



सत्यमेव जयते

# Agro - Techniques of Selected Medicinal Plants

Volume-IV

*Compiled and Edited by:*

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and

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## NATIONAL MEDICINAL PLANTS BOARD

Ministry of Ayush

Government of India

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**Name of Medicinal Plants on Cover Page :**

1. *Phyllanthus emblica* Linn.
2. *Rauvolfia serpentina* Benth.
3. *Sida cordifolia* Linn.
4. *Symplocos cochinchinensis* (Lour.) Moore spp. *laurina* Retz. Nooteb.

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राज्य मंत्री (स्वतंत्र प्रभार)  
आयुष मंत्रालय और  
राज्य मंत्री  
स्वास्थ्य एवं परिवार कल्याण मंत्रालय  
भारत सरकार



प्रतापराव जाधव  
PRATAPRAO JADHAV

Minister of State  
(Independent Charge) of  
Ministry of Ayush and  
Minister of State in  
Ministry of Health and Family Welfare  
Government of India



#### MESSAGE

Medicinal plants have been vital source for treating and preventing diseases for centuries. India has a rich documented history of traditional medicines such as Sushrut Samhita and Charak Samhita, with around 8,000 herbal remedies codified in the Ayush systems. Traditional medicine remains the preferred primary healthcare system in rural areas due to its accessibility, affordability and effectiveness.

The demand for medicinal plants has surged exponentially with pharmaceutical advancements over the past three decades. Thus, understanding their demand and production systems is crucial for their cultivation, conservation and commercialization. Cultivating medicinal herbs is revolutionizing agriculture by providing quality raw materials to the pharmaceutical and Ayurveda, Siddha, Sowa Rigpa and Unani (ASU) industries and offering farmers new income opportunities and economic empowerment. Good cultivation practices and awareness of medicinal plants are essential for sustainable agriculture.

The National Medicinal Plants Board (NMPB), Ministry of Ayush, is publishing Agro-Technology Volume-IV on important medicinal plants. I hope that this volume-IV will be beneficial to farmers, researchers and various stakeholders. I am sure that this book will create better understanding of medicinal plant cultivation and its importance for sustainable production.

I congratulate the entire team of the National Medicinal Plants Board and all project investigators for their efforts in developing this valuable resource on agro-techniques.

(Prataprao Jadhav)

25<sup>th</sup> July, 2024  
New Delhi



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### FOREWORD

For centuries, traditional medicine systems worldwide have leveraged the potential of medicinal plants to promote human health and wellbeing. India is renowned for its rich heritage of plant-based healthcare systems, including Ayurveda, Unani, and Siddha, which are widely acclaimed for their holistic approach to healthcare. However, the increasing demand for medicinal plants and heavy reliance on forest resources pose risks of species extinction and compromise medicine quality due to unsustainable practices and lack of standardization.

Cultivating medicinal plants can help reduce pressure on wild resources, preserve plant species and promote sustainable socio-economic growth. A scientific approach is crucial to standardize nursery techniques and sustainable post-harvest management, ensuring optimal yield and quality. The National Medicinal Plants Board (NMPB) under Ministry of Ayush prioritizes conservation, development and cultivation of medicinal plants, offering opportunities for crop diversification, income generation and standardized raw materials, thus enhancing product quality. The agro-techniques developed by NMPB and research institutes offer crucial scientific insights, bridging knowledge gaps and promoting sustainable cultivation practices.

The publication "**Agro-techniques of selected Medicinal Plants volume IV**" by NMPB covers 24 important plants, offering comprehensive guidance for sustainable production. I am confident that this resource will significantly contribute to the sustainable cultivation of medicinal plants and the preservation of wild resources.

I congratulate the entire team of NMPB for publishing this resourceful compilation.

(Rajesh Kotecha)

31<sup>st</sup> May, 2024  
New Delhi.





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National Medicinal Plants Board



## PREFACE

India has a rich biodiversity of medicinal plants and these are extensively used in traditional medicines like Ayurveda, Unani, Siddha and Sowa Rigpa. The traditional medicine systems based on plants are holistic systems of medicine and a way of life. Nowadays medicinal plants have gained momentum and recognition because of rising faith in herbal medicine as there are lesser side effects or no side effects compared to allopathic medicine. And, this leads to continuous destruction and exploitation of wild bio-resources thus making challenging to meet the requirements as well as to conserve biodiversity.

National Medicinal Plants Board (NMPB), Ministry of Ayush continuously take forward steps to conserve wild resources and promoting sustainable collection and harvesting practices. Further, NMPB disseminating knowledge about medicinal plant and their use, agro-technology through training programs particularly among the farmers, stakeholders, researchers etc.

