is not suitable for its cultivation. Temperatures exceeding 28°C, hampers the growth and growing stems and leaves become black, which increases the possibility of subsequent drying

PROPAGATION

This plant can be propagated with both sexual and vegetative methods. Plants are raised through seeds and tubers in sexual and vegetative method respectively.

Propagation though Seeds

Seeds are sown in the month of November-December. The seeds sown during spring season have little germination capacity. For sowing, 2 grams/m^2 of seeds are required. The seeds are very fine, so they should be sown by broadcasting in lines having less than 1 cm in depth. Seeds start germinating in the month of April. It is a slow growing plant.

For this reason, one-year-old plants should be transplanted from the nursery to the fields in the month of June-July. By planting 16-20 plants /m^2, the farmers can grow 44,000 plants in one acre. Shade arrangements should be made

during summer months so that the temperature remains around 25 °C. Appropriate Agro-shade Nets (50% or 75%) should be installed for shading from the month of March onwards (Sharma and Singh, 2014) for better production.

Vegetative Propagation

Plants can also be grown by tubers. It takes at least three years for the good root establishment in the seed-grown plant. While it takes slightly less time i.e. 2 years for the good root establishment in tuber-grown plants. The best time of planting the Atish is rainy season i.e. July-August (Sharma and Singh, 2014). Therefore, the top portion of two year tuber should be cut approximately 0.5 cm length and planted properly. 16-20 plants per sq. meter should be planted in field and plantation area. The roots emerge from these plants in one year and in the second year the tubers are formed from these root discs and the mature tubers are formed during third year.

Farm Preparation

For cultivation of Atish fields/beds should be well ploughed making the soil finer. After that, manure should be mixed in the soil properly by again ploughing the fields. Beds should be the size of 5-10 m^2 at least 15 cm high from ground. There should be proper drainage system. Excess moisture or water-logged conditions also damages Atish crop.

SILVICUTURAL AND MANAGEMENT PRACTICES

Compost and Fertilizer

The medicinal plant should be grown without the use of chemical fertilizers, because such fertilizers can alter their medicinal quality. Use FYM or compost 15-20 tons per hectare. Accordingly, vermi-compost, green manure, neem cake etc. can also be used as per the fertility status of the soil.

Irrigation

The beds in the nursery should be irrigated lightly on regular intervals so as to enhance survival of the crop. It also depends on the soil type. Since the plants of the Atish are moisture loving, so irrigation should be done daily during summer. It is advisable to irrigate once a week during the winter. This plant does not tolerate excessive moisture or dryness. It has also been observed that in the case of excessive moisture or drought in the nursery, the growth stops and also lead to mortality. Increase in temperature (> 28° C) in the summer, causes blackening of the upper leaves of Atish plants. Due to this situation, there has been a considerable decrease in the survival of Atish plants (Sharma and Singh, 2014).

Weeding and Hoeing

Weeding and hoeing works are very important in the nursery. It is very important with respect to establishment and development of crop. It helps in proper development of roots. By removing the weed, nutrients present in the soil are readily available to the crop plants. Weeding and hoeing works should be done carefully during early months of growth, so that the roots and tubers are not damaged.

Insect-Pest and Disease Management

Atish plants are often free from insect pest and diseases. In the direct sunlight leaves turns black and plant starts dying. Therefore provision of light shade must be ensured. During rainy seasons, sometimes plants get infected and need to be treated by adopting bio-control measures.

Intercropping

Himachal is a horticulture state. There are orchards of apple, pear, cherry and stone fruits. The part of land in the interspaces of fruit tees in the orchard is mostly under-utilized. To make proper use of that land, Atish can be planted as an inter-crop. It will fetch additional income to the farmers. But it is important that wherever Atish is planted as inter-

cultivation crop, it is advisable to grow in the plants by organic farming so that the medicinal properties of Atish remain intact.

Production

Atish is an herbal plant whose production capacity is limited. This species is harvested after 3 years of planting. Its roots are tuberous, jointed, conical, 6-8 cm long and light white in colour. New tubers grow from its mother tubers which are thicker than the older ones. Tuber of the first year is called maternal tubers. At present, the price of its roots and tubers is between 6,000 to 8,000 rupees per kg (India mart rates, 2019).

HARVESTING AND POST HARVEST MANAGEMENT

Harvesting of Atish is done in the month of September-October. Plants are often taken out/dug out from the soil. Their productivity is high at this time. But as per literature, the amount of Atisin and other alkaloid is highest in the month of June-July. After harvest, the roots and tubers are washed with water and dried in the shade. There should be 8-10 percent moisture content in dried tubers and roots. Powder can also be made by grinding the roots. Their roots and seeds of the species should be stored in moist and freezing temperatures (< 5 ° C), in which they have long-term medicinal properties.

ECONOMICS OF THE SPECIES

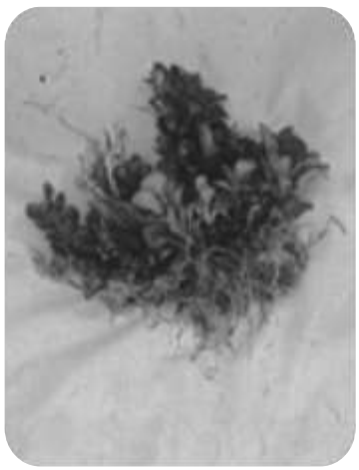
S. No.	Items	Expenses per Acre (Rs.)
1.	Cost Norms (Preparation of Farm, Hoeing and Weeding and irrigation)	64421.00*
2.	Other Expenses (FYM, Fungicides etc.)	10,000.00
3.	Harvesting, Drying and Transport Expenses	5,000.00
	Total	79,421.00

**Source: NMPB Cost norms for medicinal plants cultivation for the year 2017-18*

- Estimated Production of dry roots and rhizomes after 3 years : 120 Kg / acre
- Latest rates of market : Rs. 6,000 Per kg
- Income from dried roots : Rs. 7,20,000.00
- Total income : Rs. 7,20,000.00
- Total expenses : Rs. 79,421.00
- Total Net profit after 3 Years : Rs. 6,40,579.00
- Yearly profit/income : Rs. 2,13,526.00

33 *Picrorhiza kurroa* Royle ex Benth.

• English Name :	Hellebore, Picroliv
• Hindi/ English :	Karru, Kadu, Kutki Katuka, Katurohini, Katukkurohini, Kaur Kutki, Kaur, Karru, Tikka, Karvi
• Family :	Scorphulariaceae
• Part Used (s) :	Rhizome and Roots



Mature Plant of Kutki

INTRODUCTION

It is a small Himalayan perennial herb which is found in the high temperate Himalayan ranges. Its roots and rhizomes contain resinsified glocosides, picrorhizinand picrorhiztin (Jia *et al.*, 1999). Apart from this, its rhizomes also contain, kurien, vanelik acid, kuticiol, kutkin, apocynin, alkanol, alken and Bita-Systosterol. The roots of this plant are commonly used in the traditional medical system to cure diseases like fever, headache, abdominal pain, etc. Due to excessive and unscientific exploitation from forests in the past few decades, this plant has reached the brink of extinction. Therefore, there is an urgent need to take appropriate steps for its conservation.

GEOGRAPHICAL DISTRIBUTION

It grows in the high temperate Himalayan ranges from Kashmir to Sikkim at an altitude of 2,700-4,500 meters. In Himachal Pradesh, it is found in Thamasar and Dainasar of Chhota Bhangal and Bara Bhangal of Kangra district, Jatadar of Pangi-Bharmour and Mani Mahesh in Chamba district, elevated areas of Lahaul and Spiti, in Sangla valley, Chotta Kamba and Bara Kamba, Roopi-Bhava and Rakkham-Chitakul Wildlife Sanctuary and high altitude areas of Pooh tehsil (Kinnaur), in Rohtang Pass, Great Himalayan National Park (Kullu) and in Chansal Valley, Dodra Kwar, Kashapat (Shimla) (Chauhan, 1999).

BOTANICAL DESCRIPTION

It is a perennial herb which grows parallel to the soil. Underground stems are zig-zag and roots connected together are called rhizomes. Off-shoots arise from joints of rhizome and roots arise from nodes. The leaves of the species are spathulate with dentate margins.

Phenology

Fruiting and flowering in this species occur from June to September. Flowers are bluish-white arranged in dense terminal and spicate racemes inflorescence. The capsules are oval shaped. Their seeds are very subtle inside the capsules and break out of capsules in September month. Its capsule are ovoid and conical shaped. As seeds of this plant species are very fine; hence it is very difficult to raise this plant from seeds.

USES

Kutki is a valuable medicinal plant which has been used in the treatment of various types of diseases in the traditional medical practice since ancient times. In the market, it is also sold as an alternative to *'Gentiana kurroo'*. Generally, its rhizomes and roots are used to make various types of formulations in the traditional healthcare. The medicines made from its rhizomes and roots are used to treat diseases like disorders of liver, stomachache, cough, constipation, fever, colds, asthma, dropsy and arthritis (Atal *et al.*, 1986). Its use increases appetite and improve digestion. It is also a good antioxidant and blood purifier (Rajkumar *et al.*, 2011). It also lowers heart disease and high blood pressure.

PROPAGATION

Natural Regeneration

In nature species regenerate through seeds and rhizome.However, due to over exploitation of species from its natural habitat, natural regeneration of species is less. Seeds remain dormant for 9-10 months and germination starts in following spring after the melting of snow.

Artificial Propagation

This plant is raised by both vegetative and sexual methods. The seeds are very small and difficult to handle having low germination capacity. For this reason, it is mainly raised through asexual method.

Climate

It can be easily grown in the temperate regions of the Himalaya in moist areas ranging from 1,800m to 3,000m. The maximum summer temperature of 25 to 30°C and the minimum winter temperature up to 1 to 5°C is optimum for this species. The crop can be harvested in areas where the amount of rainfall ranges from 1,500 ml to 2,000 ml. It is difficult to cultivate this plant in soil with low moisture content. It easily grows in porous and exposed soil layers. Such type of soil helps parallel outbreaks of rhizomes, as a result of which small seedlings arises from nodes of rhizomes, which grow as cluster. Proper soil moisture is necessary for the cultivation of this plant. When the amount of water in the soil is high, the leaves of this plant are decayed, because it requires optimum moisture and shade conditions for proper growth and maximum productivity. Loam soil with drainage facility is considered best for its cultivation. This plant can be grown as inter crop under the temperate fruits including apple trees.

Cultivation

Preparation of land should be done in a planned manner for the best yield. After deep ploughing of the fields, compost / manure (5 to 10 trolley/Acre) is mixed in the top soil. After this, it is again deep ploughed. For better yield, one meter wide and 15-20 cm raised nursery beds are prepared with adequate drainage system. After leveling the beds, holes of 5-6 cm depth are done with the help of planting rods of the size of 18X18 or 20X20 cm with appropriate spacing. After that, planting of seedlings raised through “macro-proliferation technique” in the holes. After leveling the soil in the beds, it is very important to make arrangements for proper drainage as water logging conditions leads to high mortality.

Propagation through Seeds

The seeds of Kutki should be sown by mixing with equal quantity of fine sand or ash. Sowing of seeds should be performed in the germination beds/ trays, only on the surface soil and then covering the seeds with very thin layer of soil or sand. In low- altitude areas, in order to maintain moisture, the seeds are covered with a thin layer of moss. Seeds are sown in poly-house in the month of November-December in low altitudes. It is sown in the months of March-April in mid altitude areas and in the month of May in high-altitude areas. The plants grown in germination beds or trays, when 2-4 leaved stage is reached, are pricked out and planted in the field.

Macro-proliferation Technique

The vegetative propagation method mainly involves stem cuttings, rhizome cuttings and runner cuttings. This plant can also be prepared by "Macro-proliferation" technique. The macro-proliferation is basically a low cost vegetative multiplication technique for the production of quality planting material (QPM) of Kutki. By this technique, a healthy mature plant of Kutki can be multiplied 8 to 10 times successfully. In addition to multiplication >50% yield of rhizomes and roots can be recovered for marketing or various other uses. In this method, in the maternal plants having buds are separated by cutting with the help of scissors, in this way, 8-10 buds / infant plants are raised from a single plant. Every new plant produced through this technique should contain small part of stem, rhizome, rootlets (one or more) and leaves (one to two), so that every plantlet have a chance to survive. This technique should be applied in the hours of dusk and dawn in the shady areas. Plants produced through this technique on sand tray in the nursery during rainy season showed 90 % success. While, raising plants through this technique in the poly houses in the month of April to October almost gives 100% success. The plantlets develop fine roots when grown in poly houses in the sand beds within one and a half month. After developing the roots, these small plants are planted at a spacing of 20 plants / sq. meter in the field with the help of planting rods (Sharma *et al.*, 2008). Detailed specifications of the technique are as follows:

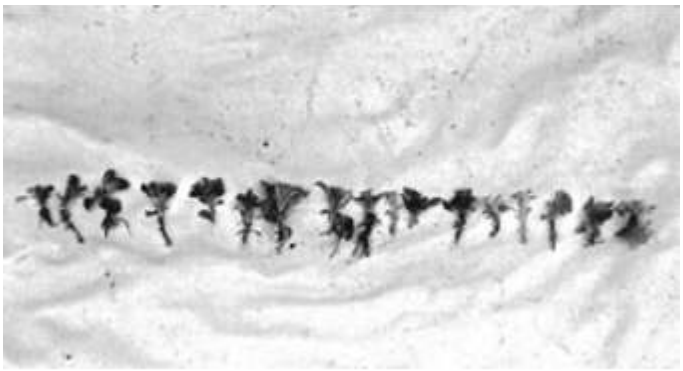
SPECIFICATIONS

This vegetative multiplication technique requires each separated propagule to have following specifications:

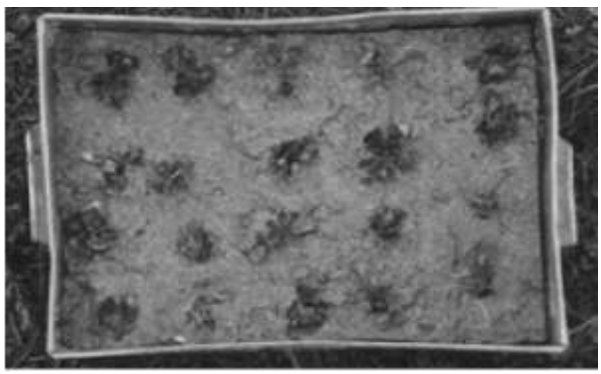
i) Shoot length : 3-5 cm
ii) Presence of leaves on separated propagule : ½ to 2
iii) Rhizome length : 3-6 cm
iv) No. of roots : 1-3

Besides the above specifications, time of separation and appropriate growing conditions after planting of separated propagules are found to be critical factors for achieving success through this technique and given in the Table:

Time of Macro-proliferation (Month of the year)	Conditions for rapid establishment of macro-proliferated propagules	Success Rate
April to October	Placement in Poly-hose conditions for 1½ months and subsequent planting in the field	Almost 100%
July to September	Placement in Sand trays for 1 ½ months and subsequent planting in the field	> 90%
August	Direct planting in field for 2 ½ to 3 years	>75%



Macro-proliferated Propagules



Macro-proliferated Propagules in Sand

Planting

In areas where irrigation facilities are available, plant can be raised anytime from April to October. In those areas where there is no facility of irrigation, planting should be done in rainy season from July to August because in these months the humidity in the environment is high, which is necessary for the growth of new roots in the plant.

Nursery Raised Kutki Plants

Raising of Kutki in Polyhouse

Number of plants per Acre

In order to obtain the best yield of this plant species, 12 plants per square meter should be planted in the fields at 30 x25 cm spacing. 30,000 plants can be easily planted in one acre of land.

Inter Cropping

Farmers can grow Kutki crops/plants through intercropping practices. In the interspaces of apple orchard, field beds can be prepared along with sufficient paths during the month of February-March. A basal dose of FYM 25

Intercropping of Kutki with Apple

tonne/ hectare should be applied in the field beds. Nursery plants of Kutki should be planted in the spacing of 30x40 cm^2 in the field beds. Apple orchard of age between 26 to 36 years has been found to be best for optimum yield of Kutki. Apart from this, it can also be grow under other fruit bearing trees. These plants can also be grown conveniently under poplar trees. Through intercropping practices, farmers can get additional income. In orchards, one has to grow Kutki only by adopting organic farming to avoid accumulation of pesticide residues in plants.

SILVICUTURAL AND MANAGEMENT PRACTICES

Use of Manure

Prior to the cultivation of this plant, proper manuring of soil should be done in fields and planting areas by mixing FYM or compost. According to an estimate, in the lower areas 60-70 quintals / acre and in higher areas 40-46 quintals / acre manure is required. The areas rich in organic matter, manuring should be done only according to the requirement.

Hoeing and Weeding

The work of hoeing and weeding should be done as per requirement. At the initial stage of roots formation, least weeding and hoeing works should be done as the possibility of damage to plants is quite high. Hand weeding and hoeing in the fields should preferly be done for the proper growth and development of plants.

Irrigation

Proper irrigation arrangements are required for Kutki cultivation. After planting in beds, light irrigation should be done daily in the morning and evening hours with small rosecane. Irrigation should be done according to requirements of crop after establishment of roots. Irrigation once in a week is sufficient for proper growth and development of plants. During the months of July to September owing to rainy season there is no need to irrigate Kutki crop. Proper drainage should be ensured during these months.

Insect Pest Control

Usually insect pest attack is very rare on Kutki crop. In the high altitude areas, the crop remains unaffected and in the lower areas, their leaves are burnt due to high temperature. In highly irrigated and submerged areas, fungus is found on the leaves, interfering with the growth of the plant. To save the crop from diseases, irrigation should be proper. In addition to this, make proper arrangements for drainage of exceesive water in the fields during rainy season. If there is no proper drainage, its roots are more likely to get infection due to excess water. In case of outbreak of any disease or pest problem in this crop, its effective control should be done in time through bio-control measures.

HARVESTING AND POST HARVEST MANAGEMENT

The root part can be harvested after two and half years generally during the month of September-October.

Production

The production capacity of Kutki is very good. From the natural habitat, its roots and rhizomes are harvested after the interval of 3-4 years. However, crop raised in the field can be harvested in 2 ½ to 3 years interval. Farmers can sell roots produced from its mother plants or its cuttings can be used to produce more plants for further propagation. Nowadays, the prices of dried rhizomes and roots in the market are around Rs. 600/kg. With proper care of the plants, the yield of 8 to 10 quintals dry roots per hectare can be easily obtained (Sharma *et al*, 2008).

Washing of the Roots and Rhizomes

The harvesting of this crop is done by digging the roots and rhizomes and the thin roots are also extracted. After digging, the roots are cleaned and new planting material is raised through Macro- proliferation Technique. Roots and rhizomes are washed thoroughly in the baskets and shade dried. Dried roots have moisture content around 8 to 10 percent. Dry roots should be stored in cold dry and ventilated space so that it can be protected from rotting.

ECONOMICS OF THE SPECIES

Description of Estimated Income from Cultivation of Kadu

S. No.	Items	Expenses per Acre (Rs.)
1.	Cost of preparation farm	20,000.00
2	Cost of 50,000 new plants produced through Macro-proliferation technique (Rs 1.0/plant)	30,000.00
3	Cost of Hoeing & Weeding and irrigation (For three Years)	1,50,000.00
4	Other Expenses	30,000.00
5	Harvesting, Drying and Transport Expenses	20,000.00
	Total	2,50,000.00

- Estimated Production of dry roots and rhizomes after 3 years : 4 quintals / acre
- Latest rates of market (2016-2017) : Rs. 600 Per kg
- Income from dried roots : Rs. 2,40,000.00
- The number of new plants produced through Macro Proliferation Technique - 30000x 8 : 2,40,000.00
- Income From selling plants (Rs 1.0 / plant) : Rs 2,40,000.00
- Total income : Rs. 4,80,000.00
- Total expenses : Rs. 2,50,000.00
- Net profit : Rs. 2,30,000.00
- Net profit per year : Rs 76,667.00

Note: In the business of herbs, there is still a situation of uncertainty, so in this economics the shuffle is possible according to the market prices nowadays.

34 *Podophyllum hexandrum* Royle

• English Name/ Trade Name :	May apple
• Common/Local Name :	Hindi (HP): Bankakri; Bhotias in Uttaranchal: Ghi-cupra
• Family :	Berberidaceae
• Part Used (s) :	Roots, Rhizomes

Podophyllum hexandrum

INTRODUCTION

Podophyllum gets its name from the Greek words podos and *phyllon*, meaning foot shaped leaves. The genus *Podophyllum* is also called as May apple because its fruits ripen in spring. *P. hexandrum* also known as the Indian *Podophyllum* or Ban-kakri is a perennial herb, growing on the lower slopes of the Himalayas in scrub and forest from Afghanistan eastwards to central China commonly distributed in Himalayan region of Asian continent. It is now being considered as a rare and threatened species mainly due to the large scale removal of its underground parts that still continues at rates well over natural regeneration. Therefore, immediate thrust has to be given for generating the reliable conventional protocols of mass cultivation of *P. hexandrum*. Moreover, wild populations may be represented by various genotypes growing under different environmental conditions which may affect drug profile leading to problems in the purity of the final product. Thus cultivation of suitable genotypes would ensure a reliable supply of the material with consistent quality.

GEOGRAPHICAL DISTRIBUTION

It is indigenous to India and grows in high temperate and in sub-alpine and alpine meadows at an altitude of 3000-4500m, in the inner verge of Himalayas of Jammu and Kashmir, Himachal Pradesh, Sikkim, Uttaranchal and Arunachal Pradesh. It is found growing on open slopes having moist humid condition, as undergrowth in the forest rich in humus and decaying organic matters at Zanskar and Suru valleys of Ladakh. In Himachal Pradesh it is found in Lahaul &Spiti, Kullu, Kangra, Chamba, Kinnaur and Shimla district (Chauhan, 1999). The species is generally found in association with

Rhododendron, Salix, Juniperus etc. Himalayan Forest Research Institute (HFRI) has studied its distribution in Himachal Pradesh and Jammu Kashmir and each site has been geo-referenced along with characterization of micro habitat. It has been observed that Bankakri has been found growing in open slopes and under forest covers, along sides of Nallas and along the borders of cultivated fields. Generally the species prefers moist habitat having organic matters rich soil.

BOTANICAL DESCRIPTION

It is an erect, un-branched tall herb with somewhat fleshy and smooth stem, 35-60 cm high. Mostly found in aggregation, which gives the plant a shrubby look. Stem modified into creeping rhizome bearing numerous roots. Leaves usually palmate, peltate deeply 3- 5 lobed, the sharply toothed lobes encircle the large solitary flower or fruit. Flowers are white or pink. Fruit which is a berry, 2.5-5.0 cm, oblong ovoid or oblong-ellipsoid, scarlet or red when ripe and many seeded. Fruits are edible and relished by shepherds and gujjars. Seeds are small and light black embedded in the red pulp. Rhizome fleshy, short, horizontally creeping with long dense fibrous roots, the underground part is known as rhizomatous root. Each node has the tendency to develop into a new offshoot plant.

USES

The rhizomes of Bankakri are known to contain several lignans. The lignans occurring in *Podophyllum* posses anti-tumor properties. It is being the most active cytotoxic herb contains 4.3% Podophyllotoxin on a dry weight basis. It is considered a cholagogue, purgative, alternative, emetic and a bitter tonic. Owing to its cytotoxic action it is used as paint in the treatment of soft venereal and other warts. The whole plant has also got great importance in traditional systems of medicines including Ayurveda, Unani and Tibetian systems for curing several diseases. The rhizomes and roots of *Podophyllum* species have gained much importance throughout the world as being the main source or the starting material for the alkaloid podophyllotoxin and its semisynthetic compounds, the etoposide, teniposideand etoposide phosphate since their use in treatment of specific types of cancers (Chattopadhyay *et al.*, 2002). The rhizomes in trade are also adulterated with the rhizome of wild growing *Ainsliaea latifolia* (Asteraceae). Traditionally, decoction of the root is given in diarrhea and hepatic disorder. The fruits are edible and are sometimes used against cough.

PROPAGATION

Development of cost effective propagation methods will further help to mass multiplication of elite planting material thus making sure for the availability of quality planting stock to go for commercial cultivation of the species. Because the species is already endangeredand exploitation of its underground parts continues to exceed the rate of natural regeneration, it needs immediate attention for conservation. In an endeavor to develop this species, the Institute has made an effort to develop appropriate propagation methods and identified the superior chemo-types of *P. hexandrum* by screening different populations from Himachal Pradesh and Ladakh valley.

Natural Regeneration

In nature species regenerate through seeds and rhizome. However, due to over exploitation of species, its natural regeneration is less. Seeds remain dormant for 9-10 months and germination starts in following spring after the melting of snow.

Artificial Propagation

Species is propagated through seeds and vegetative propagation.

Propagation through Seeds

The seeds are collected during the month of June to July after it gets ripened. Each fruit contains small dark brown seeds ranging between 30 to 69 depending upon the size of fruit and locality. Seeds are separated from pulp, washed under running tap water for 10-15 minutes and dried under shade and stored at 4°C until used. Seeds with hot water treatment for 24 hours give better germination percentage (24-60%). To overcome the seed dormancy and to achieve good germination percentage various hormonal, stratification and hot water treatments have been found effective. Good seed germination (66%) has been achieved with GA_3 200 ppm application within 20 days under lab conditions. In Hiko trays under poly-house condition seed germination took place within 55 days while under nursery condition it took almost 210 days. In a field trial it has been observed that potting mixture of Humus: Soil: Sand in the ratio of 1;1:3 found to be good for germination percentage and growth. Transplantation of seedling in the field at a spacing of 30X30 cm should be carried out when seedlings attain height of about 6-10 cm. About 4-5 Kg seeds per ha are required for direct sowing.

Vegetative Propagation

Rhizome propagules of 1.0-2.5cm in length are taken from the youngest tip portion. The rhizome cuttings may be planted from May to the beginning of July to get the best results. Rhizomes cuttings treated with IBA 200 ppm gives maximum germination percentage of 91.67 %. The growth of plants is slow and it takes up 3-4 years to produce rhizome suitable for exploitation. Application of farm yard manure and humus increase plant growth and yield. Mixing of well- rotted and sieved farm yard manure should be done before or at the time of plantation. Generally 50-60 quintal farmyard manure is required for one hectare of land.

Nursery Raising

Generally light and well drained soils are good for nursery raising. Before sowing of seeds, the beds should be properly ploughed and be mixed with farmyard manures @ 04 kg/m^2. Seeds are generally sown during the month of July-August and start germinating by March-April. Owing to its slow growth the seedlings become ready for transplantation in next year.

Transplantation and Planting Density

Under natural conditions Bankakri prefers organic matter rich light soil and adequate moisture. The plant also prefers open slopes as well as partial shade condition for luxuriant growth. The rhizomatus system is to some extent deep and therefore soil must be at least 60 cm deep, free from stones/pebbles, etc. for its optimum growth and yield. Hence these points should be kept in mind before selection of cultivation site. Due to slow growth of seedling generally plants raised through vegetative propagation is preferred as later takes less time for maturity. For the field transplanting there should be 30 cm spacing between plant to plant and same distance for row to row. The planting materials i.e. fresh rhizome of size 1-2 cm with growing apical buds, made from uprooted rhizome in March –April should be planted 4-6 cm deep in the soil.

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

Regular watering (at least twice/week) is required for proper and healthy growth of nursery seedlings. Irrigation depends upon soil type and weather condition during the dry period. At the time of seedlings transplantation and

plantation through rhizome cuttings, the crop requires watering alternate day during April-June. After proper establishment of plants, the crop requires watering twice in a week. The crop undergoes dormancy during frozen and prolonged winters (Nov-Mar) and therefore, there is no requirement of watering.

Weeding

Weeds growing along with crop affect the growth and yield of the plant. Hence regular weeding is required for optimum growth and yield.

Diseases and its Management

In water logged area, mortality of species takes place, hence, these conditions should be avoided. In case of any insect pests attack, Neem based insecticide should be used. However no major insect pests have been observed under nursery and cultivation condition.

HARVESTING OF CROP

The rhizomes are ready for harvesting, when they are 3 years old if raised through vegetative propagation method. However, seed raised plants are ready for harvesting after 4 year of plantation. Freshly harvested rhizomes are reported to contain higher quantities of active principles which are lost on prolonged storage. The rhizomes harvested in spring (April- May) are reported to contain higher resin content than those obtained in autumn (October- November).

POST HARVEST MANAGEMENT

After harvesting the crop, fresh rhizomes should be thoroughly washed with running water so that all the foreign material is removed. For the ease of drying, the properly washed rhizomes are chopped with the help of sharp stainless steel blade into small pieces of size 2-4 cm. After harvesting the crop after 3 to 4 years post-harvest management is very important to maintain the quality of crop. Rhizomes are the main parts which contain the drugs and the trade depends upon the size and quality of rhizomes. Hence it is of paramount significance that scientific post-harvest management practices should be followed to maintain the potency and vigor of drugs.

Drying and Storage

The chopped rhizomes immediately need to be properly dried. These fresh small pieces may be dried under partial shade which takes about 8-12 days for proper drying. Damp place for drying should be strictly avoided and there should be proper ventilation, failing which fungus attack may be there which will severely affect the quality of marketable product. The fresh rhizomes can be dried in a dryer under hot circulating air at 45°-50° C for about 20-24 hours. The dried rhizome should have minimum 10-12 % moisture content. After drying the rhizomes are properly packed in gunny bags and kept in cool places for storage. Storage in polythene bags should be avoided.

YIELD

The yield of dried rhizomes and roots varies from 1.5 to 2.0 t/ ha.

ECONOMICS OF THE SPECIES

S. No.	Expenses per Acre	Rupee
1.	Cost Norms (Preparation of Farm, Hoeing and Weeding and irrigation)	58,564.00*
2.	Other Expenses (Planting Material)	10,000.00
3.	Harvesting, Drying and Transport Expenses	5,000.00
	Total	73,564.00

**Source: NMPB Cost norms for medicinal plants cultivation for the year 2017-18*

- Estimated Production of dry roots and rhizomes after 3 years : 2 quintals / acre
- Latest rates of market : Rs 450 Per kg
- Income from dried roots : Rs 90,000.00
- The number of new plants produced
  In the nursery from seeds/Vegetative propagules- 2000x 3Years : 6,000.00
- Income From selling plants (Rs 5.0 / plant) : Rs 30,000.00
- Total income : Rs 1,20,000.00
- Total expenses : Rs. 73,564.00
- Net profit after 3 years : Rs. 46,436.00

Note: In the business of herbs, there is still a situation of uncertainty, so in this economics the shuffle is possible according to the market prices nowadays.

35 *Valeriana jatamansi* Jones

• English Name/ Trade Name :	Jatamansi
• Common/Local Name :	Hindi (HP): Nihani, Jatamansi, Mushkbala, , Sughandbala
• Family :	Valerianaceae
• Part Used (s) :	Roots, Rhizomes

Mature Plant of Mushkbala

INTRODUCTION

V. jatamansi plants has been used by the people since time memorial for the treatment and eradication of various types of human diseases. It is in use in almost all kinds of natural therapeutics, whether Ayurvedic, Greek Homeopathic or traditional therapeutic method. It is used as a tranquillizer and sedative (Wagner *et al.*,1980; Grusla *et al.*,1986) primarily in the treatment of epilepsy, hysteria, mental discomfort, convulsions, cardiovascular disease, cholera, cough, eyes defects, obstruction in the nerves, fever, etc. (Chauhan, 1999). The powder of its roots mixed with sugar is used in the treatment of urinary disease. It is also used in the formulations of hair oil, incense sticks, perfume and pesticide. Its oil is extensively used to flavor tobacco products and beer.

GEOGRAPHICAL DISTRIBUTION

It is found in the areas of high altitude (1,600-3,600 m) in the Western-Himalayan temperate regions of India. In Himachal Pradesh, this medicinal herb is very common in temperate forest undergrowth. It is found in Chamba, Kangra, Kullu, Sirmor, Mandi, Kinnaur and Shimla districts of the state (Chauhan, 1999).

BOTANICAL DESCRIPTION

Mushkbala is a pubescent, perennial herb having tuffed stem, which is about 15 to 30 cm in length. Every year new leaves arise from stem. It produces thick fibrous roots, having 15 to 45 cm length. The bark of its rhizome is brown in color. The leaves arise in tufts from stem. The stem leaves are small, entire or pinnate and few in number while the leaves arising from rhizomes are wider and large in number. The flowers are white or light pink in terminal corymb inflorescence. They are often unisexual and small orange coloured seeds are formed from them (Chauhan, 1999).

Phenology: New leaves start to come from February to March. In March, flowers of white color found to be in abundance. Seeds are formed in the months of May and June.

PROPAGATION

Natural Regeneration

In natural habitat, plant regenerates through seeds as well as through rhizomes. In wild this plant is found more in moist and shady areas.

Artificial Propagation

The crop of Nihani can be easily grown in areas with an altitude ranging from 1,300 to 3,000 m. The maximum suitable temperature for cultivation of this species is up to 30 °C and the minimum temperature is 1-5°C. It can be easily grown in areas with rainfall more than 1200 mm in both irrigated and non-irrigated land. It grows in all sorts of soils, but moist loamy soil is best for its growth. The plant gets decayed in water logged conditions (Sharma *et al.*, 2014).

This species can be raised through sexual or asexual (vegetative) methods. Seeds are very subtle and need to be mixed with equal amount of sand and sprinkled over the nursery beds. They have good germination capacity. They are sown in the months of July-August and in the month of October, the small seedlings are transplanted in transplantation beds.

Macro-Proliferation Technique

In vegetative propagation, plants are raised through cuttings of roots/rhizomes. The macro-proliferation is basically a low cost vegetative multiplication technique for the production of quality planting material (QPM) of Mushkbala. By this technique, a healthy mature plant of Mushkbala can be multiplied 10 to 12 times successfully. In addition to multiplication >50% yield of rhizomes and roots can be recovered for marketing or various other uses.

Specifications

It is a vegetative multiplication technique which ensures that each propagule must possesses some part of shoot along with rhizome part. Separated propagule must have the following specifications:

(i) Shoot length : 5-8 cm
(ii) Presence of leaves on separated propagule : ½ to 2
(iii) Rhizome length : 2-5 cm
(iv) Number of roots : 1-4

Besides these, times of macro-proliferation (separation) from mature plant and appropriate conditions for rapid establishment of macro-proliferated propagules are very critical and have been given in Table:

Time of Macro-proliferation (Month of the year)	Conditions for rapid establishment of macro-proliferated propagules	Success Rate
April to October	Placement in Poly-hocse onditions for 1½ months and subsequent planting in the field	Almost 100%
June to September	Placement in Sand trays for 1 ½ months and subsequent planting in the field	> 95%
June to August	Direct planting in field for 2 ½ to 3 years	> 90%

Macro-proliferated Propagules obtained from Single Mature Plant

Plants prepared by this method are planted in 4-5 inch deep hole in the fields and transplantation areas at the rate of nine plants per square meter with spacing of 30 x 30cm. HFRI Shimla has also developed a special type of tool called 'Multiple Nursery Planting bar' for maintain the optimum spacing of Mushkbala plants. This is a type of planting rod, with the help of which, nine holes can be made up to the depth of 6 inches at a distance of 30 x 30 cm in a single run. The spacing is important for growth and development of each individual.

Preparation of beds in Plantation Area

Preparation of beds/fields should be done well for the cultivation of Mushkbala crop. Manure the beds/ fields well before sowing by adding 15-20 tonnes per hectare of FYM or compost or 4-5 tonnes per hectare vermin-compost, so that the quantity of organic matter is sufficient in top soil. After this, level the fields by deep plowing before bed preparation. Then with the help of planting rods, make 2-4 inches deep holes at a distance of 30 cm. Then plant raised by Macro-proliferation technique should be planted in the holes. Press the surrounding soil of the plant properly so that its roots don't get extra air. Also make drainage channels for draining out extra water (Sharma *et al.*, 2014).

Planting Time

This species can be planted from March to December, in areas having proper irrigation facilities. In areas, where there is no irrigation facility, the work of planting can be done in rainy season.