Medicinal plants have so far been collected from wild resources. However, the plant material collected from these sources is replete with the problems of adulteration and mis-identification. Further, the plant material collected from the wild may also be contaminated by other species or parts thereof. All such conditions may have adverse consequence on the quality and efficacy of the ASU drugs. In view of this, cultivation of genuine, authentic variety of plants may be the only way to have raw material of required quality. However, cultivation of these plants has never been easy and commercially viable. The medicinal plants are the basic source of raw-material for preparation of Ayurvedic medicines. Therefore, the quality of Ayurvedic products critically depends upon the quality of raw-material. By adopting good agro-technique of medicinal plants, the safety and quality of medicinal plant materials and finished products could be assured.

NMPB has compiled "Agro-techniques of selected Medicinal Plants volume IV" on 24 important medicinal plants. The agro technologies are developed by the different Research organizations/institutions/Universities under the supported projects of NMPB as well as their own funds. Present book showcase all the necessary aspects which are essential for sustainable cultivation and production of medicinal plants so that farmers, stakeholder researchers and others can easily acquire information.

I am extremely delighted to bring out "Agro-techniques of selected Medicinal Plants volume IV" on important medicinal plants and it will be beneficial in disseminating scientific information to the farmers who are keen to adopt the cultivation of medicinal plants.

I congratulate team National Medicinal Plants Board and Project Investigators from various research organizations, who have been involved in bringing out this publication.

**Dr. Mahesh Kumar Dadhich**



## Acknowledgement

The Medicinal Plants provide opportunities for developing a variety of safe, cost-effective, prophylactic, and curative medicines for various disorders. World Health Organization, estimated that the primary health care of over 80% of the world's population still depends on plant-based traditional medicines. Medicinal plants play vigorous roles in disease prevention and treatment and are considered very safe as there are no or nominal side effects. Due to increasing demand of medicinal plants unscientific collection and overexploitation without evaluating the resource abundance lead to endangerment of the potent species in the natural habitat. Conservation of medicinal plants resources and the capability to utilize them in a sustained manner are essential for the well-being of mankind

NMPB has published agro-techniques of 50 medicinal plants entitled as "Agro-techniques of Selected Medicinal Plants" (Volume – I), 32 medicinal plants entitled as "Agro-techniques of Selected Medicinal Plants" (Volume – II), 22 medicinal plants entitled as "Agro-techniques of Selected Medicinal Plants" (Volume – III) and 24 medicinal plants have now have been selected for the publication as the Volume-IV. The Agro-techniques of medicinal plants selected for this publication are based on the reports received from different organizations/institutions. Development of Agro-techniques of such plants is an attempt of NMPB towards promoting medicinal plants cultivation through standardized Agro techniques and thereby to make available to the industry the raw material of quality and standardized chemical ingredients. This would not have been possible without the efforts of Principal Investigators (PIs) and Project Staff in the respective organizations that were assigned the projects for development of Agro-techniques. The National Medicinal Plant Board acknowledges the contribution of all the PIs, Co-PIs and their respective Organizations as this publication is primarily based on the reports provided by Research. Some information on plants regarding their morphological characters, therapeutical characters, chemical constituents and taxonomical characters have also been taken from the published literature of Ayurvedic Pharmacopoeia of India (API), Homoeopathic Pharmacopoeia of India (HPI), Unani Pharmacopoeia of India (UPI), Indian Pharmacopoeia (IP), Ayurvedic, Homoeopathic, Unani, India formularies/ pharmacopeias, Wealth of India etc.

I would like to extend my gratitude and wish to place on record the guidance and encouragement provided by Hon'ble Minister of State (Independent Charge) Shri Prataprao Jadhav ji.

I express my sincere gratitude to Dr. Mahesh Dadhich, Chief Executive Officer, NMPB for his excellent guidance and also for her painstaking efforts, in spite of shouldering huge responsibilities, while preparing the book. This publication would not have been possible without the active involvement of Team NMPB.



I would like to extend my gratitude and wish to place on record the guidance and encouragement provided by Padmashri Vaidya Rajesh Kotecha, Secretary, Ministry of Ayush, and CEO, Prof (Dr.) Mahesh Kumar Dadhich. I wish to thank former CEOs namely Shri R.B.S Rawat, Shri B.S. Sajwan, Shri Bala Prasad, Sh. Jitendra Sharma, Ms. Shomita Biswas, Dr. JLN Sastry and Prof. (Dr.) Tanuja Manoj Nesari who had put in untiring efforts for the development of medicinal plants sector throughout the country. I also acknowledge the valuable contributions made by Ms. Meenakshi Negi, and Ms. Padamapriya Balakrishnan former Deputy CEOs for their contribution to NMPB. I am also thankful to for their support to make this book possible. I would like to extend my gratitude to Dr. Kavita Tyagi, Senior consultant and Dr. Vineeta Pandey, Consultant (JFMC), NMPB for their efforts in compiling this publication, from gathering data, analysing progress reports to liasoning with Project Investigators, which made this book possible.