The number of plants per acre

Crop yield is quite good in Mushkbala crop. For better yield 9 plants per square meter should be planted with spacing of 30 cm. Approximately 30,000 plants can be planted easily in one acre of land.

Inter-cropping

In the apple orchards of the high hill temperate region, field beds should be prepared along with sufficient paths in the

Macro-proliferated Propagules planted in the Nursery

interspaces during the month of February-March. Farm Yard Manure 20 tonne/ hectare should be applied as a basal dose to improve the fertility/nutrient content of field beds. Seedlings of Valeriana should be planted in the spacing of 30x40 cm^2 in the field beds. Apple orchard of age 30 years has been found to be best for optimum yield. Through intercropping practices, farmers can get additional income.

Intercropping of Mushkbala with Apple Orchard

SILVICUTURAL AND MANAGEMENT PRACTICES

Use of Fertilizers

Always use natural manures in the cultivation of medicinal plants, because their use does not affect the compositional quality of plants. In the cultivation of Mushkbala, good quality compost/manure especially vermi-compost should be mixed in adequate amount with soil for a good yield. Chemical fertilizers should not be used in the cultivation of medicinal plants and the use of organic fertilizers is advised to maintain soil fertility.

Hoeing and Weeding Works

After the sowing of Mushkbala seeds, least weeding and hoeing works should be done as the possibility of damage to growing seeds/plants at initial stage is quite high. Weeding and hoeing in transplanted areas/ beds is done as per the requirement. The work of weeding and hoeing in the fields can be done by hand or by small draw hoe etc. The work of weeding and hoeing is necessary for the proper growth of plants.

Irrigation

There should be proper irrigation facility for the cultivation of Mushkbala. Nursery trials have shown that with proper irrigation, the yield of this plant can be increased. After trans-planting, water should be given daily in the morning and in the evening with small pore fountains. Irrigation should be according to need after establishment of roots. It should be given once in a week for proper growth and development of plants. Even in the moist areas, irrigation is required daily during summer periods.

Disease and Pest Control

Usually insect pest attack is very rare on medicinal crops. In highly irrigated and submerged areas or during rainy season fungal infestation is seen on the leaves, there by hampering with the growth of the plant. To save the crop from diseases, irrigation should be proper. In addition to this, make proper arrangements for drainage of water in fields. If there is no proper drainage, its roots are likely to get rot due to excess water. In case of pests/ fungal outbreak, it is advisable to use biological insecticides/ fungicide nowadays, available in the market (Sharma *et al.*, 2014).

HARVESTING AND POST HARVEST MANAGEMENT

Production

The production capacity of the species is quite good. Dried roots and rhizomes weight from two to 2-2.5 year old

plant are 30-35 gm/ plant and total weight (root + stem + leaf) is about 100-110 gm/plant. With due care, yield of dry roots of 20 to 22 q / ha can easily be obtained. It is also necessary to mention here that even though this species can be harvested even after one year but for good quality yield it is recommended to harvest this crop only after two years as the essential oil content is higher in roots and rhizomes of those plants (Sharma *et al.*, 2014).

Washing of Roots and Rhizomes

The harvesting of this crop is done by digging out roots and rhizomes. After digging the roots are cleaned. Roots and rhizomes are washed thoroughly in the baskets and shade dried. Dried roots have moisture content of 8 to 10 percent. They should be stored in cold dry and ventilated space so that the roots can be protected from rotting.

ECONOMICS OF THE SPECIES

S. No.	Expenses per Acre	Rupee
1.	Cost Norms for cultivation	35,139.00*
2.	Other Expenses (FY etc.)	10,000.00
3.	Harvesting, Drying and Transport Expenses	5,000.00
	Total	50,139.00

**Source: NMPB Cost norms for medicinal plants cultivation for the year 2017-18*

- Estimated Production of dry roots and rhizomes after 3 years : 800 Kg / acre
- Latest rates of market : Rs. 200 Per kg
- Income from dried roots : Rs. 1,60,000.00
- Income from selling of Macro-proliferated plants (Rs. 0.5 per plant) : Rs. 1,20,000.00
- Total income : Rs. 2,80,000.00
- Total expenses : Rs. 50,139..00
- Total Net profit after 3 Years : Rs. 2,29,861.00

Note: In the business of herbs, there is still a situation of uncertainty, so in this economics the shuffle is possible according to the market prices nowadays.

36 *Andrographis paniculata* (Burm. f) Wall. ex Nees

• English Name/ Trade Name :	Kariyat, Green chirayta, Creat, King of bittersandrographis, Kalmegh
• Common Name :	Kirayat, Kalmegh, Chooraita, Siriyaa Nangai
• Family :	Acanthaceae
• Part Used (s) :	Leaves and Roots

INTRODUCTION

Andrographis paniculata is a plant used for its flavor, or therapeutic properties, scent and medicinal products made from them are frequently taken to improve health as dietary supplements (Kanokwan and Nobuo, 2008). It is a herbaceous plant. Mostly leaves and roots have been traditionally used over centuries for different medicinal purposes in Asia and Europe as a folklore remedy for a wide spectrum of ailments or as a herbal supplement for health promotion.

GEOGRAPHICAL DISTRIBUTION

A. paniculata grows abundantly in southeastern Asia, i.e., India, Pakistan, Java, Malaysia, Indonesia and Sri Lanka. It is cultivated extensively in India, China ,Thailand and Mauritius (Mishra *et al.*, 2007; Kanokwan and Nobuo, 2008). It is distributed in tropical Asian countries having hot and humid climatic conditions but it can be cultivated in subtropical regions during the monsoon season (Niranjan *et al.*, 2010; Kumar, 2011). Kalmegh is normally grown from seeds ubiquitously in the native areas where it grows in pine, evergreen and deciduous forest areas & roads and in villages. Any soil having fair amount of organic matter is suitable for commercial cultivation of this crop (Mishra *et al.*, 2007).

BOTANICAL DESCRIPTION

It is an annual, branched, herbaceous plant erecting to a height of 30-110 cm in moist shady places with stem acutely quadrangular, much branched, easily broken, fragile texture stem. Leaves are simple, opposite, lanceolate, glabrous, 1-3 cm wide; 2-12cm long; with margin acute and entire or slightly undulated and upper leaves often bractiform with short petiole. Inflorescence of the plant is characterized as patent, terminal and axillary in panicle, 10-30 mm long; bract small;

pedicel short. Flowers small and calyx 5- particle, small, linear; corolla tube narrow, about 6 mm long; limb longer than the tube, bilabiate; upper lip oblong, white with yellowish top; lower lip broadly cunneate, 3-lobed, white with violet markings; stamens 2, inserted in the throat and far exserted; anther basally beared. Superior ovary, 2-celled; style far exerted. Capsule of the plant is erect, linear-oblong, 1-2 cm long and 2-5 mm wide, compressed, longitudinally furrowed on broad faces, acute at both ends, thinly glandular hairy. Seeds are very small, sub quadrate.

USES

It is an active constituent in majority of Ayurvedic preparations and is official in the Ayurvedic Pharmacopoeia (Rammohan *et al.*, 2011). Although all parts of the plant have been reported to be used traditionally, the leaves are the most common medicinal part of this plant. The plant is commonly used to get rid of body heat, dispel toxins from the body, treat common cold, acidity, liver complaints, upper respiratory tract infections such as sinusitis and fever (Gabrielian *et al.*, 2002; Caceras, 1997), it also act as antidote against snake's and insect's poisons (Samy *et al.*, 2008). Despite of antibacterial property, the plant is also known for its anti-inflammatory, antipyretic, anti-viral, anti-hyperglycemic, antioxidant properties etc. The primary medicinal component of *A. paniculata* is andrographolide, which is a 'diterpene lactone' water soluble substance and has been known to exhibit anticancer (Sheeja and Kuttan, 2007), anti HIV (Calabrese, 2000), cardioprotective and hepatoprotective properties.

PROPAGATION

It can be cultivated on wide range of soils from loam to lateritic soils with moderate fertility. The climatic requirement of the plant is hot and humid conditions with ample sunshine.

Seed sowing is most regular method used for cultivation of Kalmegh. Seeds are sown in the month of May and seedlings of 45 days can be shifted to the field. Seeds must be treated in hot water for five minutes to get the optimal germination. 25^0C is the optimal temperature for seed germination (Kumar *et al.*, 2011).

For raising the crop in one hectare six beds of 10 × 1 m size should be tilled, pulverized and leveled during the month of April, so that soil weathering may be there before sowing. Appropriate use of organic manure is advised for raising healthy seedling. Seeds should be covered by very thin layer of soil and compost mixture. Beds should be covered properly by suitable mulch and irrigated regularly with water fountain till seedlings emerge (6-7 days).

Kalmegh can be planted in the field at a spacing of 30 x 30 cm or 30 x 45 cm depending upon the site quality after 45 days of sowing. For best growth, fertilizer application i.e. Vermi-compost @ 10 ton per hectare (Kumar, 2013) / FYM @ 15 t/h + NPK @ 75:75:50 kg/ha + Panchagavya @ 3 % foliar spray (Sanjutha *et al.*, 2008) is recommended. In the beginning one or two weeding/hoeing are essential till the crop gets established. After establishment, crop grows well during monsoon and does not face any competition from weed.

The species can also be propagated by tissue culture. A rapid and efficient method for the large-scale propagation of *A. paniculata*, through in vitro culture of nodal explants obtained from 15 days old aseptic seedling has been developed by Purkayastha *et al.*, 2008.

HARVESTING AND YIELD

The harvesting should be performed from the beginning of the flowering period until around 50% blooming and when the plants have an age of 110 - 150 days (Suwanbareerak and Chaichantipyuth, 1991). This period will give highest percent of active ingredients (diterpene lactones). The plant will bloom fast or slow depending on the environmental situation (Promto *et al.*, 1997). For harvesting the stem it should be cut 5 - 10 cm above ground level to allow for renewed growth for the next harvest. Fresh and dry weights were found maximum when Kalmegh was harvested following non-destructive

practice (cutting from the base) and 80 % harvest resulted in more regeneration in the next season (Pandey and Das, 2013). After harvesting the plants should be cleaned in water and cut in pieces at the size of 3 - 5 cm. Drying can be done by using dehydration or hot air oven at 50°C for 8 hours and after that 40 - 46°C until the material is dried properly (MPRI, 1999).

The dried material can be stored in airless plastic bags. If it is only a small amount it can be kept in a dry clean glass. It should be kept in a clean cool place. It is important not to store it for more than 1 year because the percent of total diterpene lactones will decrease up to 25% after 1 year. A well-maintained crop grown during monsoon season yields 3.5 to 4.0 tons of dried herb per hectare.

37 *Flemingia macrophylla* (Willd.) Merr.

• English Name/ Trade Name :	Flemingia, Large Leaf Flemingia
• Common/Local Name :	Samnaskahat, Bhalia
• Family :	Fabaceae
• Part Used (s) :	Seeds

INTRODUCTION

Flemingia macrophylla is a woody, perennial shrub up to 3 m in height. It usually occurs in nature in sub humid to humid environments of tropical and subtropical regions. Due to its profound tap root system it withstands drought periods of 3 to 4 months while retaining green leaves (Asare, 1985; Godefroy, 1988). *F. macrophylla* tolerates poor soil drainage or water logging (Budelman and Siregar, 1997; Shelton 2001), resists fires and is well adapted to acid, infertile soils with high soluble Al-saturation (Budelman, 1989). *F. macrophylla* has significance as shade plant in young coffee or cocoa cultivations, medicinal plant, silk dye, host for lac producing insects and as fuel wood (Andersson *et al.*, 2003). It is a good example of a formerly neglected species that became interesting as the demand for soil improving germplasm adapted to degraded sites (Hanson and Maass, 1997) and drought arose (Andersson *et al.*, 2003).

GEOGRAPHIC DISTRIBUTION

This species is native to humid to sub humid tropics and subtropics of Taiwan, southern China, Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Malaysia, Bhutan, India, Nepal, northern Pakistan, Srilanka and Papua New Guinea. It is found mostly under trees along water courses and in grasslands, on clay and lateritic soils. Although native to Asia, it is cultivated and naturalized in sub-Saharan Africa and South America.

BOTANICAL DESCRIPTION

Perennial, deep-rooting, leafy shrub, 0.5-2.5 m (rarely-3 m) high. Prostrate to erect growth habit, numerous stems arising from the base. Leaves trifoliolate, leaflets elliptic-lanceolate, 5-15 cm long, 2-8 cm wide, silky or hairless, papery when old. Inflorescences mostly dense, axillary racemes, 5-30 cm long, with 15-40 pea flowers; calyx 7-13 mm long; corolla 14 mm long, white to pink or yellowish, densely silky, standard greenish with distinct red blotches or stripes and purple apex,

wings rose-pink. Pods oblong, 11-15 mm long, 5-7 mm wide, dark brown and slightly silky, dehiscent, 2-seeded. Seeds globular mottled brown or shiny black, 2-3 mm in diameter. 45,000- 97,000 seeds/kg.

USES

It is commonly used in contour hedgerows for erosion control, often in association with *Desmodium cinereum*. Now a days, this is favorable plant for lac cultivation. Pruning is used for mulch (slow breakdown of leaf due to high concentration of condensed tannins) and green manure in alley cropping systems. It is also used to shade young coffee and cocoa plants, for weed suppression and soil enrichment in orchards and to provide fuel wood and stakes for climbing crop species. It is considered a poor forage since it has a high fibre and condensed tannin concentrations and is not readily eaten by stock. Pods provide a brilliant orange dye for silk.

CULTIVATION

Not much work on cultivation packages has been carried out in this genus. Seeds are sown in the month of May. Plants are planted in the field in July month with spacing of 1 x 1 m. The soil nutrients NPK are applied twice in a year in the month of July and February. The plants are also provided with 1kg FYM in the month of July once in a year. Urea (46%N) is used for nitrogen nutrient supply; DAP fertilizer is used for phosphorous nutrient supply and Murate of Potash is supplied for supply of potash. N15:P5:K5 dosage is recommended for optimal growth.

BROOD LAC YIELD

Brood Lac Yield 270 to 300 gm/plant is obtained in first year, however in the second year 1000g/plant can be obtained.

38 *Gymnema sylvestre* R. Br ex Schult.

• English Name/ Trade Name :	Gurmar, Australian Cowplant, Cowplant, Periploca of the wood
• Common Name :	Gurmar, Madhunashini, Chakkarakolli
• Family :	Asclepiadaceae
• Part Used (s) :	Leaves

INTRODUCTION

Gymnema sylvestre (Madhunashini) commonly known as 'Gudmar' in Hindi is an important medicinal climber belonging to the family Asclepiadaceae, acclaimed for its anti-diabetic properties. This climber is extensively used in almost all the Indian system of medicine.

OCCURRENCE

It is widely found in the tropics of Africa, Asia and Malaysia. In India, this plant is found growing in abundance in the forests of Karnataka, Tamil Nadu and Bihar. Due to its heavy demand in South East Asian countries, the plant is becoming endangered and under cultivation in southern states of India, particularly in Tamil Nadu.

USES

G. sylvestre extracts (formulated as a mint lozenge) reduced the desire for high-sugar foods and the pleasant taste of candy. Research also suggests that *G. sylvestre* extracts reduce cravings for sugar. In Eastern and Ayurvedic medicine, *G. sylvestre* leaves and extracts have been used to treat eye diseases, allergies, constipation, cough, dental caries, obesity, stomach ailments and viral infections. It has also been used as an antioxidant, antimicrobial and aphrodisiac.

It is also useful in inflammations, dyspepsia, constipation, jaundice etc. Roots have been reported as a remedy for snakebite. The anti-diabetic property of the plant is attributed to the presence of mixture of triterpines and saponins in the leaves. These have been designated as gymnemic acids A, B, C and D, which have the gymnemagenin and gymnestrogenins.

PROPAGATION

The plant can be multiplied either by seeds or by stem cuttings.

Propagation by Seeds

The plant bears the fruits during November- December months. Seeds are collected from freshly harvested fruits. Then they are soaked overnight in water and next day the seeds are sown in the seed pan containing soil mixed with sand. The seed pans are watered daily and the seeds germinate in about 15 days. After 40-50 days they are transplanted to polythene bags containing a mixture of soil, sand and FYM mixed in equal proportion. About 2-3 kg seeds are required for raising one hectare crop.

Madhunashini is an evergreen climber and the best season for planting is June-July. After the ploughing and leveling of the land, 45 cm^3 sized pits are made at a distance of 2.5 m between the rows and 1.75 m between plants (within the row). The pits are dug open 15 days earlier to planting, they are filled with green leaves and top soil and 2 kgs of well rotten manure per pit is added. The pits are to be irrigated and left for one week, then the rooted cuttings are planted in the pits.

Irrigation is given immediately after planting and fertilizers are applied depending upon fertility of land. Later on, irrigation once in 5-6 days is sufficient. During summer depending on the weather conditions irrigation frequency need to be increased. Since weeds compete with the plants for water and nutrients, an area of one metre around the plant needs to be kept clean by hand weeding at periodical intervals.

Propagation by Cuttings

This is the commercial method. The matured stem cuttings of 15 cm length are treated with 500 ppm IBA for about 18 hours. Then they are planted in the polythene bags containing equal proportions of soil, sand well rotten FYM. Before planting in the polythene bags the cuttings are also treated with 1 per cent Bavistin and have to be watered every day. Roots develop after ninety days of planting and then they are transplanted in the main field.

In Vitro Cultivation

For in vitro regeneration of mature nodal explants of *G. sylvestre*, Murashige and Skoog (MS) media can be used for the inoculation of single node explants having different combinations of 6-benzyl amino purine (BAP) or kinetin with naphthalene acetic acid (NAA) and auxins like indole acetic acid (IAA) alone or in combinations. The MS medium containing BAP (5 mg/L) and NAA (0.2 mg/L) exhibited maximum number of shoot (7 per explants). Further, the regenerated shoots were subjected to rooting on MS half strength medium in absence of any growth regulator (IAA, IBA and NAA). In cultures where the shoot explants were inoculated on auxin-free half strength MS basal medium, root primordia emerged from the shoot base 15–20 days after implantation and subsequently developed into roots without basal callus as compared to MS media supplemented with different concentrations of auxins, which did not lead to root formation.