Further contributions by my team at NMPB, comprising Dr. R Murugeswaran, Deputy Advisor (MPs), Sh. Saurabh Sharma, Manager (Marketing & Trade), Sh. Sunil Dutt, Research Officer (MPs/Agro), Dr. Jeetendra Kumar Vaishya, Research Officer (MPs/Agro), Dr. Chinmay Rath, Research Officer (Botany) and Dr. Bidhan Mahajan, Research Officer (Ayurveda) are sincerely acknowledged for undertaking editing of the whole document.

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Further, I extend my thanks to entire team of the National Medicinal Plants Board, Ministry of Ayush who has put their efforts for making this book.

  
**Dr. Chandra Shekhar Sanwal,**  
Dy. CEO NMPB

## Abbreviations

ASU	Ayurvedic, Siddha and Unani
AYUSH	Ayurveda, Yoga & Naturopathy, Unani, Siddha & Homoeopathy
@	at the rate of
asl	Above sea level
BA	Butyric acid
BAP	6-Benzylaminopurine
cm	Centimeter
°C Celsius	Degree Celsius
CAGR	Compound Annual Growth Rate
CIMAP	Central Institute of Medicinal and Aromatic Plants
DAP	di-ammonium phosphate
DDVP	2,2-dichlorovinyl dimethyl phosphate
Dicho	Dichotomous
DP	Di-phenyl
DRDO	Defence Research and Development Organisation
DW	Dry Weight
EC	Emulsion Concentration
ft	Feet
FYM	Farm Yard Manure
FW	Fresh Weight
FWB	Fresh Weight Biomass
GA <sub>3</sub>	Gibberellic acid
GCA	Giant cell arteritis
gm	Gram
ha	Hectare=10000 sqm
HMV	Hibiscus Mosaic Virus
IAA	Indole acetic acid
IBA	Indole butyric acid
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forestry Research and Education
K	Potassium
K <sub>2</sub> O	Potassium Oxide

kg	Kilogram
lit	Litre
m	Metre
mg	Miligram
ml	Mililiter
mm	Milimeter
µm	Micro metre
µg	Micro gram
msl	Mean sea level
MT	Metric tones
N	Nitrogen
NAA	Naphthalene acetic acid
NMPB	National Medicinal Plants Board
NPK	Nitrogen + Phosphorous + Potassium
O	Oxygen
P	Phosphorous
P <sub>2</sub> O <sub>5</sub>	Phosphate
ppm	Parts Per Million
pH	Measure of acidity & alkalinity of soil (below 7 pH – acidic; above 7 pH- alkali)
qt	Quintals
M	Part per million
RH	Relative humidity
SSP	Single Super Phosphate
Sps	Species
sqm	Square metre
t	Tonne
TMTD	Tetramethylthiuram Disulfide
TRF	Triademophon
VAM	Vesicular Arbuscular Mycorrhiza
WHO	World Health Organization
WDP	Wettable Dispersible
Zn	Zinc



## Introduction

Medicinal plants are resources of traditional medicines and many of the modern medicines are produced indirectly from plants. Also, medicinal plants are considered as major resources of raw materials that can be used in drug development due to the presence of natural compounds. Medicinal plants based traditional systems of medicines are playing important role in providing health care to large section of population, especially in developing countries. Around 80% population of developing countries rely on traditional medicine mostly plant drugs, for their primary health care needs as they are natural, safe, non-synthetic, having almost no side effects (WHO).

Traditional systems of medicine have been used since time immemorial throughout the world to treat illness and the general well-being of mankind. Ancient medical systems such as Ayurveda (the holistic system of medicine from India), Unani and Tibetan medicine heavily rely on medicinal plants and are still used extensively. People have used herbal medicines to prevent illness, cure infection, relieve fever, and healing of wounds. Further, herbal medicines are used as herbal teas, extracts, food supplements, and in fresh or dried plant or plant part form. Recent trend shows that medicinal herbs have emerged as a popular complementary system of medicine and assumed significance as dietary substances. The use of traditional medicines for improving immunity and treating various other diseases has been approved by WHO. India has a rich documented history of traditional medicines such as Sushrut Samhita and Charak Samhita.