PLANT PROTECTION

Major insects	:	Thrips, mites and green fly
Major diseases	:	Powdery mildew and leaf spot

Schedule

- Spray the vines with 2 ml of Rogor per liter of water to control thrips. Mites can be effectively controlled by any Acaricide. To control green fly spray 1 ml nuvacron mixed in one liter of water.

- The diseases can be controlled by spraying 3 g of water soluble sulphur (or) 2 g of Mancozeb in one liter of water at an interval of 10-15 days.

HARVESTING AND YIELD

The crop is ready for harvest two years after planting. Leaves are the economic part and the harvesting of the leaves begins when plants start flowering i.e., during end of June or first week of July. Leaves can be harvested along with flowers either by hand or can be cut with sickle/knife. The harvested leaves are dried under shade by allowing sufficient air to circulate by spreading thinly on clear ground for about 7-8 days. Direct sunlight should be avoided to maintain the quality of the leaves.

The crop is harvested only once in a year during flowering and on an average 5-6 kg dried leaves per plant can be obtained from a 4 years old plant yielding about 10,000 – 15,000 kgs of dried leaves per hectare. The crop can be cultivated for 10-15 years under good management.

39 *Schleichera oleosa* (Lour.) Merr.

• English Name/ Trade Name :	Kusum Tree, Gum Lac Tree
• Common/Local Name :	Kusum; Posku; Kosumb
• Family :	Sapindaceae
• Part Used (s) :	Wood, seed, bark

Schleichera oleosa

INTRODUCTION

Schleichera oleosa is medium sized to large tree 15- 32 meters in height with a dense spreading crown and smooth pale brown bark exfoliating in small irregular flakes (Sala, 2010). Kusum timber is very hard and durable and used for the roller of oil and sugar mills, rice ponders, agricultural implements. Destruction of natural habitat of plants, over exploitation of natural green cover due to increasing needs of human resulted in biodiversity loss and environmental deterioration in most tropical forests

GEOGRAPHICAL DISTRIBUTION

S. oleosa occurs naturally from the foothills of the Himalaya and the western Deccan to Sri Lanka and Indo-China. It was probably introduced to Malaysia and has naturalized in Indonesia, Sulawesi, Moluccas, Ceram and the Kai Islands. It is occasionally cultivated throughout the tropics, especially in India.

BOTANICAL DESCRIPTION

It is a medium to large tree, up to 40 m tall. Branches are black when young, later yellowish-brown. Leaves are 2-4 jugate, young leaves deep purple, petioles, flattened or grooved above, 2-6 cm long. Flowers are pale yellow or pale green. Sepals are ovate to deltoid, 1.5 mm long. Fruits are broadly ovoid to sub-globular, 15 × 13 mm long. Seeds are sub globular, 12 × 10 mm. Flowering and fruiting occurs during March-November.

USES

S. oleosa has many important uses. The wood is suitable as firewood and makes excellent charcoal, the wood is very hard and durable, excellent to make pestles, cartwheels, axles, ploughs, tool handles and rollers of sugar mills & oil presses. Oil extracted from the seed, called "kusum oil", is a valuable component of true Macassar oil used in hair dressing, it is also used for culinary and lighting purposes and in traditional medicine it is applied to cure itching and other skin afflictions. In Madura and Java the oil is used in the batik industry and in southern India as cooling bath oil. Cooked young leaves make a side dish. Powdered seeds are applied to wounds and ulcers of cattle to remove maggots. A dye is obtained from the bark. The bark contains tannin and is astringent and used against skin inflammations and ulcers, while an infusion is taken against malaria. It is also utilized occasionally for tanning leather. Leaves, twigs and seed-cake are used to feed cattle. In India, it is used as host for the lac insect (*Laccifer lacca*). The product is called kusum lac and is the best in quality and in yield.

PROPAGATION OF THE SPECIES

By Seed

Natural regeneration is by seed and root suckers. Seed can be stored in gunny bags for 1 year, in sealed containers for up to 2 years. Propagation is by direct sowing in thoroughly prepared soil or by stump planting. In nurseries, seed is sown 7.5 cm apart immediately after collection. Stumps are prepared after one year, when the seedling stem is about 1 cm in diameter. The stem is cut back to about 4 cm, the roots to 25 cm. Plant holes should be about 30 cm deep and wide enough. Regular weeding and protection from grazing is required.

Fig 1a: Cutting Trial

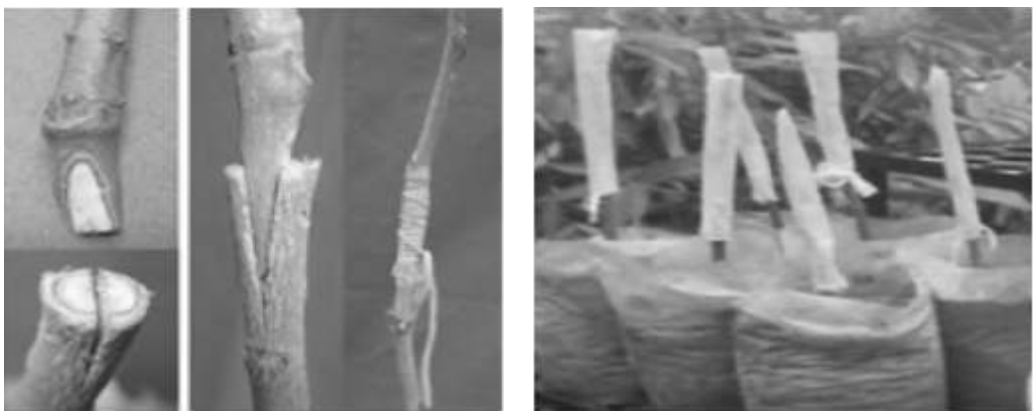
Stem Cuttings

Mature stem cuttings of Kusum can be collected during February to May. The cuttings have to be subjected to 2000 ppm IBA added with 5% sucrose i.e. hormonal treatment for optimal rooting. It was done by dipping the cuttings (2-3 cm) base into the root promoting auxin solution for 1 hr. Subsequently cuttings were placed into hypocots.

Fig 1b: Rooting after 3.5 months in Soilrite

Grafting

Root stock of 30-40 cm is taken. Scions are cut to a length of 15-20 cm without leaves having the end of 1.5 cm long. A split is made and scions are inserted into rootstock and grafts are tied with polythene tape. Only cleft grafting has been standardized.



Grafting

Air-layering

Air layering can be carried out in the month of June to September. The branch spot is treated with a combination of rooting hormones (IBA (1000 ppm) + IAA (500 ppm) + NAA (500 ppm)) before covering soilrite and polythene sheet (Sinha, 2015). After 2-3 months the air layering branches are detached from tree.

Air-layering

Lac cultivation on pollarded plants

New shoot emerged from the pruned branches are allowed to develop for one year and inoculated using broodlac during July. Removal of phunki is done after two weeks of inoculation. Stick lac per plant are harvested during March on crop maturity.

YIELD

In India, a mature tree yields 21-28 kg depulped seed per year. For depulping, fruits are kept in heaps for 2-4 days and are then rubbed clean. After crushing the depulped seed, the oil is extracted by boiling or pressing. The oil yield obtained by boiling is 32-35% of the kernel weight, by pressing 25-27%.

Raw lac is harvested with the branches as stick-lac. It is washed, dried and winnowed to yield a granular substance called seed-lac.

I INSTITUTE OF FOREST BIODIVERSITY (IFB) HYDERABAD

40 *Sterculia urens* Roxb.

• English Name/ Trade Name :	Gum Karaya
• Common/Local Name :	Hindi: Kulu Telugu: Tapsi
• Family :	Sterculiaceae
• Part Used (s) :	Gum

Steculia urens tree in natural habitat

INTRODUCTION

Sterculia urens is a profitable tree species which is found around the country. It grows well in rocky areas, hill tops and slopes. These trees cannot survive in water logged areas. This plant is quite valuable for the forest dwelling tribes as they traditionally extract gum from Gum Karaya and sell it in their local market which account for their livelihood generation. Gum Karaya is oozed from *S. urens* as a result of cut or wond/damage to its trunk. Not only gum, tree is also has timber quality. It plays a vital role in the tribal wealth (Damle, 2014).

GEOGRAPHICAL DISTRIBUTION

The species of is distributed all over India including tropical Himalayas, west and central India and Eastern & Western Ghat regions. Gum karaya is one of the Major NTFP in Telangana Andhra Pradesh, Karnataka, Maharashtra, Orissa, Gujarat, Rajasthan and Bihar. It is also found in Chhattisgarh and Madhya Pradesh (Damle, 2014).

BOTANICAL DESCRIPTION

S. urens is a wooded soft deciduous tree, 15m tall, usually with white papery outer bark, inner fibrous, trunk erect, branches, spreading, marked with large scars, wood greyish or reddish brown. Leaves palmately 3-or-5-lobed, 20-30 cm

diameter crowded at the tip of the branchlets, 12-15 x 10-15 cm, glabrous above, velvety below, base cordate, entire, apex acccuminate. Flowers are greenish yellow, small, in terminal panicles; follicles 4-6, ovoid-oblong, about 2.5 cm diameter, coriaceous, red, covered with stinging hairs. The specific name *urens* means stinging in reference to the hairs on flowers. Fruit made up of 5 sessile, radiating, hard, coriaceous carpels, 7.5 cm long, red when ripe, covered outside with many stiff bristles.

USES

Gum Karaya being a commercially utilized product is used in food, pharmaceutical and other industries such as textile, petroleum and gas, leather and allied products, paper and pulp, ammunition and explosive, adhesives, confectionery, medicine and cosmetics (Kumar, 2016). Being a natural thickener and stabilizer with a long history of safe use it is used in the food, medical and pharmaceutical industry (Setia *et al.*, 2010). The property of cold water swelling and viscosity make use of Gum Karaya in the food industry. It is used in a variety of food items such as condiment bases, sauces, sweet pickle, cheese, salad dressing, ice creams etc. Thousands of tribal families are dependent on this gum yielded by this pant for their livelihood. Gum Karaya is also an excellent binder thus used in many other industries including petroleum and gas, fabric printing, leather etc. The value of the gum depends on quality which determines the clearance for its use as food additive (Anonymous, 1976).

PROPAGATION

Sterculia species is mainly propagated through seeds. Presently, the trees are available only in forests or marginal lands near the villages. The seeds are the major source of regeneration of Karaya tree. The major problem in the reforestation of *Sterculia spp* is the low percentage of germination of seeds. Another basic problem is the presence of hard seed coat which leads to low germination capability.

Flowering and fruiting of *S. urens* take place between January and April while mature seeds are harvested in last week of April to end of May. Rayudu (2003) reported that around 4 kg of seeds produced 7,500 seedlings while seedlings from few days old to 3 weeks old transplanted into polythene bags have 80% survival under control regular watering to avoid water logging conditions. During water logging conditions in the species, the tuber is damaged. Somashekar and Sharma (2002) also reported that seeds start sprouting in 10-15 days, with a germination success of 32- 77%. Water the seedlings regularly and apply copper fungicide to control damping off of the seedlings.

Vegetative propagation of *S. urens* stumps were also done. The stumps were planted in the nursery. 50 stumps of 12 cm long and above 30 mm girth and 5 stumps were servived. 30 to 40% survival was recorded from big size 20 sturdy wood stumps i.e. 20 stumps were 1 ½ feet length and 60 mm girth without any hormone treatment (Rayudu, 2003).Tissue culture techniques have also been used for the propagation of the *S. urens* (Hussain *et al.*, 2007).

DISEASE MANAGEMENT

Effect of *Sylepta balteata* and *Oglasa separata* defoliation was observed in nurseries, young plantations and forest trees. *Cercoseptoria sterculiae, Alternari amacrospora var. sterculiae, Myrothecium roridum, Macrophomina phaseolina, Phoma jolyana* and *P. macrostoma* have also been recorded (Orwa *et al.*, 2009).

TAPPING RULE FOR THE GUM KARAYA (WORKING PLAN, KHAMMAM, TELANGANA)

The yield of gum mostly depends on the area, size, vigor of growth, methods and season of tapping. In general, a tree of minimum permissible girth with single blaze on an average may yield 2-5 kg of gum per year. It is recommended by the Forest department that tree below 90 cms GBH shall not be tapped. Blazing and tapping shall be limited to the main trunk from 50 cm above the ground level upto the point of the first main branch. The depth of the wound/blaze shall be 1.25 to

3.0 cm for trees from 91 to120 cm GBH and 2.5 to 3.75 cm for trees over120 cm GBH. The blaze should be on the fresh healthy part of the tree only not on the partially healed surface of the old cuts. The blaze shall be slant and rectangular shapes. The initial blaze shall be 10 cm wide and 15cm long, gradually increasing to 32 cm length. Blazing shall be done in the evening during hot weather. Tapping of gum shall be done during the period of October to June.

MARKETING OF THE GUMS BY GIRIJAN COOPERATIVE SOCIETY, HYDERABAD, TELANGANA AND VISHAKHAPATNAM, ANDHRA PRADESH

Girijan Cooperative Society, Hyderabad, Telangana and Vishakhapatnam, Andhra Pradesh is the government society which takes care of the NTFP procurement as well as welfare of the tribal's. The data on the gum procurement by the GCC from 2012-13 to 2016-17 are listed below. The society procured the gum karaya @Rs.108.00/kg which is fixed by the Government of India.

S.No.	Commodity	2012-13		2013-14		2014-15		2015-16		2016-17	
		Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh
1	Gum	1334.16	200.6	1155.02	165.82	2008.92	359.71	812.76	111.86	0	0

41 *Strychnos nux-vomica* L.

• English Name/ Trade Name :	Nuxvomica
• Common/Local Name :	Hindi: Poisonous Nut Telugu: Musthi
• Family :	Loganiaceae
• Part Used (s) :	Seed

Strychnos nux-vomica L. branch with fruit

INTRODUCTION

Strychnos nux-vomica is a medicinal plant and mainly known for its seed importance in pharmaceutical industries due to their poisonous alkaloid strychnine (Tiwari, 2000). The pan-tropical genus *Strychnos L.* is well known as a source of poisonous alkaloid strychnine. Pharmaceutical companies depend mainly upon material collected from natural stands that are being frequently vanished. To meet the future needs of raw materials for pharmaceutical industries and local medicinal consumption, urgent attention should be paid to cultivation of this medicinal plant.

GEOGRAPHICAL DISTRIBUTION

Strychnos nux-vomica (also known as poison nuts or quaker buttons) is native to Southeast Asia, especially India and Myanmar (American Cancer Society, 2000). It is a medium-sized deciduous tree that grows naturally on wastelands and degraded forests in the West Coast and in the Eastern and Western Ghats of India. In India, it is commonly observed in moist deciduous and semi-evergreen forests of West Bengal, Bihar, Maharashtra, Odisha, Central and South India up to altitude of 500m (Pulliah and Rani, 2011). In its natural habitat *Strychnos nux-vomica* occurs at the edges of dense forest, on river banks and along the shores. Five species of genus *Strychnos* are endemic to South India and Andaman Islands (Victor *et al.*, 2016; Hill, 1917).

BOTANICAL DESCRIPTION

It is a deciduous tree with 5-25 m in height. Its leaves have an opposite decussate arrangement and are papery, while the leaf blade is sub-orbicular, broadly elliptic or ovate, 5–18 cm in length and 4–3 cm in width. Its 5-merous flower is dull-green and white. Its fruit consists of brownish-yellow berries the size of small oranges and contains a gelatinous pulp in which one to five seeds are embedded. The dried ripe seed is very hard, 1.5-3 cm in diameter and 3–6 mm in thickness.

The seed has a flattened disk shape, is slightly concave and completely covered with hairs radiating from the center to the sides; thus giving the seed a very characteristic sheen. The seed with dark gray horny endosperm, where the small embryo is housed, has no odor but tastes very bitter. These seeds can be kept for long periods (Guo *et al.*, 2018).

USES

S. nux-vomica is a promising drug plant of many traditional systems of medicine including Unani, Ayurveda, Tibetan, Chinese and Homeopathy (Behera *et al.*, 2017). Almost all part of this tree contains alkaloids of medicinal importance but seed is official in many pharmacopeia. The Ayurvedic Pharmacopoeia of India recommends detoxified seeds for ailment of paralysis, facial paralysis, sciatica and impotency (Kirtikar and Basu, 1991). The seeds are bitter and used as aphrodisiac, appetizer, anti-periodic, digestive, purgative and stimulant. They are applied in the treatment of anemia, lumbago, asthma, bronchitis, constipation, diabetes, malarial fever, skin disease, paralysis, muscle weakness, emphysema, colic, insomnia, nervous debility, dyspepsia, diarrhoea, hysteria, mental emotions, epilepsy, chronic constipation, gout, chronic rheumatism, hydrophobia and spermatorrhoea (Behera *et al.*, 2017).

PROPAGATION

It is a potential medicinal plant for cultivation in Deccan and peninsular India. It can be propagated through seed and vegetative methods but reproduction through seed is more assertive (Bhatt *et al.*, 2001).

Propagation by Seed

Ripe berries are collected from trees during March-April. The seeds are removed from the fleshy pericarp, cleaned, dried and sorted. 750-800 seeds weigh one kilogram. Seed is orthodox and mesobiotic in nature (Vanangamudi *et al.*, 2006). Seeds are desiccation tolerant, dry seed (10% moisture content) can be hermitically stored at ambient temperature for 30 weeks without losing their viability. Seeds exhibit physiological dormancy and hence slow and erratic germination (10% germination) is recorded from freshly harvested seeds (Sivakumar *et al.*, 2006). Dormancy can be removed (after-ripening) by storing seeds with 10% moisture content at ambient temperature for 30 weeks or by treating with hormones gibberellic acid (GA_3) or indole butyric acid (IBA). Treating seeds with gibberellic acid (Soaking seeds in 500 ppm gibberellic acid (GA_3) for 24 h), incubation of seeds at 40 ^{0}C for 3 days and alternate water soaking (16 h) and drying (8 h) for 14 days, the germination can be improved up to 32%. But 92 percentage of seed germination can be achieved by using after ripened seeds. Growth of seedlings is very slow but it can be improved by using medium sized polythene bags containing pot mixture of farm yard manure (FYM), soil and sand in ratio of 1:1:1. The plant can rise well in dry or humid tropical areas of the country. It grows over laterite, sandy and alluvial soils. A nursery of the plant is raised in December or January in climatic conditions of South India. Seeds are sown in polybags of size 25 cm × 20 cm, filled with soil, sand and FYM mixture. Seeds are directly sown in the polybags after appropriate pretreatment. The polybags are watered regularly so as to keep them moist (Behera *et al.*, 2017).

The seeds germinate in about 20-30 days. Sometimes the germination may continue up to 45 days (Somashekar and Sharma, 2002). The seedling growth is very slow but roots grow very fast. For vegetative propagation, semi-hardwood cuttings can be prepared in early summer and kept under moist conditions after treating with commercially available rooting hormones. Rooting percentage is quite low, often less than 25%. About 1 kg seeds are required to raise 1 hectare of plantation. Seeds have low germination rate and fresh seeds of *S. nux-vomica* lose viability early. Germination can be increased by treating the seeds with hot water (50° C) for 6-12 hours prior to sowing (Behera *et al.*, 2017).

Propagation through Vegetative Methods

Macro-propagation through cuttings and root suckers is suitable (NMPB, 2008). Semi-hardwood cuttings are prepared in early summer and kept under moist conditions after treating with rooting hormones. Rooting percentage is quite low, often less than 25%. Root suckers from mother plant are pricked out and transplanted in polybags for

eventual planting out. Micro-propagation/ clonal propagation of Kupilu can be successfully done through shoot proliferation and hypocotyl culture in suitable media. For shoot proliferation, nodal explants excised from healthy mature trees are cultured on Murashige and Skoog medium with various additions. IAA and NAA were the most suitable growth regulators, both promoting shoot and root formation (Kumar, 1990).

For hypocotyl culture seeds were germinated in MS medium supplemented with 1000 ppm gibberellic acid (GA_3) under dark condition. Hypocotyls segments of 3mm size are cultured in MS medium with various additions and maintained at 25 ± 1^0C with 16 hr illumination at fluorescent light. Kinetin is most suitable for shoot formation and NAA is best for root formation (Kumar, 1989).

Transplantation

The land is ploughed with disc harrow and tillers to achieve a fine tilth and make it weed-free and arable. Pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 5 m × 5 m and refilled with mixture of soil and manure in 1:1 ratio. Appropriate quantities of sand may be added if the soil is heavy. About 10 kg of well-rotten FYM is applied in each pit at the time of its refilling. In South India, the seedlings are transplanted with the onset of South-west monsoon in May or early June. An optimum spacing of 5 m × 5 m is recommended, which gives a stand of 400 trees per hectare.

Inter-culture and Maintenance Practices

About 10 kg of well-rotten FYM is mixed in the soil during refilling of pits before planting. Additional 10 kg manure may again be applied to the soil around the plants during October-November at the time of weeding. A total of 20 kg FYM/plant/year in subsequent years results in best growth of plants. This is to be applied in two split doses in June-July and September-October. Supplementary doses of inorganic fertilizers (NPK) do not lead to any significant additional growth in the young plantations. The area around the basin of the plant should be kept weed-free by frequent weeding. The interspaces can be kept weed-free by hand weeding or spraying of herbicides like 0.8% paraquat or 0.4% glyphosate.

Irrigation Practices

The crop needs no irrigation during the rainy season and in dry weather; saplings may be irrigated on alternate days, especially in the early years of growth. For matured trees, irrigation by ring method around tree base at a distance of 30 cm during summer months is beneficial.

Disease and Pest Control

No significant pest or disease is observed on the crop. Plant is normally free of pest and diseases but in few instances leaf spot disease caused by *Colletotrichum gloeosporioides* is being reported (Sankaran, 1980).

POST HARVEST MANAGEMENT

The orange-light red colour of fruit indicates maturity. Matured fruits are manually collected, fleshy pericarp was removed, washed properly and shade dried up to 10 % moisture content. Seeds are then graded according to size. Seeds of light weight and those float on the surface of water are discarded. Storage does not affect the total alkaloid content of seeds particularly strychnine and brucine. Processed mature seeds can be stored in gunny bags at ambient temperature in the usual way for a long time or till preparation of tincture (Punkambekar, 1947).

YIELD

Considering a crop stand of 400 plants per hectare and average produce range of 50-75 kg of dry seeds per tree per year, a yield of 12-20 tonnes/hectare is estimated from a 20 year old plantation annually.

MARKETING OF THE GUMS BY GIRIJAN COOPERATIVE SOCIETY, HYDERABAD, TELANGANA AND VISHAKHAPATNAM, ANDHRA PRADESH:

Girijan Cooperative Society, Hyderabad, Telangana and Vishakhapatnam, Andhra Pradesh is the government society which takes care of the NTFP procurement as well as welfare of the tribal's. The minimum selling price for 1 kg seed is Rs. 16. The data on the *Strychnosnux-vomica* procurement by the GCC from 2012-13 to 2016-17 are listed below:

S.No.	Commodity	2012-13		2013-14		2014-15		2015-16		2016-17	
		Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh	Qty in Qtls	Val in lakh
1	Nuxvomica	326.85	7.09	5732.23	140.51	2690.41	62.39	1558.13	49.98	824.09	31.47

42 *Swertia chirayita* (Roxb.) Buch.-Ham. ex C.B. Clarke

• English Name/ Trade Name :	Chirayita
• Common/Local Name :	Chirayita
• Family :	Gentianaceae
• Part Used (s) :	Roots, Rhizomes

Swertia chirayita

INTRODUCTION

S. chirayita is critically endangered medicinal plant of temperate Himalayas having important position in several world pharmacopoeias as well as traditional medicinal systems like Ayurveda, Unani, Siddha etc. Crude drug supplies of *S. chirayita* still depend on wild sources which are becoming critical on account of over harvesting leading to its categorization under 'Critically Endangered' category (Shrestha and Joshi 1992; Samant *et al.,* 1998; Rai *et al.,* 2000; Badola and Pal, 2002). Extensive habitat loss, low seed viability and germination, very minute seed size and long gestation period contribute to its dwindling natural population and sparse cultivation (Samant *et al.*,1998; Joshi and Dhawan, 2005). The species has also been put in negative export list of Ministry of Commerce, GOI and also amongst the 32 medicinal species for intensive cultivation by NMPB, New Delhi (Kala and Sajwan, 2007). Despite its threat

Swertia chirayita plants

status, the raw material of this species is still wild harvested from leftover locations which emphasize the urgency to bring this species under cultivation.

Correct identity of the traded raw material of *S. chirayita* is always under doubt as several species of genus *Swertia* and *Andrographis paniculata* are also marketed sometimes as 'Chirayata' affecting the quality and efficacy of the drug. Some of the common adulterants/substitutes of *S.chirayita* are *S. angustifolia, S. alata, S. bimaculata, S. ciliata, S. dilatata, S. densifolia, S. minor and S. lawii* (Anonymous, 1976; Joshi and Dhawan, 2005). *Swertia nervosa* is the main substitute of *S. chirayita* in trade (Pant *et al.*, 2005).

GEOGRAPHICAL DISTRIBUTION

The plant is a native of temperate Himalayas, found at an altitude of 1,200-3,000 m (4000 to 10,000 ft.), from Kashmir to Bhutan and in the Khasi hills at 1,200-1,500 m (Clarke, 1885, Kirtikar and Basu, 1984; Bhatt *et al.*, 2006). The plant prefers cool and humid climate and North and Northwest-facing moist habitats in forests, rangelands and around cultivated lands. According to earlier studies, 2000m altitude is the suitable range preferred by the species in Nepal (Bhattarai and Shrestha, 1996); 1800-2300 m in Sikkim Himalayas (Pradhan and Badola, 2010) and in temperate Himalayas, between 1800 to 3200 m. The plant can be grown in variety of soils with sandy loam rich in carbon and humus. The plant prefers to grow in acidic soil condition with pH of 4.7 to 5.5 (Bhattarai and Shrestha, 1996). It is also found in open ground and recently slash-and-burnt forests. It is also reported to grow under the canopy of *Acer* and *Quercus* mixed forests, mostly on a southeast aspect (Bhatt *et al.,* 2006).

BOTANICAL DESCRIPTION

S. chirayita is an erect, profusely branched, around 2–3 ft tall robust herb. The stem is erect, circular in lower region and quadrangular in upper portion especially in the branches with prominent decurrent line at each angle. The colour of stem varies from dark green with purple tinge in lower region to light green with or without purple tinge in upper region and containing large continuous yellowish pith (Bentley and Trimen, 1880; Joshi and Dhawan, 2005). The plant bears two types of leaves, radical leaves which are subsessile, broadly lanceolate, light green to purplish–dark green, 24 to 29 cm in length and 5.5-6.4 cm in breadth five to seven nerved having lance shaped lamina with multicostate convergent reticulate venation. Cauline leaves are broadly ovate lanceolate, 5-7 nerved, subsessile with acute tip, opposite and decussate, 9.7cm to 17.2 cm in length and 3.1 to 6.8 cm in breadth. It is the only tetramerous species with presence of nectar glands present at the base of each petal (Raina *et al.*, 2013).

The root is simple, yellowish, somewhat oblique, or geniculate, tapering and short, almost 7–8 cm long and usually half an inch thick (Bentley and Trimen, 1880; Clarke,1885; Scartezzini and Speroni, 2000). Plant bears numerous small flowers in leafy panicles having axillary or terminal clusters of 3-5 flowers with quadrangular peduncle. Calyx consist of four equal sized persistent sepals fusing at base, green, lanceolate with acute tip and shorter than corolla, elongating at capsule maturation stage. Corolla consisted of four equal sized petals which are longer than calyx and divided near the base into four radiating ovate, lanceolate greenish yellow tinged with purple streaks towards the margin and acuminate tip segments. Each petal lobe bears a pair of nectar glands at its base covered with oblong hairy scales extending up to half the length of the corolla lobes (Bentley and Trimen, 1880). The fruit is a small, one cell capsule, green, egg shaped with yellowish pericarp. It dehisces from above, septicidally into two valves. Seeds are numerous, minute, many sided and angular.

Phenology

S. chirayita is a pluri-annual herb (once flowering and senescence in the third year after seed sowing). The seedlings bear dense rosette of radical leaves which persists for almost a year after pricking and withers with the onset of winter. Initiation of aerial shoot and subsequent appearance of cauline leaves in pairs which was followed by the appearance of lateral branches pairs in the axils of cauline leaf pairs occurs during spring of following year. Flowering commences in third year of growth during August–September followed by seed setting in October–November after which plant shows senescence (Shah, 2011).

Importance and Uses

S. chirayita holds a place of pride in the Indian system of medicine since ages and forms a valuable household remedy used primarily as blood purifier, carminative, digestive, expectorant, febrifuge, anthelmintic, antidiarrhoetic, antiperiodic, laxative and also useful in flatulence, indigestion, skin diseases, malarial fever, gout, bronchial asthma etc. All parts of the plant are bitter and known to possess antipyretic and anthelmintic properties (Kirtikar and Basu, 1984).

PROPAGATION

Natural Regeneration

The natural regeneration of plant takes place by seeds, when the seeds become biologically mature having high potentiality of viability during November (Bhattarai and Shrestha, 1996).

Artificial Regeneration

Seedlings are raised in nursery. Polybags or naked root seedlings are transplanted in the field. Raised nursery beds are prepared under protected conditions. The nursery media consist of fine sieved soil: sand: FYM: 2:1:1. To maintain the moisture in the nursery media, coco-peat may be added to the nursery media. Seeds are mixed with fine sand and then broadcasted on top of nursery beds very carefully and then covered with fine layer (1-2 mm) of coco-peat so as to maintain moisture on top layer. Irrigate the nursery beds 2-3 times a day carefully with fine mist of water using spray pump daily till seed germination and thereafter once a day irrigation is sufficient. For healthy seedling production, the growing media is enriched with bio-fertilizers *viz*. Azotobacter and VAM. Seed germination starts in 15-18 days. Second fortnight of April to first fortnight of June is appropriate time for seed sowing in nursery. As seed germination is poor in *S. chirayita*. Treatment of seeds for 18 hrs with growth regulators (GA_3 100 ppm, IAA 400 ppm and KNO_3 200 ppm) improved seed germination and reduced mean germination time (Bhatt *et al.*, 2007). Initial growth of seedling is very slow and seedlings attain 6-8 true leaves stage in about 120 days. At 6-8 true leaves stage, seedlings are pricked in nursery bags. The seedlings are then grown in nursery bags for about 6-7 months till transplanting in the main field in March- April month.

Field preparation is done during March- April by ploughing 2-3 times and leveled. Farm yard manure 15-20 tonnes/ha is incorporated at the time of last ploughing. Mostly, flat beds of 1.5-2m width and 4-6m length are formed. The soil is enriched with bio-fertilizers *viz. Azotobacter* and VAM for healthy plant growth and development. The nursery raised plants with soil bowl are transplanted in the field at a spacing of 30cm x 30cm. Next year of transplanting, aerial shoot development starts during April month and the plants starts flowering by end of July month.

SILVICUTURAL AND MANAGEMENT PRACTICES

Irrigation

Regular watering is required for proper and healthy growth of nursery seedlings. Irrigation depends upon soil type and weather condition during the dry period.

Weeding

Weeds growing along with crop affect the growth and yield of the plant. Hence, regular weeding as per requirement is done at regular interval for optimum growth and yield.

Harvesting

All plant parts of Chirayata are medicinally important; therefore, the plants are harvested at full bloom stage during end of August to September month. Whole plant along with roots is uprooted and lower part is washed with water to remove soil. The harvested plants are tide in small bundles and dried in shade and stored in well ventilated place.

43 *Terminalia chebula* Retz.

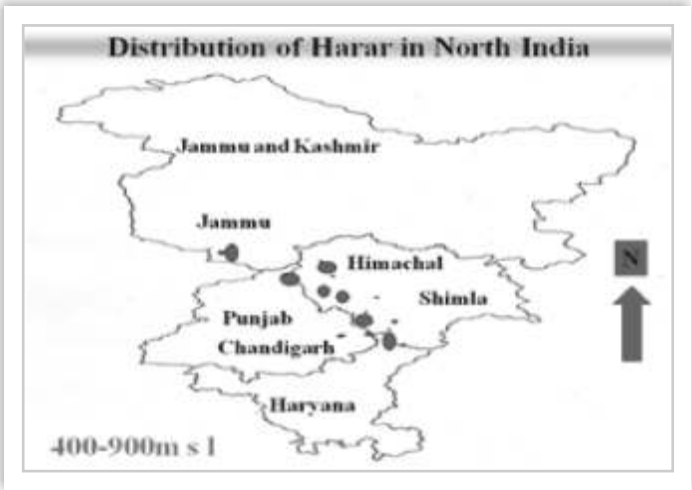
• English Name/ Trade Name :	Harad
• Common/Local Name :	Hindi: Harar, Hirda; Marathi: Anale; Tamil: Karaka; Telgu: Panga
• Family :	Combretaceae
• Part Used (s) :	Fruits

INTRODUCTION

Harar or Haritaki is an unique gift of nature to mankind. It has been given the status of mother in Ayurveda.It is called king of medicines in Tibetan system of medicines and always listed first in the *Materia Medica*. The medicine Buddha, Bhaisajyaguru is always shown with a blooming branch of Harar in his right hand which exhibits the importance of this tree as medicine. The species is prized for its fruit which has medicinal value and magical healing power. Due to several alkaloids present in fruit, it is used as laxative, purgative and astringent for curing a number of ailments. According to Ayurveda, there are seven varieties of Harar (Vijaya, Putana, Rohini, Amrita, Abhaya, Jivanti and Chetaki). The annual demand for the Harar fruit in India is 6778.4 tonnes which is growing @ 4.6 per cent annually. The quality Harar produced in northern India particularly in Himachal and Haryana is in great demand in Pakistan, Afghanistan, Iran, Iraq and other Gulf countries.

Different types of Harar

GEOGRAPHICAL DISTRIBUTION



The species is found throughout the greater part of India in mixed deciduous forests. It ascends to elevations up to 1500 meters in the outer Himalayas. In Assam, it is common in the Bhabar tract fringing the outer hills on the deep boulder formation in mixture with *Shorea robusta* and *Lagerstroemia parviflora*. In Himachal Pradesh, the species is confined to subtropical zone (400- 900 m above msl) particularly in Kangra and Sirmour districts. A sporadic distribution of Harar is also found in Hamirpur, Bilaspur, Chamba and Mandi districts. The trees are mainly found naturally in forests, grasslands or on the bunds of agricultural fields. However, with the development of new land races and vegetative propagation technology of Harar, some manmade plantations are also coming up in farmers' fields.

BOTANICAL DESCRIPTION

Harar is a moderate to large sized deciduous tree with a round crown, spreading branches and usually a short trunk. Bark dark brown, often longitudinally cracked, exfoliating in woody scales. Wood is very hard and highly durable. The hard seed coat splits in two and radical emerges from one end. The cotyledons which are convulate in the seed coat unroll emerging. Primary root is moderately long, somewhat thin and yellow turning brown. Hypocotyle is much thicker than the root. Growth of seedling is slow, a height of 8-12 inches is obtained at the end of the first season increasing to 1-2 ft by the end of second season. Stem is erect, zigzag at the nodes, green rusty pubescent, internodes 0.5-1.2 inches long. Leaves are simple, alternate, exstipulate.. The leaf fall starts in November and by Febuary - March, the trees are leafless. The new leaves appear in March - April. The spikes of greenish white flowers appear with new leaves in March-April. The plant is self-fruitful but needs the help of pollinators for pollination. In the open pollinated inflorescence, the fruit set varies from 2.23 to 9.15 per cent. The fruit ripens from November to March. The fruit is a hard drupe, 3-8 cm long, oval to ovoid, pale yellow to green yellow.

SILVICULTURAL CHARACTERS

The tree is strong light demander. It is hardy against frost and draught resistant as well. The species withstands fire and coppices very well.

USES

Harar is considered to cure all diseases and eliminate all waste from the body. At the same time, it is known to promote tissue growth and health. With its rejuvenating and cleansing properties, it is excellent for digestive system as mild, safe and efficacious laxative because of Anthraquinone. As a preventive supplement, it has antiviral attributes and strong cardio tonic properties. Juice is highly beneficial in the treatment of acidity and heartburn. The fruit of the tree is one of the ingredients of the famous Ayurvedic preparation Triphla which is considered as panacea for stomach disorders and also used in the treatment of enlarged liver. The tree is very useful in skin disorders like chronic ulcers, wounds, scalds and considered an effective hair tonic. Harar along with Aonla and Bahera is used in 219 proprietary drugs. Triphla, Liv. 52, Pilex, Chawanprash etc. are few of the formulations which contain harar.