Medicinal plants are an important global resource in terms of healthcare however they are also an important economic resource, traded extensively in the domestic as well as in the global market. Medicinal plants are at increasing risk from destruction of their habitats, bioprospecting for new sources, and overharvesting of known medicinal species. Plant parts like leaves, bark, roots, fruits, seeds or even whole plants are indiscriminately collected from wild sources without sustainable harvesting. Many of the important useful species are on the verge of extinction due to over-exploitation and habitat destruction. More than 95% of the medicinal plants are collected from the wild; a number of them have become endangered in their natural habitats. A number of species have been rendered vulnerable to extinction due to lack of cultivation and also due to unsustainable collection of these plants from forests.

The sustainable use of medicinal plants should be practiced and good harvesting and cultivation practices must be popularized among farmers, growers, and stakeholders. Root and whole-plant harvesting are more destructive to medicinal plants than collecting their leaves and flowers or buds. As our lifestyle is now getting techno-savvy, we are moving away from nature. While we cannot escape from nature because we are part of nature. As herbs are natural products they are free from side effects, they are comparatively safe, eco-friendly, and locally available. Traditionally there are a lot of herbs used for the ailments related to different seasons.

Plants are the only major source bank down for finding solution for our afflictions and infirmities. As per a study that had been commissioned by NMB through FRLHT, there are around 7500 medicinal plants species exist in India, out of which 758 are normally traded and 178 are highly traded in quantity of more than 100MT. With the increasing awareness about Indian Medicine System and people finding no solution and enduring side effects in modern medicine system especially for communicable diseases, the demand for nature based drugs (ASU drugs) is increasing day by day and pushing the source material {Medicinal Plants (MPs)/xiv species} towards extinction. If the supply chain is studied, more than 80% of MPs species by volume and variety are sourced from wild. The collection from wild is generally unsustainable leading to degradation of natural resources hence to have a sustained supply of quality raw material to meet the ever increasing demand of ASU drugs we need to bring these wild species under cultivation. Due to the rising demand for medicinal plants in traditional health care systems and pharmaceuticals intensive harvesting of wild resources can cause over-exploitation which can be a serious threat to biodiversity in the region. Further, it is also important to focus on disseminating knowledge and awareness on medicinal plant uses and their conservation aspects, sustainable harvesting, and scientific cultivation methods. In order to meet the increasing demand for medicinal plants both domestic and from overseas markets we need to focus cultivation of medicinal plants as well as *ex-situ* & *in-situ* conservation efforts.

In an effort towards this NMPB has taken an initiative to develop agro-technology of highly demanded medicinal plants species. With the help of various Research Organisations and Universities, 104 medicinal plants species Agro-technology has already been published in Vol.I, Vol.II and Vol.III. At present vol IV which contains Agro-technology for 24 species is being published to disseminate the knowledge of technology to interested stakeholders *i.e.* cultivators and farmers. The agronomic package of practices would make aware of the stakeholders on points underlined below:

- Suitability of the region-climatic conditions
- Soil and land preparation
- Seed treatment and nursery techniques
- Spacing and lay-out in the planting site
- Cultivation practices
- Cultural practices
- Harvesting practices
- Post Harvest Management

National Medicinal Plants Board, Ministry of Ayush supports projects on ex- situ and in-situ conservation, research and development, post-harvest management technologies and development of quality planting material for mass scale propagation. The present book complies agro-techniques of selected 24 medicinal plants *i.e.* *Abelmoschus moschatus* Medik, *Aegle marmelos* (Linn.) Correa, *Artemisia annua* Linn., *Azadirachta indica* A. Juss., *Carum carvi*

Linn., *Chrysanthemum cinerariifolium* (Trevir) Boccone, *Chrysopogon zizanioides* (Linn.) Roberty, *Gloriosa superba* Linn., *Hippophae rhamnoides* Linn., *Jurinea macrocephala* (DC. ex Royle) Benth. ex C.B. Clarke, *Ocimum sanctum* Linn., *Paris polyphylla* Smith., *Phyllanthus emblica* Linn, *Plantago ovata* Forssk., *Polygonatum cirrhifolium* (Wall.) Royle, *Polygonum rumicifolium* Royle ex Bab., *Pogostemon cablin* (Blanco) Benth., *Rauvolfia serpentina* (Linn.) Benth. ex. Kurz., *Rheum moorcroftianum* Royle, *Sapindus trifoliatum* Linn., *Saussurea lappa* C.B. Clarke, *Sida cordifolia* Linn, *Symplocos cochinchinensis* (Lour.) Moore spp. *laurina* Retz. Nooteb. and *Woodfordia fruticosa* (Linn.) Kurz. The knowledge assimilated in this book will surely guide farmers to adopt package of practices in their farming to ensure quality and assured quantity production from unit area. It would also allow them a choice in diversification of crops, which serve as an alternative livelihood option. The purpose of assured supply of quality raw material to the ASU industries from arable land also ensure conservation of natural bio-resources in its habitat in the wild for generations to come. This book is a complete handbook on therapeutic uses, nursery techniques, post-harvest management and market potential of selected medicinal plants.