PROPAGATION

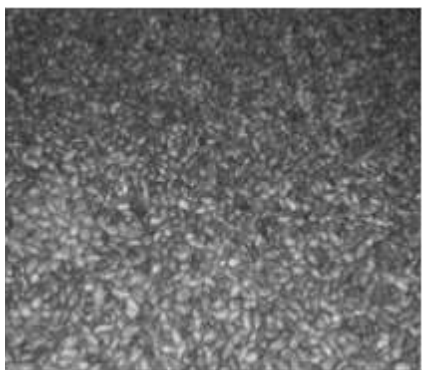
Natural Reproduction

The ripened fruits fall during January to March. The fallen fruits are partially buried by rain and the soil round them is blackened with tannin. With the time, fruit flesh is eaten by the insects (white ant) or it disintegrates leaving hard nut exposed. The seed germinates only if it is covered with soil or debris than lying on earth surface. Germination takes place in the rainy season. However, seed germination is very low, not more than five per cent. The scarcity of natural reproduction is due to hard seed coat and biotic interference particularly attack by insects, rodents, squirrels and small animals.

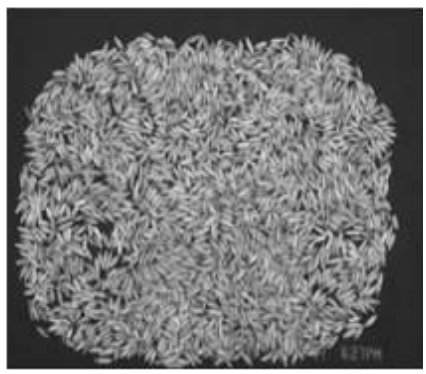
Artificial Propagation

Through seed: The fruit is collected from middle-aged trees in the month of December to January. The fleshy pulp is removed and the stones (endocarp) are dried in shade. The dried stones are stored in tin containers or gunny bags. The seed loses viability after one year, however, fresh seed should be used for sowing which gives higher germination per cent. Harar is an obstinate species to germinate because of very hard stone which hinders germination. Hence, pre-sowing seed treatment is required to break hard seed coat induced dormancy and improve the germination per cent.

Harar Fruit



Harar Stone



Harar Kernel

The seed is pretreated by the following methods;

- Cow dung scarification: Pack loosely the seed in small sized gunny bags. Keep these bags for five weeks in a heap of fresh cow dung at 2-3 feet deep in such a way so that no heat loss takes place. It helps in softening the hard seed coat, which hasten the germination of the treated seed.

  However, the germination percentage is not more than 50% by this treatment.

- Alternate wetting and drying: The seed is soaked in tap water during night and spread over cement floor in open sun during day. The process is repeated for eleven days. It helps cracking the hard seed coat without damaging the kernel inside. The maximum germination percentage, however, obtained by this method is 45%.

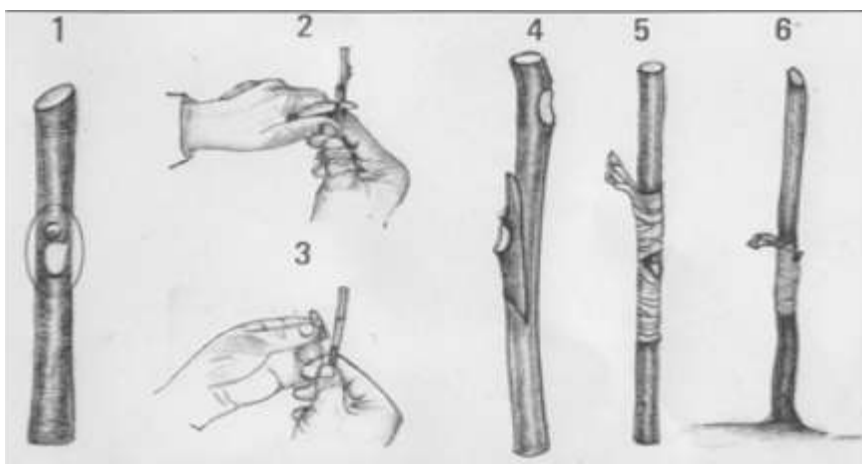
- The kernel is taken out by breaking hard stone with a hammer. The kernels are treated with Bavisitn (1gm/litre) and sown in polybags. This treatment increases the germination up to 90 %.

The pretreated seed is sown during second half of March, in 9" x 4" sized polybags filled with sand, soil and FYM in ratio of 1:1:1. The polybags are watered regularly twice a day during hot summer and weeding is done as per need. The branches arising from the base of the seedling are removed to prepare the plant for grafting/budding.

Harar nursery different stages

Through Vegetative Means

Budding/Grafting: Grafting is done on one year old plants of harar having pencil thickness. The bud wood should be taken from bearing trees of recommended strains of harar. A chip of the bark is removed from the rootstock and is replaced by another of the same size with one bud, taken from the mother tree (Ortet). The cambium layer of the bud piece should coincide with that of the rootstock. The chip with bud after insertion is wrapped immediately with plastic tape and waxed. Buds that remain green and active after some time indicate that union has taken place. Chip budding in April and July gives 65-70 per cent success. The plants raised by this method are true to type and flower just in two to three years. Another method of vegetative propagation developed recently i.e. modified side veneer grafting covering the rootstock and scion with a poly cap of two inches diameter and nine inches long just after grafting has been found highly useful for enhancing success rate up to 90 per cent. The poly cap maintains temperature and humidity thereby resulting in higher success. The sprouts arising from the rootstock are removed regularly and the bud sprouts arising from scion wood are encouraged. Maintenance of proper moisture in poly bag is very crucial factor for bud success. Hence, regular watering along with weeding is recommended.



Harar grafting different stages

Harar budding technique

Harar grafting polybag

Harar fruiting in two year old grafted plants in nursery and in pot

Recommended Strains

Five promising strains as advocated by the farmers, traders and as per evaluation by the scientists associated with the work have been identified.

- Jachh Harar-1 (JH-1): Selection from village Pragpur, Tehsil Dehra, District Kangra (H.P.). Mother tree age, height, girth, spread were 90 years, 18.0 m, 1.60 m and 16.40 x 12.30 m, respectively. Mean fruit length, diameter and dry weight is 6.53 cm, 3.23 cm and 10.35 gm, respectively. Fruit is long necked, pale yellow in colour, high quality and locally known as Koonj.

- Jachh Harar -2 (JH-2): Selection from village Kothi Harar, District Bilaspur (H.P.). Mother tree age, height, girth, spread were 250 years, 12.5 m, 2.20 m and 24.0 x 22.0 m, respectively. Mean fruit length, diameter and dry weight is 5.43 cm, 3.15 cm and 15.45 gm, respectively. Fruit is oval, light yellow with reddish tinge, high quality Murrabi type.
- Jachh Harar-3 (JH-3): Selection from village Tamber, Tehsil Palampur, District Kangra (H.P.). Mother tree age, height, girth and spread were 70 years, 22.0 m, 1.65 m and 15.0 x 13.5 m, respectively. Mean fruit length, diameter and dry weight is 5.00 cm, 3.31 cm and 10.00 gm, respectively. Fruit is oval, pale yellow, high quality Murrabi.
- Jachh Harar-4 (JH-4): Selection from Kallar, District Bilaspur (H.P.) area. Mean fruit length is 5.0 cm and diameter 2.61 cm. Fruit is necked, pale green, high quality, locally known as Koonj.
- Jachh Harar-5 (JH-5): Selection from Palluri, Sirmaur area.Mean fruit length, diameter and dry fruit weight is 6.18 cm, 3.45 cm and 16.29g, respectively. Fruit is oval, light yellow in colour, high quality Murrabi.

TRANSPLANTATION AND PLANTING DENSITY

Planting work should be started in the month of June. Pits of size 1x1x1 m^3 should be dug at a distance of 8x8 m on the land where planting is to be done. The pit size can be reduced to 60X60X60 cm^3 if the soil is deep and free from stones. The dug out soil is well exposed to sun for at least 15 days to kill harmful germs, fungi and bacteria. Fill the pit with a mixture of well rotten FYM and dug out soil after removing pebbles. Planting should be carried out after 1-2 good showers in July. Grafting point should be kept 10 cm above ground while planting. The practice reduces the incidence of collar rot.

After Care

The sprouts arising from root stock are removed regularly. Irrigation, if available is given during September- October in case of long dry spell. Watering is also done in the ensuing summer season to minimize the mortality. The basins of

the plants are kept weed free as far as possible. Newly planted saplings in frost prone areas should be covered in the month of December with straw so as to protect them against frost damage during first year. The plant should be covered properly from top and sides leaving south side open to harvest the sun.

Improved Harar plantation

HARVESTING

The fruit is harvested from August to January depending on the market demand. On an average a fully grown tree may yield up to two quintals of fruit.

MARKETING

Fruits of Harar are harvested by the farmers or sold to the traders through middlemen when on the tree itself. Fruit is marketed in two ways. During August- September, the fruit harvested in green stage is sent to Delhi, Hoshiarpur and Amritsar markets. The raw fruit is either exported to Pakistan and other foreign countries or used for making preserve by the local canning units in these cities. The remaining fruit retained by the farmer is harvested during December - January. After harvesting, the fruits are processed by roasting in sand till their colour turns golden brown and are then allowed to dry in shade on bamboo mats locally known as Keeras in Himachal Pradesh for about one month with periodic turning around to avoid fungal attack. The fruits which fall down during rainy season are also collected, processed and sold in the market as "Jangi Harar". Majority (90%) of the trees bear fruits of inferior quality. The cost of picking, grading and transportation being the same for low as well as high quality fruits, market price is far less for low quality fruits resulting in meager net returns. The fruit is collected by the owners themselves or the trees are sold to the local contractors who gather the fruit through local labour. The common practice employed by the local contractor is to buy the fruit of the tree for four to five seasons or more through onetime payment. As large number of farmers own only a very few trees, they prefer to sell the produce or the trees to local petty contractors to avoid high cost of transportation to distant markets. These petty contractors exploit these farmers by paying them very low price. The farmers do not get remunerative price as the markets for medicinal plants is not controlled by government in terms of fixation of price.

Harar Trader, farmers and scientists in farmer's orchard

In Haryana, harar is considered an agricultural produce by the government. Therefore, permission is not required for exporting the fruit out of state. In Himachal Pradesh, however, harar is regarded as minor forest product. Farmers have to obtain permission from the forest department for every lot to be transported out of state. This creates hindrance in quick transport of the green produce thereby resulting in monetary losses.


Harar trading in Mandi

ECONOMICS OF HARAR CULTIVATION

Total No. of plants at 8 x 8 m spacing	150 / ha
Production of fruit after 10 yrs	100 Kg/plant
Production of dry fruit	30 Kg/plant
Production of fruit	15.0 tonnes fresh fruit/ha 4.5 tonnes dry fruit/ha
Price	Dry fruit - Rs. 60/kg
Cost of cultivation for 10th yr	Rs. 30,000
Total returns @ Rs 60/kg	Rs. 2.70 lacs
Net Profit	Rs. 2,40,000 after 10 yrs
Production Period	5 - 80 yrs

Harar is very useful plant, however, the quality planting material of improved genotypes is available to a very limited scale and hence, manmade plantations of improved strains are not coming up at desired level. Under changing climatic scenario and threat to agriculture/horticulture from monkeys and stray cattle, plantation of harar in frost prone and animal affected areas can be a remunerative proposition. The improved strains and technology developed by University of Horticulture and Forestry, Nauni, Solan (H.P.) for nursery raising and cultivation of this species will go a long way to attract farmers back to cultivation of their abandoned lands.

REFERENCES

Alagu Lakshmanan, Manikandan,G.M. and Panneerselvam, R. (2013). Plectranthus forskohlii (Wild) Briq. (Syn: *Coleus forskohlii*) – A Compendium on its Botany and Medicinal uses. *International Journal of Research in Plant Science,* 3(4) : 72-80.

Ameer, J.B.M., Vijayakumar, A.and Selvaraju, P. (2013). Standardization of seed dormancy breaking treatment in Senna *(Cassia auriculata). Journal of Plant Breeding and Crop Science*, 5(11): 220-223.

American Cancer Society. (2000). Guide to Complementary and Alternative Methods. American Cancer Society.

Andersson, M.S., Schultze-Kraft, R., Peters, M., Tohme, J., Franco, L.H., Avila, P., Gallego, G., Hincapié, B., Ramírez, G., Lascano, C.E. (2003). Shrub legumes with adaptation to drought. In: CIAT Annual Report 2003. CIAT, Cali, Colombia, pp 99–107

Anonymous, (1950). The wealth of India (Raw material) CSIR, New Delhi, 2(c), 313.

Anonymous, (1976). Wealth of India: a dictionary of Indian raw materials and industrial products. Vol. X (Sp-W). 44-47, CSIR, New Delhi.

Anonymous. (1969). *Solanum nigrum* L. Wealth of India-Raw Material, Vol. II, CSIR, New Delhi. 391-392.

Anonymous. (1976). The wealth of India, Vol. X: sp-W (Raw material) CSIR Publication, New Delhi, 77-81

Ansari, S. H. (2006). Essential of Pharmacognosy, Birla Publication. 726.

Aruna, K. R., Raju, B., Umesha, K., Smitha, G. R. and Sreeramu, B. (2011) Integrated Nutrient Management on Growth, Yield, Quality and Economics of *Bhumyamalaki (Phyllanthus amarus)* – An Anti-jaundice Plant. *Open Access Journal of Medicinal and Aromatic Plants,* 1(2): 34-39

Atal, C. K., Gupta, O. P. and Afaq, S. H. (1975). *Commiphora mukul:* source of guggal in Indian systems of medicine. *Economic Botany,* 29(3): 209-218.

Atal, C.K., Sharma, M.L., Kaul, A. and Kajuria, A. (1986). Immuunomodulating agents of plant origin. 1: Preliminary screening; J. Ethnopharmalol. 18 133-141.

Badola, H. K. and Pal, M. (2002). Endangered Medicinal Plant species in Himachal Pradesh. *Current Science,* 83: 797-798

Begum, A. Junaithal M., Vijayakumar A. and Selvaraju P. (2013). Standardization of seed dormancy breaking treatment in Senna *(Cassia auriculata)*. *Journal of Plant Breeding and Crop Science*, 5(11): 220-223.

Behera, M. C., Mohanty, T. L. and Paramanik B. K. S. (2017). Phytochemistry and ethnopharmacy of endangered poison nut tree (Strychnos nux-vomica L.): A review. *Journal of Pharmacognosy and Phytochemistry,* 6(5): 1207-1216

Bentley, R. (2010). Medicinal plants. London: Domville- Fife Press; pp. 23–46.

Bentley, R. and Trimen, H. (1880). Medicinal Plants(eds Bentley, R. and Trimen, H.), J and A Churchill, London , 183.

Bhat, D. M., Murali, K. S., Ravindranath, N. H. (2001). Assessment of propagation techniques for forest species of the Western Ghats region of India. Forests, Trees and Livelihoods. http://dx.doi.org/10.1080/14728028.2001.9752391. 11(3):233-250.

Bhatt, A., Rawal, R. S and Dhar, U. (2007). *Effect of seed pre-treatments on germination of Swertia chirayita-a rare medicinal plant. Seed Research*, 35(1): 66-69.

Bhatt, A., Rawal, R.S. and Dhar. U. (2006). Ecological features of a critically rare medicinal plant, *Swertia chirayita,* in Himalaya. *Plant Species Biology,* 21: 49–52.

Bhattarai, K. R. and Shrestha. (1996). Ecology study on Chiraito in Northern Gorkha. *J. Net. Hist. Mus. (Nepal)*, 15: 13-16.

Bhuiya, M. R. H., Habib, A. K. M. A.and Rashid, M. M. (1977). Content and loss of vitamin C in vegetables during storage and cooking. *Bangladesh Hortic,* 5(1): 1-6.

Bhuyan, T. C. (2009), Bamboo Cultivation : An opportunity for livelihood Needs. Bamboo in North –East India, A management Guide Vol – II, Chapter – 1, pp. 1 – 14.

Billore, K. V., Audichya, K. C and Bishnupriya, D. (1987). Conservation of medicinal plants in Rajasthan with special reference to conservation and propagation of Guggulu'. *Bill. Med. Ethn. Bot. Res.*, 8(1-2): 118-127.

Bjaj, M. and Williams, J. T. (1995). Healing Forests-Healing People (report on workshop on medicinal plants, L; Calicut), IDRC, New Delhi, 62.

Budelman, A. (1989). *Flemingia macrophylla*—a valuable species in soil conservation. NFT Highlights, NFTA Hawaii, p 2

Budelman, A., Siregar, M. E. (1997). Flemingia macrophylla (Willd.) Merrill. In: Faridah Hanum I, van der Maesen LJG (eds) Auxiliary plants. PROSEA (Plant Resources of South-East Asia) No. 11. Backhuys Publishers, Leiden Netherlands, pp 144–147

Cabieses, F. (1993). Apuntes de medicina traditional. La racionalizacion de lo irracional. Notes of traditional medicine. Consejo Nacional de Ciencia Technologia Concytec Lima-Peru, 414.

Caceras, D. D., Hancke, J. L., Burgos, R. L. A., Wickman, J. K.(1997). Prevention of common cold with *Andrographis paniculata* dried extract. A pilot double blind trial. *Phytomedicine*, 4:101-104.

Calabrese, C., Berman, S. H., Babish, J. G., Ma, X., Shinto, L., Dorr, M., Wells, K., Wenner, G.A., Standish, L. J. (2000) A phase I trial of andrographolide in HIV positive patients and normal volunteers. *Phytother* Res., 14:333-338.

CAMP. (2003). CAMP (Conservation Assessment and Management Prioritization for the Medicinal Plants of J and K, H.P. and Uttaranchal), Workshop Report, Shimla, H.P., FRLHT, Bangalore, India, 206

Chang, L. C., Chavez, D., Gills, J.J., Fong, H. H. S., Pezzuto, J. M. and Kinghorn, A. D.. Rubiasins, A. C. (2000) new anthracene derivatives from the roots and stems of R*ubia cordifolia. Tetrahedron Letter,* 41 (37): 7157-7162.

Chattopadhyay, S., Srivastava, A., Bhojwani, S. S. and Bisaria, V. S. (2002). Production of podophyllotoxin by plant cell cultures of Podophyllum hexandrum in bioreactor. *Journal of Bioscience and Bioengineering,* 93(2): 215-220.

Chauhan, N. S. (1999). Medicinal and aromatic plants of Himachal Pradesh. Indus Publishing. 500

Chen, Shi-Lin, Hua, Yu, Hong-Mei, Luo, Qiong, Wu,Chun-Fang Liand Andre ,Steinmetz. (2016). Conservation and sustainable use of medicinal plants: Problems, progressand prospects. *Chinese Medicine,* 11(1): 37.

Chenniappan, K. and Kadarkarai, M. (2010). "In vitro antimalarial activity of traditionally used Western Ghats plants from India and their interactions with chloroquine against chloroquine-resistant Plasmodium falciparum," *Parasitology Research,* 107, 6: 1351-1364.

Chevallier, A.(2000). Encyclopedia of Herbal Medicine: Natural Health, Second ed. Dorling Kindersley Book, USA, 336 .

Chinthana, T. A. (2012). Protective effect of *Solanum nigrum* and *Solanum trilobatum* aqueous leaf extract on Lead induced neurotoxicity in Albino mice. *Journal of Chemical* and *Pharmaceutical Research,* 4(1): 7.

Chitra, R., Rajamani, K. and Vadivel, E. (2009). Regeneration of plantlets from leaf and internode explants of *Phyllanthus amarus Schum.* and Thonn. *African Journal of Biotechnology,* 8 (10): 2209-221.

Chopra, R.N, Nayar, S.L.and Chopra I.C. (1956). Glossary of Indian medicinal plants. New Delhi: CSIR, 125–126.

Clarke, C. B. (1885). The Flora of British India, *Vol. IV, Hooker, J.D. (ed) L. Reene and Co., London,* 780

Dahiya Kheem Singh. (2016). Medicinal Values of Tanner's Cassia *(Cassia auriculata Linn.) – Madhav Research and Review. A Multidisciplinary International Journal*, Vol-1. No. 2.

Damle, (2014). Thesis of Indira Gandhi krishi vishwvidhalaya raipur.

D'Arcy, W.G. (1991). The Solanaceae since 1976, with a review of its biogeography. In lG. Hawkes, R.N. Lester, M. Nee and N. Estrada-R. (eds.), Solanaceae III: Taxonomy, Chemistry, Evolution, 75-137.

Darshan, S. and Ved, D. K. (2003). A balanced perspective for management of Indian Medicinal Plants. Ind. For, 275-288.

Defelice, M. S. (2003). The black nightshades, *Solanum nigrum* L.. Poison, poulticeand pie. *Weed Technology,* 17:421-427.

Dev, S. (2006). A selection of Prime Ayurvedic plant drugs Ancient-Modern Concordance. New Delhi, Anamaya publishers;

Dhale, D.A and Kalme, R.K. (2012). Pharmacognostic Characterization of stem and root of *Adhatoda zeylanica* Medicus. *Int J Pharm Sci Res.*, 3(11): 4264-4269.

Dhar, U. and Kachroo, P. (1983). Alpine Flora of Kashmir Himalaya. Scientific Publishers, Jodhpur, India

Dilip, K. J., Saroja, K. A.and Murthy, R.V.(2012). Pharmacognostic study of kakamachi *(Solanum nigrum linn): Journal of pharmaceutical and scientific innovation,* 1(4) : 4.

Elumalai, A. and Chinna, M. E. (2011). A pharmacological review on garcinia indica choisy. *International Journal of Universal Pharmacy and Life Sciences,* 1(3).

Farooqi, A. Aand Sreeramu, B .S .(2004). Cultivation of Medicinal and Aromatic Crops (Revised Edition), Universities Press. Hyderabad.

Firake, D. M., Venkatesh, A., Firake, P. D, Behere, G. T. and Thakur, N. S. A. (2013). *roxburghii*: an underutilized

Gabrielian, E. S., Shukarian, A. K., Goukasova, G. I., Chandanian, G. L., Panossian, A. G., Wikman, G.and Wagner, H. (2002). A double blind, placebo-controlled study of *Andrographis paniculata* fixed combination Kan Jang in the treatment of acute upper respiratory tract infections including sinusitis. *Phytomedicine,* 9(7), 589-597.

George, W. (1892). The Commercial Products of India. London: George Bell and Sons Publisher.

Godefroy, J., (1988). Observations de l'enracinement du stylosanthes, de la crotalaire et du flémingia dans un sol volcanique

Grivetti, L. (1976). Dietary resources and social aspects of food use in a Tswana tribe. PhD Dissertation Department of Geography, University of California, Davis.

Gruenwald, J., Freder, J., Armbruester, N. (2010) Cinnamon and health. *Crit Rev Food Sci Nutr.* 50:822–834. doi: 10.1080/10408390902773052.

Grusla, D., Holzl, J. and Kriegstein, J. (1986). Effect of valerian on rat brain. Dtsch. *Apoth. Ztg,* 126: 2249-2253.

Guo, R., Wang, T., Zhou, G., Xu, M., Yu, X., Zhang, X., ... and Wang, Z. (2018). Botany, phytochemistry, pharmacology and toxicity of Strychnos nux-vomica L.: a review. *The American journal of Chinese medicine*, 46(01): 1-23.

Gupta, A. K., Sharma, M.(2007). Reviews on Indian Medicinal Plants. Vol.5, Medicinal Plants Unit ICMR, New Delhi, 620

Gupta, L. M., Rana, R. C., Raina R. and Gupta Meenakshi. (2005). Colchicine contents in Gloriosa *superba* L. *SKUAST-J,* 4: 238-241.

Guruprasad, C. Nille, K. R. C. Reddy (2015). A Psychopharmacological Review of Plant – *Cassia auriculata. International Journal of Pharmaceutical and Biological Archives,* 6 (6): 1 –9.

Hanson, J., Maass, B.L. (1997). Conservation of tropical forage genetic resources. Proceedings of the XVIII International Grassland Congress, 8–19 June 1997, Winnipeg, Saskatoon, Canada. The Canadian Forage Council, the Canadian Society of Agronomy and the Canadian Society of Animal Science, Calgary, Alberta, Canada, pp 31–35

Haroon, K., Murad, A. K.and Iqbal, H. (2008). Enzyme inhibition activities of the extracts from rhizomes of *Gloriosa superba* Linn (Colchicaceae). *Journal of enzyme inhibition and medicinal chemistry,* 22 (6): 722-5.

Helen, A., Foluso, O.A.and Olutayo, F. (2018). Propagation of Black Nightshade *(Solanum nigrum L.)*: Effect of Light and Shade. European Journal of Experimental Biology, 8(3) : 19.

Henderson, R. J. F. (1974). *Solanum nigrum* L. (Solanaceae) and related species in Australia. Contributions from the Queensland Herbarium.

Hill, A. W. (1917). The Genus Strychnos in India and the East. Bulletin of Miscellaneous Information, Royal Botanic Garden, *KEW.*4/5:121-210.

Hussain, T. M., Chandrasekhar, T.and Gopal, G. R. (2007). High frequency shoot regeneration of Sterculia urens Roxb. an endangered tree species through cotyledonary node cultures. *African Journal of Biotechnology,* 6(14) : 1643-1649.

Inchem.(2004).http://www.inchem.org/documents/pims/plant/pim245.htm.

Jain, A., Katewa, S. S., Galav, P. K.and Sharma, P. (2005). "Medicinal plant diversity of Sitamata wildlife sanctuary, Rajasthan, India," *Journal of Ethnopharmacology,* 102 (2): 143-157.

Jakhetia, V., Patel, R., Khatri, P. (2010). Cinnamon: a pharmacological review. *Journal of Advanced Scientific Research,* 1(2):19–12.

Jansen, P. C. M., 2005. *Senna auriculata* (L.) Roxb. In: Jansen, P.C.M. and Cardon, D. (Editors). PROTA Plant Resources of Tropical Africa / Resources végétales de l'Afrique tropicale), Wageningen, Netherlands. Accessed 11 April 2019.

Jayram, K. and Prasad, M. N. V. (2008) Selection of Superior Quality Germplasm of *Oroxylum indicum*- an endangered species" (Completed project DST of NWFPs Division, FRI) *Afr. J. Biotechnol,* 7(3): 254-262.

Jia, Q., Hong, M. F and Minter, D. (1999). Pikuroside: a novel iridoid from Picrorhiza kurroa. *Journal of natural products,* 62(6),: 901-903.

Joshi, K., Joshi, R. and Joshi, A.R. (2011). Indigenous knowledge and uses of medicinal plants in Macchegaun, Nepal. Indian Journal of Traditional knowledge 10: 281-286.

Joshi, P. and Dhawan, V. (2005). *Swertia Chirayita* – an overview. *Current Science.* 89(4): 635-640.

Kala, C. P, Dhyani, P.P. and Sajwan, B. S. (2006). Developing the medicinal plants sector in northern I ndia: Challenges and opportunities. *Journal of Ethnobiology and Ethnomedicine,* 2: 1-15.

Kala, C. P. (2005). Indigenous uses, population density and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. *Conservation Biology,* 19:368- 378.

Kala, C. P. and Sajwan, B. S. (2007). Revitalizing Indian systems of herbal medicines by the National Medicinal Plants Board through institutional networking and capacity building. *Current Science.* 93(6),:797-806.

Kanokwan, J. and Nobuo, N. (2008). Pharmacological aspects of Andrographis paniculata on health and its major diterpenoid constitute andrographolide. *J of Health Sci.*, 54 (4): 370-381.

Kapoor, L. D. (2001). Handbook of Ayurvedic Medicinal Plants. Boca Raton, Fla, USA: CRC Press. 416-7.

Kavitha, C., Rajamani, K. and Vadivel, E. (2009). *Coleus forskohlii:* A comprehensive review on morphology, phytochemistry and pharmacological aspects. *Journal of Medicinal Plants Research,* 4(4) : 278-285.

Khan, B. A., Akhtar, N., Anwar, M., Mahmood, T., Khan, H., Hussain, I. and Khan, K.A. (2012). Botanical Description of *Coleus forskohlii:* A Review. *Journal of Medicinal Plants Research,* 6(34): 4832-4835.

Khan, M. I., Ahmed, A., Akram, M., Mohiuddin, E., Usmanghani, K. and Shah, S.M. (2010). Monograph of Embelia ribes Burm. *f. Plant Science,* 4: 503-505.

Khare, C.P. (2007). Indian Medicinal Plants, An Illustrated Dictionary, Springer International,18.

Khatun, S. (2012). Management of fusarial wilt of the medicinal plant *Coleus forskohlii*_Willd_Briq, Doctoral thesis. The University of Burdwan.

Khuraijam, J.S. and Huidrom, Deepak. (2013). Ethno botanical uses of medicinal plant, *Justicia adhatoda* L. by Meitei community of Manipur, India. *Journal of Coastal Life Medicine,* 1: 322-325.

Kirtikar, K. R. and Basu, B. D. Eds. (1984). Indian medicinal plants. Vol. 3. Allahabad ,1664-1666.

Kirtikar, K.R., Basu, B.D. (1991). Indian Medicinal Plants. Vol. 3. Bishen Singh Mahendra pal Singh Publisher: Dehradun, India., 629-630.

Kuete, V. (2014). Physical, Hematologicaland Histopathological Signs of Toxicity Induced by African Medicinal Plants. *Toxicological Survey of African Medicinal Plants,* 635-657.

Kumar, A. (1990) Regeneration of forest tree *Strychnos nux vomica* L. through tissue culture. Indian *Journal of Forestry,*13(3): 263-265.

Kumar, A., Datta, S.K. (1989). Plantlet regeneration from hypocotyl tissue of Strychnos nux-vomica Linn. *Current Science,* 58(14): 812-813.

Kumar, B., Verma, S. K.and Singh, H. P. (2011). Effect of temperature on seed germination parameters in Kalmegh (Andrographis paniculata Wall. ex Nees.). *Industrial Crops and Products,* 34(1): 1241-1244.

Kumar, V. (2016). Gum karaya (*Sterculia urens* Roxb.): A potential gum tree. Van Sangyan, 3: 10. 34.

Kurian, A. (1999). Final Report of the ICAR Adhoc Project "Evaluation and selection of Medicinal Plants Suitable for a Coconut Based Farming System', Kerala Agriculture University, Vellanikkara, Thrissur.

Lokesh, B., Deepa, R. and Divya, K.(2018). Medicinal Coleus *(Coleus forskohlii Briq)*: A phytochemical crop of commercial significance – Review. *Journal of Pharmacognosy and Phytochemistry,* 7(5) : 2856-2864.

Mahishi, P., Srinivasa, B. H. and Shivanna, M. B. (2005). "Medicinal plant wealth of local communities in some villages in Shimoga District of Karnataka, India," *Journal of Ethnopharmacology,* 98 (3): 307–312.

Maikhuri, R. R., Kottapalli, C., Kinjalben, K. L. S., Pratti P.and Chandrasekaran, R. (2003). Development of marketing of medicinal plants and other forest products - Can it be a pathway for effective management and conservation. pp.169-178.

Mamgain, S. K., Goel, A. K. and Sharma S. C. (1998). Conservation of assessment of some important threatened medicinal plants of India. *J. Non-Timber Fore. Prod,* 5: 1-9

Mastiholi, Anand.B. (2008). Effect of spacing, time of harvest and NPK levels on growth, yield and quality of medicinal coleus *(Coleus forskohlii briq.)* under irrigated condition.

Mishra, C. and Rawat, G. S. (1998). Livestock grazing and biodiversity conservation: comments on Saberwal. *Conservation Biology,* 12(3): 712-714.

Mishra, S. K., Sangwan, N. S.and Sangwan, R. S. (2007). Phcog Rev.: Plant Review *Andrographis paniculata* (Kalmegh): A Review. Pharmacognosy Reviews, 1(2): 283-298..

Morton, J. F.(1981). Atlas of Medicinal Plants of Middle America. Library of Congress Cataloguing in Publication Data. Thomas books, 1420.

MPRI. (1999). Medicinal Plant Research Institute, Department of Medical Science, Ministry of Public Health. Standard of Thai Herbal Medicine: Andrographis paniculata (Burm. f.) Nees. The War Veterans Organization Press, Bangkok. pp. 66. (Thai language).

Nadkarni, A. K: Indian Materia Medica. 3rd ed. Bombay: *Popular prakashan;* 2000.

Naik, K. G., Shah, C. C.and Pandya, H. G. (1951). Ascorbic acid content of some common fruits and vegetables available in Gujarat. I. Vitamin 'C' content and their stability. *Journal of the University of Bombay,* 19: 51-58.

Nanden, A. T. (1998). Medicinale planten: tips en simpele recepten voor eengoede gezondheid. In: Medicinal Plants and Simple Recipes for a Good Health. *Paramaribo-Suriname,* 18.

Nandhini, T. (2013).Genetic diversity studies in Makoi (Solanum nigrum l.) genotypes. Doctoral Thesis. Tamil Nadu Agricultural University, Coimbatore.

Nandkarni, K. M. and Nandkarni, A. K. (2000). Indian Materia Medica, Vol-I, Bombay Popular Parkashan,40.

Nautiyal, M. C. and Dhyani, P. P. (1994). Effects of auxins on rooting of stem cuttings of two Aconitum species at two altitudes. *Indian J. For, 17(*1): 58-60.

Naz, A., Umesha, K., Smitha, Gr. and Chandre Gowda, M. (2011). Standardization of post harvest practices in *Makoi (Solanum nigrum L.), Journal of Medicinal and Aromatic Plant Sciences* 33(4): 435-438.

Negi, A. and Gurung, D. (2009). Post harvest treatment of bamboo for durability enhancement. Bamboo in North –East India, A management Guide Vol – II, Chapter – 7, pp. 59– 78.

Neuwinger, H. D. (1994). African ethnobotany. Poisons and drugs. Chemistry, Pharmacology, Toxicology. Chapman and Hall, Weinheim.

Niranjan, A., Tewari, S. K.,Lehri, A., (2010). Biological activities of Kalmegh (Andrographis paniculata Nees.) and its active principles- a review. *Indian J. Nat. Prod. Resour,* 1: 125-135.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Anthony, S. (2009). Agroforestree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya.

Pandey, A. K. and Das R. (2013). Good field collection practices and quality evaluation of medicinal plants: prospective approach to augment utilization and economic benefits. *Reaserch Journal of Medicinal Plant.* ISSN 1819-3455/DOI: 10.3923/rjmp.2013.

Pant, S. R. and Bimb, H. P.(2005). Morphological variation in *Swertia nervosa* (G. Don) C. B. Clarke of Nepal. *Nepal Journal of Plant Sciences,* 1:78–82.

Patel, D. K. (2016). Vegetative Propagation of *Coleus forskohlii* (Wild) Briq using their Stem Cutting for Ex-situ Conservation in Herbal Garden. *Medicinal and Aromatic Plants,* 5: 261.

Patel, J. R., Tripathi, P., Sharma, V., Chauhan, N. S. and Dixit, V. K.(2011). "Phyllanthus amarus: ethnomedicinal uses, phytochemistry and pharmacology: a review," Journal of Ethnopharmacology, 138 (2): 286-313.

Pattanaik, S., Pathak, K. C., Trivedi, S., Khatri, P. K. and Prasad, K. G. (2002). Cohort mapping in bamboo resource management. Proceeding of Expert consultation on strategies for sustainable utilization of bamboo resources subsequent to gregarious flowering in north east on 24 -25 April, 2002, pp 11-17

Phondani, P. C., Negi, V.S and Bhatt I. D. (2011). Promotion of medicinal and aromatic plants cultivation for improving livelihood security: a case study from West Himalaya, India. *International Journal of Medicinal and Aromatic Plants,* 1:245- 252.

Pradhan, B. K and Badola, H. K.(2010). Chemical stimulation of seed germination in ex-situ produced seeds in Swertia.