## *Abelmoschus moschatus* Medik

Family- Malvaceae

Ayurvedic Name	Muskdana
Hindi Name	Kanghi
English Name	Ambrette
Unani Name	Habbul-Mushk
Trade Name	Muskdana, Kasturidana
Parts used	Leaves and seeds



*Abelmoschus moschatus*

### Morphological Characteristics

Plant is an erect annual or perennial herbs or under shrubs, about 1-3 m tall. Stem and branches hirsute with simple prickly or stellate yellow hairs. Leaves alternate, palmately lobed, transversely orbicular to elliptic, usually sagittate to hastate, lanceolate-obovate, margins dentate-serrate, rarely entire, apex acute to acuminate, sparsely hirsute with simple hairs both above and beneath, petiole usually longer than the leaf lamina, about 2-20 cm long, stipules filiform, linear, about 5-12 mm long. Inflorescence axillary or terminal solitary.

### Floral Characteristics

Flower are hermaphrodite, solitary, yellow, axillary, regular hypogynous complete pentamerous, mucilaginous, hairy. Bracteoles 8-9 green and free from epicalyx. Involucral bracts are 8-12 fulvous hairy, persistent into fruit, shorter than calyx, linear to subulate or lanceolate, caducous. Calyx is green, hairy, void cuspidate in bud, sepals 5 toothed at the apex, coriaceous except at the tips. Corolla is yellow, petals-5, free, twisted. Stamens are numerous, monadelphous, filament fused to form a short staminal tube. Anthers are reniform, monothecous, green coloured. Ovary is superior, pentacarpellary, syncarpous, pentalocular with many ovules in each locule, axil placentation. The fruit is dry, dehiscent capsule, oval to fusiform, speculately terete to slightly angled, usually five chambered. Seeds are ovoid, reniform, musk scented black concentrically striate and pubescent. Oil secretion begins when the seeds start developing brown colouration on the seed coat.

### Distribution

*Abelmoschus moschatus*, commonly known as musk mallow, is native to South East Asia and Northern Australia tropical. The plant can be found naturalized, across tropical Asia, Central and South America, the Caribbean, Madagascar, Europe and on many islands in the Pacific region. It is cultivated in Java, India, Madagascar and in parts of South America. In India the area under cultivation of plant is increasing and seeds are exported to France, Germany, Japan, Singapore and Spain for oil extraction, which is highly valued in perfumery and in aromatherapy. Collections of plant parts from Lucknow, Pantnagar, Bhubaneswar, Bangalore, Arunachal Pradesh are domesticated.



### Climate and Soil

The climatic requirement of crop is tropical, warm and humid but it can grow in sub-tropical climate also and has the ability to adopt to wide variation in climatic condition including day length. Muskdana is sensitive to day length. It can be grown up to an elevation of 1000 meter. It requires sufficient rainfall during growth but comparatively dry weather during flowering and fruiting stage. Seeds require warm temperature to germinate and it grows well during summer months. Temperature ranging from 20-28°C is favorable for its vegetative growth. It prefers fertile well drained loamy and sandy loam soil. Heavy clay and sandy soil, water logged or highly alkaline soils are not suitable for muskdana cultivation.

The desirable range of soil pH lies between 6.0-8.5.

### Propagation material

Seeds

#### Agro-Technique<sup>1</sup>

### Nursery techniques

**Raising Propagules:** Seeds free from any infestation should be used for sowing. Seeds are generally sown by broadcasting method. Five to six kg seed is sufficient for one hectare.

Seeds are sown from middle of June to end of July with pre monsoon showers (kharif). Seeds germinate in 4-10 days. If irrigation facilities are available, it can be sown even in mid-April to May also. Three to four seeds are sown per hill at 3-5 cm depth and thereafter covered lightly with the soil.

Seeds should be soaked in water for a day prior to sowing which hasten its germination. Under favorable moisture conditions in the soil the musk seed germination percentage is about 80%. In direct row sown crop, weak and off type plants should be removed after germination. The seedlings may be thinned out later when they have taken 4-6 leaves leaving one seedling to a hole and spacing them 75x50 cm apart both from row to row and plant to plant. Sowing by dibbling requires 1.0-1.5 kg. It can also be sown on flat beds in furrows space 80-100 cm apart maintaining plant to plant distance of 50-60 cm.

### Planting in the field

- **Land Preparation and Fertilizer Application:** Muskdana crop requires a well pulverized but compact seedbed for uniform germination. Therefore, one ploughing with soil turning plough and two to three cross harrowing with soil pulverizer are essential. Proper levelling is desirable which can be accomplished by planking. During summer a light irrigation may be applied before land preparation which will bring a fine tilth.

Muskdana requires 18-20 tones FYM per hectare. It should be added and mixed at the time of ploughing 3-4 weeks before sowing. On an average muskdana requires about 100kg nitrogen, 50-60kg phosphorous and potash each depending upon the fertility status of the soil. In poor soils nitrogen may be applied up to 160 kg N/ha. Nitrogen can be applied in 3 split doses. One third of the nitrogen and entire quantity of phosphorus and potash can be incorporated into the soil as a basal dose one week before sowing. The remaining quantity of nitrogen can be applied in two split doses one at branching stage (65 days after sowing) and the other at flowering stage (100 days after sowing). If neem cake is available it can also be mixed in the soil one week before sowing.

<sup>1</sup> Agro-technique study carried out by  
Central Institute of Medicinal and Aromatic Plants, Lucknow, Uttar Pradesh

- **Transplanting and Optimum Spacing:** The crop is raised in kharif season from seed in wellprepared field. Under favorable conditions, germination starts 415 days after sowing and is complete after 1530 days. The optimum temperature for germination is about 30°C. The germination rate of good commercial seed is about 85%. In row planting, thinning is required; in India the spacing followed for Muskdana is 40 cm x 30 cm or 60 cm x 30 cm.
- **Intercultural and Maintenance Practices:** Muskdana requires frequent weedings because it is grown during rainy season. First weeding and hoeing is usually done by the end of July. Weeding is done manually till the plants are young at an interval of 2-3 weeks. Later the plants grow big enough to suppress the growth of weeds. At this stage root system develops a shallow net work underneath the plant and it should not be disturbed. In all, two to three weedings together with hoeing is required. In early stage hand hoes can be used for hoeing and weeding. Line sowing facilities in performing intercultural practices smoothly by hand hoes.
- **Irrigation Practices:** One irrigation is initially required for preparing the land for sowing. If the monsoon rains are regular, usually no irrigation is required till September. After this 5-6 irrigations are given at an interval of 20-30 days each. Of these, one irrigation to coincide with the flowering stage is beneficial to induce profuse flowering and maximum seed set in the fruits.
- **Pruning:** Heavy vegetative growth of the crop results in lesser fruiting and consequently low seed yield unit area. Topping of the plants 50-60 days after sowing helps to induce early pod formation and more branches, thereby more seed yield. The plants may be pruned at a height of 50 cm to encourage branching. In early pruning the growth and production of sympodial branches is arrested and causes reduction in seed yield.
- **Disease and Pest Control:** Muskdana crop suffers from many pests, several fungus and viral diseases from the time of its germination till the fruiting stage. When the same crop is grown in vast contiguous area, pests attack becomes epidemic. The major pests are: aphids, thrips, pink boll worm, spotted boll worm and red spider mites. The early season sucking insects *i.e.* aphids, thrips, etc. cause considerable damage to the crop in early stage of its growth, particularly the early sown summer crop. The foliar spray of dimethoate, endosulphan, malathion, phosphomidon, vamidothion reduces the risk of aphids and thrips. Nymph and the adults of leaf hopper are prevalent throughout the cropping season and maximum damage is caused during July-September in kharif season and during November-January in winter season. Severe infestation results in the retarded growth of plants and premature defoliation. Caterpillars of leaf roller, roll the leaves from edge to midrib forming a cover around it and feed inside which results in defoliation of leaves. The spotted boll worm attacks succulent shoots, vegetative buds, flowers and pods during vegetative growth and fruiting stage. The infested shoots, above the point of infestation become brown, bend down and die. The fruits are also infested which causes damage of seeds in pods. Thiodon 35 EC @ 0.15-0.2% can be sprayed at 10-15 days interval right from the stage of one month old crop to the last picking. The deep pink coloured caterpillar of pink boll worm also infest the crop bore into the pods and seed. Healthy seeds free from infestation should be sown as precautionary measure. The web forming red spider mite feeds on the under surface of leaves produces white mesh (specks). The infested plants become yellow, weak and shed leaves. 0.05% Dimethoate, Phosohomidon, Folidol can be sprayed once on the infested plants to bard off the infestation of red spider mite. The red cotton bug and the cotton aphids feed on the surface of hairy leaves. Spray of pyrethroids (Cypermethrin or Fevaluate 0.01%) may control the red