Prajakta, J., Kiran, B.and Vijayalakshmi, P. (2015). Phytopharmacological Review on Garcinia indica. *International Journal of Herbal Medicine,* 3(4): 02-07.

Prajapati N.D., Purohit, S.S., Sharma, A.K.,and Kumar, T. (2003). A Handbook of Medicinal Plants, Agrobios Publishers, India, 162 .

Prasad, R. and Bhattacharya, P. (2003). Sustainable harvesting of medicinal plant resources. In S.B. Roy, ed. Contemporary studies in natural resource management in IndiaNew Delhi, India, Inter-India Publications. pp. 168–198.

Promto, H. C., Sanguensubpayakorn, Y., Phisuksanthiwattana. (1997). Effect of cultivation and distance of cultivation on quality and production of Andrographis paniculata. *J. Herbal.* 4: 31-40. (Thai language).

Pulliah, T., Rani, S. S. (2011). Flora of Eastern Ghats, Regency Publication. New Delhi. India. 4,135-139.

Punkambekar, S. V. (1947). Effect of storage on the alkaloidal content of Strychnos nuxvomica seeds. *Current science,*16(11): 346

Raghu, A. V., Geetha, S. P., Martin, G., Balachandran, I. and Ravindran, P. N. (2006). Direct shoot organogenesis from leaf explants of Embelia ribes Burm. f.: a vulnerable medicinal plant. *Journal of Forest Research,* 11(1): 57-60.

Rai, L. K., Prasad, P. and Sharma, E. (2000).*Conservation threats to some medicinal plants of the Sikkim Himalaya. Biol. Conserv.,* 93: 27-33

Raina, R., Patil, P., Sharma, Y. P and Rana, R. C. (2013). Reproductive biology of Swertia chirayita-a temperate critically endangered medicinal plant. *Caryologia: International Journal of Cytology, Cytosystematics and Cytogenetics,* 66(1): 12-20

Rajakumar, N. and Shivanna, M. B. (2009). "Ethno-medicinal application of plants in the eastern region of Shimoga district, Karnataka, India," *Journal of Ethnopharmacology,* 126(1): 64-73

Rajamani, K. (2015). Medicinal plants production towards globalization. 107-111.

Rajkumar, V., Guha, G. and Kumar, R. A. (2011). Antioxidant and anti-neoplastic activities of Picrorhiza kurroa extracts. *Food and Chemical Toxicology,* 49(2), 363-369.

Rammohan, S., Asmawi, M. Z., Sadikun, A. (2011). A bitter plant with a sweet future? A comprehensive review of an oriental medicinal plant: *Andrographis paniculata. Phytochem rev.,* 10: 1007/s11101-01109219.

Rao, K. S, Semwal, R. L, Maikhuri, K. S., Nautiyal S. R., Singh K. K., Chandrasekhar K. K. and Saxena K. G.(2003).Indigenous ecological knowledge, biodiversity and sustainable development in the central Himalayas, *Tropical Ecology,* 44(1): 93-111.

Rao, M. J. P and Giri, A . (2010). Antimicrobial activity of the extract of Salacia oblonga Wall. *Recent Research in Science and Technology,* 2(10): 01-04.

Rao, M. R., Palada, M. C. and Becker, B.N. (2004). Medicinal and aromatic plants in agroforestry systems, *Agroforestry Systems,* 61: 107–122.

Rao, P. V., Gan, S. H. (2014) *Cinnamon: a multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine.* Cinnamon: a multifaceted medicinal plant. Evidence-Based Complementary and Alternative Medicine.

Rayudu, (2003). Forests are a source of life: for the planetand for its people. In world forestry congress Québec, Canada.

Reddy, C. S., Meena, S. L., Krishna, P. H., Charan, P. D.and Sharma, K. C. (2012). Conservation threat assessment of Commiphora wightii (Arn.) Bhandari-An economically important species. *Taiwania,* 57(3): 288-293.

Rema, J., Krishnamoorthy, B. and Mathew, P. A. (1997). Vegetative propagation of major tree spices, a review. *Journal of Spices and Aromatic Crops,* 6 (2): 87-105.

Ridout ,C. L., Price, K.R., Coxon, D.T.and Fenwick ,G.R. (1989). Glyco-alkaloids from *Solanum nigrum* L. alpha solamargine and alpha solasonine. *Pharmazie,* 44 (10): 732-733.

Ross, I. A. (2005). Medicinal plants of the world, Volume-3: Chemical constituents, traditional and modern medicinal uses. New Jersey: Humana Press Inc. pp: 110–32. 10.

Sailo, G. and Bagyaraj, D. (2005). Influence of different AM-fungi on the growth, nutrition and forskolin content of *Coleus forskohlii. Mycological Research,* 109(7): 795-798.

Sala, A.V. (2010). Indian Medicinal Plants, Universities press Private Limited,; 5: 84-87.

Samant, S. S., Dhar, U. and Palni, L. M. S. (1998). Medicinal plants of Indian Himalayas: diversity, distribution and potential values. *Himavikas Publication No. 13. Almora, Uttaranchal, India: GB Pant Institute of Himalayan Environment and Development.*

Samuel, J. K. and Andrews, B. (2010). "Traditional medicinal plant wealth of Pachalur and Periyur hamlets Dindigul district, Tamil Nadu," *Indian Journal of Traditional Knowledge,* 9(2): 264-270.

Samy, R. P, Thwin, M. M., Gopalakrishnakone, P., Ignacimuthu, S. (2008). Ethnobotanical survey of folk plants for the treatment of snake bites in southern part of Tamilnadu. India. *J. Ethnopharmacol.* 115:302-312.

Samy, R. P., Pushparaj, P. N. and Gopikrishnakone, P. A. (2008). "Compilation of bioactive compounds from Ayurveda," *Bioinformation,* 3 (3):00-110.

Sanjutha, S., Subramanian, S., Indu Rani, C. and Maheswari, J. (2008). Integrated Nutrient Management in Andrographis paniculata. *Research Journal of Agriculture and Biological Sciences,* 4: 141-145.

Sankaran, K. V., Rahman, M. U.and Zachariah, S. (1980). Leaf spot disease of Strychnos nux-vomica caused by Colletotrichum gloeosporioides in south India. *Plant disease,* 64(10): 953-954.

Sarma, H. and Sarma, A. (2011). *Solanum nigrum* L., a nutraceutical enriched herb or invasive weed? *International Conference on Environment and BioScience* (IPCBE) 21, 105- 109.

Scartezzini, P. and Speroni, E. (2000). Review of some plants of Indian traditional medicine with anti-oxidant activity. *J. Ethnopharmacol.*71: 23-43.

Sen, A., Sharma, M.M., Grover, D. and Batra, A.(2009). *In Vitro* Regeneration of *Phyllanthus amarus* Schum. and Thonn.: An Important Medicinal Plant. *Our Nature,*7: 110-115.

Setia, A., Goyal, S.and Goyal, N. (2010). Applications of gum karaya in drug delivery systems: a review on recent research. *Der Pharmacia Lettre*, 2(5): 39-48.

Shah, B. and Seth, A.K. (2010). Textbook of Pharmacognosy and Phytochemistry, Elsevire,p. 525.

Shah, I. A, Sharma, Y. P, Raina, R. and Rana, R. (2011). Pollination studies in Swertia chirayita-A Critically Endangered Medicinal Plant of Western Himalayas. *Open Access Journal of Medicinal and Aromatic Plants,* 2(2): 14-17.

Shah, J. J. (1983). Gum-resin and gum-resin secretion in plants, *Acta Botanica, India,* 11:91-96.

Shankar, D.and Majumdar, B. (2005). Beyond the Biodiversity Convention: the challenges facing the biocultural

Shanmugam, S., Maniknandan, K.and Rajendran, K. (2009). "Ethnomedicinal survey of medicinal plants used for the treatment of diabetes and jaundice among the villagers of Sivagangai District, Tamil Nadu," *Ethnobotanical Leaflets,* 13(1): 189-194.

Sharma, P. C., Yelne, M. B. and Dennis, T. J. (2002). Database on medicinal plants used in Ayurveda. CCRAS 478–489.

Sharma, S. and Singh, J. (2014) Atish, Choura, vankakri ki kheti. HFRI Booklet under NMPB project,7-8

Sharma, S., Negi, P. S. and Rajsekharan (2008). Kadu ki kheti. *HFRI Booklet.* 036

Sharma, S., Negi, P. S. and Thakur, K. S. (2014).Mushkbala, ek Bahupyogi Jadi- Booti. HFRI Phamphelet under NMP.

Sheeja, K., Kuttan, G. (2007) Activation of cytotoxic T lymphocyte responses and attenuation of tumor growth In vivo by *Andrographis paniculata* extract and andrographolide. *Immunopharmacol Immunotoxicol,* 29: 81-93.

Shelton, H. M. (2001). Advances in forage legumes: shrub legumes. Proceedings of the XIX International Grassland Congress, 11–21 February 2001, São Pedro, São Paulo, Brazil. The Brazilian Society of Animal Husbandry, Piracicaba, São Paulo, Brazil, pp 549–556

Shivanna, K. R. (2009). Pollination biology, breeding system and reproductive success of Adhatoda vasica, an important medicinal plant. *Current Science,* 96 (3): 10.

Shreshtha, J. N. and Joshi, S. D. (1992). Tissue culture techniques for medicinally important herbs– Orchis incarnate and *Swertia chirayita. Bank Janak,* 3(3): 24–26.

Shrivastav, J. L. and Pahapalkar, M. K. (1997). Cultivation trials on satavar in Mandla district of Madhya Pradesh. *Vaniki-Sandesh,* 21 (2): 24-23.

Singh, A. K. (2006). Flowering crops: cultivation and management. New Delhi: New India Publishing Agency, 167–76.

Singh, N. T. and Singh, K. N. (2017). Revisiting Imported Yongchak: An overview. *Global Academic Research Journal,* 5 (1): 24-28

Singh, S. K., Patel, J. R., Dangi, A., Bachle, D. and R. K. Kataria. (2017). A complete over review on *Adhatoda vasica* a traditional medicinal plants. *Journal of Medicinal Plants Studies,* 5(1): 175-180.

Singha, B. L. and Borah, R. K. (2017). Traditional methods of post harvest bamboo treatment for durability enhancement. *International journal of Scientific and Engineering research,* 8 (1), pp. 518 -522.

Sinha, A. (2015). Studies on Pollarding and Propagation in Kusum for Lacs Cultivation. Project Completion Report submitted at Institute of Forest Productivity, Ranchi. 79 p.

Siva, R. and Krishnamurthy K.V. (2005). Isozyme diversity in *Cassia auriculata L. - African Journal of Biotechnology,* 4 (8): 772-775.

Srivakumar, G. and Krishnamurthy,K.V. (2002). *Gloriosa superva L.* - a very useful medicinal plant. In: Singh, V.K., J.N. Govil, S. Hashmi and G. Singh (eds). Resent progress in Medicinal Plants, Vol.7. Ethomedicine and Pharmacognosy, Part II. Texas : Series Sci Tech. Pub II. Texas, U.S.A.

Sivakumar, V., Anandalakshmi, R., Warrier, R. R., Tigabu, M., Odén, P. C., Vijayachandran, S. N., ... and Singh, B. G. (2006). Effects of presowing treatments, desiccation and storage conditions on germination of Strychnos nux-vomica seeds, a valuable medicinal plant. *New Forests,* 32(2): 121-131.

Somashekhar, B. S. and Sharma M. (2002). Training manual on Propagation Techniques of Commercially Important Medicinal Plants: Prepared for Andhra Pradesh State Forest Department. Foundation for Revitalisation of Local Health Traditions (FRLHT), Bangalore.

Sutare Manisha and B.M. Kareppa. (2009). Studies on utility of *Adhatoda zeylanica* Medic. *Asian Journal of Bio Science,* 4 (2): 304-306.

Suthar, M., Patel, R., Hapani, K. and Patel, A. (2009). Screening of Embelia ribes for Antifungal Activity.International *Journal of Pharmaceutical Sciences and Drug Research,* 1(3): 203-206.

Suwanbareerak, K. And C. Chaichantipyuth. (1991). Num-Lai-Pung-Pornandrographis paniculata. *J. Med. Pla. Thailand Soc.,* 7(1): 3-9.

Sydow, H. and Butler, E.J. (1911). Fungi Indiae Orientalis.Pars-III. *Ann. Mycol,* 9 , 372-421.

Tewari, D. N. (2000). Report of the Task Force on Conservation and Sustainable use of Medicinal Plants. Government of India Planning Commission , India

Thantsin, K., Zhang, Q., Yang, J., Wang, Q. (2008) Composition of semivolatile compounds of 10*Cinnamomum* species from China and Myanmar. *Q Nat Prod Res,* 22: 576–83.

Tirimana, A.S.L.(1987). Medicinal Plants of Suriname. Uses and Chemical Constituents. Chemical Laboratory, Ministry of Agriculture, Animal Husbandry and Fisheries, Suriname, 92 .

T

Udayan, P. S., Tushar, K. V. and George *et al.*,S.(2007). “Ethnomedicinal information fron Kattunayakas tribes of Mudumalai Wildlife Sanctuary. Nilgiris district, Tamil Nadu,” *Indian Journal of Traditional Knowledge,* 6: 574-578.

Umesha K., S.P. Soumya, G.R. Smitha and B.S. Sreeramu. (2011). Influence of organic manures on growth, yield and quality of *makoi (Solanum nigrum L.). Indian J. Hort.,* 68(2):235-239.

Unander, D.W., Webster, G.L.and Blumberg, B.S.(1995). Usage and bioassays in *Phyllanthus* (Euphorbiaceae) IV. Clustering of antiviral uses and other effects. *Journal of Ethnopharmacology,* 45:1–18.

Upadhyay, B., Parveen, P., Dhaker, A. K.and Kumar, A. (2010). “Ethnomedicinal and ethnopharmaco-statistical studies of Eastern Rajasthan, India,” *Journal of Ethnopharmacology,* 129(1): 64-86.

Vanangamudi, K., Natarajan, K., Saravanan, T., Natarajan, N., Umarani, R., Bharathi, A., Srimathi, (2006). *Advances in seed science and Technology,* 3:162-163.

Vangalapati, M., Sree Satya, N., Prakash S. D., Avanigadda, S. (2012). A review on pharmacological activities and clinical effects of cinnamon species. *Research Journal of Pharmaceutical, Biological and Chemical Sciences.* 3(1): 653–663

Ved, D. K. and Goraya, G. S. (2007). Demand and Supply of Medicinal Plants in India. NMPB, New Delhi and FRLHT, Bangalore, India.

Verma, A., Kumar, B., Alam P., Singh V. and Kumar S. G. (2016). Rubia cordifolia – a review. *Pharmaconosy and Phytochemistry,* 7(7): 2720-2731

Victor, A. D. D., Prasad, M. P. N., Mohana, S. S. (2016). Biological active compounds with various medicinal values of *Strychnos nux-vomica*- A Pharmacological summary. *J Global Trends Pharm Sci.,* 7(1):3044-3047.

Wagner, H., Jurcic, K. and Schaette, R. (1980). Comparative studies on the sedative action of Valeriana extracts, valepotriates and their degradation products (author's transl). *Planta medica,* 39(4):358.

Warrier, P. K, Nambiar, V. P. K. and Ramankutty, C. (1995) Indian Medicinal Plants vol. 3 (editor Arya Vaidua Sala, Kottakkal), Orient Longman, 76–81.

Webster, G. L. (1994). Synopsis of the genus and suprageneric taxa of Euphorbiaceae. *Annals of the Missouri Botanical Garden,* 81:33–144.

Xavier, J. R., Gnanam, R., Murugan, M. P. and Pappachan, A. (2012). Clonal propagation of Phyllanthus amarus: A hepatoprotector. *Pharmacognosy magazine,* 8(29):78–82.

Yadav, B. B. Billore, K.V., Joseph, T.G.and Chaturvedi, D. D. (1999). Cultivation of Guggulu. CCRAS, New Delhi.

Yulianti, Nani., Edi, Santosa. and Anas Dinurrohman, Susila. (2018). Production of Fruits and Leafy Vegetables Solanum nigrum Linn under Different Shade Levels, *Journal of Tropical Crop Science,* 5 : 2.

Zhao, S. M., Kuang, B., Fan, J. T., Yan, H., Xu, W.Y. and Tan, N.H.(2011). Antitumor cyclic hexapeptides from Rubia plants: history, chemistryand mechanism (2005–2011) CHIMIA *International Journal of Chemistry,* 65(12): 952–956.

Angelica glauca

Aconitium heterophyllum

Mature plant of Kutki

Macro-proliferated Propagules in Sand

Macro-proliferated Propagules

Raising of Kutki in Polyhouse

Intercropping of Kutki with Apple

Podophyllum hexandrum

Mature Plant of Mushkbala

Macro-proliferated Propagules obtained from Single Mature Plant

Macro-proliferated Propagules in the Nursery

Intercropping of Mushkbala with Apple

IFB, Hyderabad

Steculia urens tree in natural habitat

Strychnos nux-vomica L. branch with fruit

IWST, Bengaluru

Ailanthus malabarica

Rubia cordifolia

IFP, Ranchi

Grafting in *Schleichera oleosa*

TFRI, Jabalpur

Asparagus racemosus Plant

Roots of *A. racemosus*

Calamus khasianus

C. flagellum

C. gracilis

Daemonorops jenkinsianus

Mature seeds of *C. gracilis*

Mature seeds of *C. khasianus*

Seedlings of *Calamus nambareinsis*

Seedlings of *C. khasianus*

Parkia timoriana

Green Pod of *Parkia timoriana*

Germination of seed in root-trainer

Seedlings in polybags

Yellowing of leaves

Die back of twigs

Blisters on the bark of parkia

Die back and Blisters of Parkia

Indarbela quadrinotata

Coptops aedificator insect infestation in Parkia tree

Thysanolena maxima (Broom Grass)

Cultivation of broom grass in Meghalaya

Swertia chirayita

Swertia chirayita plant

Different types of Harar

Harar nursery different stages

Harar grafting different stages

Harar fruiting in two year old grafted plants in nursery and in pot

Jachh Harar-1 (JH-1)

Jachh Harar-2 (JH-2)

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