cotton bug attack in ambrette. The green peach aphid also has been observed on ratoons in winter season. To eradicate spotted boll worms (pod worms) methyl parathion, quinolphos, toxaphene, dimethoate, phosphomidon can be applied. Chlorpyrophos 50% EC+ Cypermethrin 5% EC @0.05% also can be sprayed for the control of boll worms, pod borers, shoot and stem borers. To save crop from root damage done by nematodes and insects "Nemagon" with irrigation; in furrow granules treatment with aldicarb, carbofuran or ferosulfotheon are applied. For nematode and insect control carbofuran @ 2-2.5 kg/ha a.i (Furadan) can be applied. Often monkeys eat the unripe fruits (seeds) and destroy the crop. The blue bulls also damage the crop. Rats damage the root system and the stored seeds must be protected from their menace.

Besides, the pests, muskdana crop is also prone to several diseases. Foliar disease, wilt and root rots causes serious damage. Muskdana suffers from several fungus and virus diseases of which mosaic disease, anthracnose and leaf spot diseases are common. Repeated spray of 0.1% Ridomil can control the infection. Plants infected with Hibiscus Mosaic Virus (HMV) should be uprooted and destroyed. In anthracnose almost all parts of the plants are attacked. Infection at seedling stage has been observed. The seeds should be treated with Agrosan GN or Cerasan to save the crop from anthracnose before sowing. Fusarium wilt in ambrette plants at seedling stage also precede its death. The disease prolongs over 2-3 weeks. The crop may be sprayed with Bordeaux mixture to control the infection. Leaf spot and leaf blight disease also cause damage to this crop. Leaf drying, pod premature drying results into death of leaves and pods. During high humid condition, a white colony growth appears on diseased surface of leaves, dark brown patch cover whole leaf causing defoliation and plant dies. Cerasan treated seeds make the plants less susceptible. Repeated spray of 0.5% Diathane Z-78 at one month interval control the blight effectively. In muskdana attack of Sclerotinia rot and blight also damage the crop.

### Harvest Management

- **Crop Maturity and Harvesting:** Muskdana crop sown in June during the rainy season (kharif) starts flowering in October and fruit setting simultaneously. Fruits start ripening by the end of November. It is however advisable to stop fruit plucking by the end of February or up to Mid March as later harvesting may not be economical. The fruits should be plucked when they are ripe and before they start splitting and shedding the seeds. When three quarters of muskdana pod bodies become blackish, the pods should be considered ripe, the fruits split and seeds shatter, which may result in loss of seed yield. Since all the fruits do not mature at one time they have to be plucked as and when mature. Pods plucking should be done at an interval of 7-10 days. The pods are generally handpicked and as such is labour intensive and they possess tiny well covered while handling the plants. Pods should be shade dried and threshing may be done by beating the pods with stick and winnowing them to remove the husk. Similarly, the seeds can be also obtained by splitting the dry fruits by hand. Last picking may be completed by cutting the entire plants with sickles, shade dried upto the desired moisture level before storage. The rationing system is also advised to get yield 30% more in the next season with lesser additional inputs and care of the crop.
- **Post-harvest Management:** The oil is extracted by steam distillation (hydrodistillation) of crushed seeds. By stream distillation oil recovery is about 0.3% which also contains fatty acids. When fatty acids are removed by solvent extraction, the oil gives a strong floral musky odour. The process for

separation of its aromatic principles include separation of waxy material by adding rectified spirit and cooling the extract with ether. Acidic impurities and alkali are removed by washing. Drying is done with the help of anhydrous sodium sulphate. To obtain aromatic absolute the ethereal fraction is removed by vacuum distillation.

To isolate odorous constituents of muskdana, another process for extraction of the crushed seeds also may be applied. In this process for extraction, air dried seeds are percolated with rectified spirit at ordinary temperature, 4-5 percolations are required for complete extraction. Lipid and waxy materials are separated from alcoholic extracts are diluted with saturated brine in the ratio of 1:4. Diluted alcoholic extracts are extracted with ether, repeatedly 3-4 times. Total ethereal extract are concentrated by distillation (water bath temp. 35°C). Adherent acidic impurities (free fatty acids), if any, are removed from the ethereal extract by repeated (2-3 times) washing with cold 1% aqueous alkali (NaOH). Alkali is removed by washing it with ice cold water and drying over anhydrous sodium sulphate. Ethereal extract is firstly distilled in the usual manner and finally under vacuum to obtain aromatic absolute. Sterol bodies are removed by filtration or centrifugation after keeping the product in a refrigerator for a few days. Aromatic concrete or absolute having smooth natural aroma with real floral note about 2% yield may be obtained from muskdana seed. The finished product is light brown and highly odorous liquid. It is stored at a low temperature (5°-10°C) or in a deodorised alcoholic solution. The absolute is soluble in 1:1 and 1:2 (by volume) of 95% and 90% alcohol respectively. The absolute when diluted (500-2000 times) with deodorized alcohol, gives a persistent sweet natural musky odour of ambrettolide (resembling to that musk) with remarkable tenacity.

- **Chemical Constituents:** The seed of *A. moschatus* contains per 100 g 13-15 gm fatty oil and 0.1-0.2% linoleic acid (50-57%), stearic acid (2.5-4%) and smaller amounts of myristic acid and palmitoleic acid. When ambrette seed is crushed before steam distillation, the odourless, palmitic acid is distilled over together with the aromatic components yielding a crude oil of pastelike consistency. The aromatic components are concentrated in the outer seed coat and distillation of whole seed gives a liquid essential oil, containing only small amounts of fatty oil, but also a lower yield of essential oil.
- **Yield and Cost of Cultivation:** The average seed yield of muskdana crop is 7.5-10 quintal per hectare. With proper manuring, irrigation and cultural practices seed yield can be increased up to 15 quintal per hectare.

### Therapeutic Uses

Muskdana is the source of ambrette seed oil used in luxury perfumery, cosmetic products and as an additive in the preparation of some kinds of chewing tobacco, baked products, sweets, alcoholic (e.g. vermuth and bitters), antihysterical, stimulating and antispasmodic properties and nonalcoholic drinks. Arabs sometimes flavour their coffee with the seed and in India and the leaves and flowers are rubbed on scabies and applied as poultice to swellings, while seeds are also placed between clothes to keep away insects. Seeds are burned as incense and used in making incense sticks (agarbattis). Tender leaves, shoots and pods are occasionally eaten as vegetable.



## *Aegle marmelos* (Linn.) Correa

Family- Rutaceae

Ayurvedic Name	Bilva
Hindi Name	Bael, Bel, Bili
English Name	Wood apple, Stone apple, Golden apple
Unani Name	Bilva
Trade Name	Vilvam.
Parts used	Leaves, Root bark/Roots, stem, flowers, fruit.

Fruit of *Aegle marmelos*

### Morphological Characteristics

*Aegle marmelos* is a medium-sized tree attaining a height of 12-15 m. The trunk is short and thick with narrow oval shape ends. The bark is bluish-grey in colour and contains irregular furrows in the young stage. Leaves are aromatic trifoliate, the deciduous, alternate leaves are composed of 3 to 5 oval pointed leaflets. Leaves are 4-10 cm long, 2-5 cm wide, and the terminal one with a long petiole.

### Floral Characteristics

Bisexual flowers are 2 cm wide, fragrant, and form 4-7 clusters along the new branch. The calyx is shallow with 5 short, broad teeth, pubescent outside. There are 5 petals which are oval, blunt, thick, pale greenish-white, dotted with glands. Stamens are numerous, ovary is oblong ovoid, and numerous ovules. The ripe fruits are woody, large, 23 cm in diameter. The fruit is usually globose with a pericarp up to 2.7 mm thick. Inside the fruit the seeds are tightly packed. The flowering season is from April-May, while fruiting occurs from March-June.

### Distribution

Bael is the native to India and found in Eastern Ghats and Central India. Bael tree is growing wild in sub Himalayan tracts; it is also well grown in foothills of Himalayas, Bihar, Uttaranchal, and Madhya Pradesh. It thrives well in dry, mixed deciduous and dry dipterocarp forests. It is a subtropical species, although, it can grow well in tropical environments. Bael can thrive well in high altitude as high as 1,200 m and withstand without any significant growth retardation at 50°C and -7°C.

### Climate and Soil

The plant prefers sub-tropical origin, perform equally well in tropical, arid and semi-arid regions. It thrive well in dry, mixed deciduous, dry dipterocarp forests, require well-drained soil, but the plant is grown well in alkaline, stony and shallow soil having pH ranges from 5–8. Bael grows well and produces bountiful harvests of fruits in the “Oolitic limestone” soils of southern Florida. In India and Sri Lanka, Bael is famous as a fruit species, which can grow in very tough soils.

### Propagation Material

Bael is usually propagated through seeds, they are sown in July but it will take a year to produce the plant. To produce true to type plants stem cutting or root cutting method is followed. On the other hand, through micro propagation technique large number of plants may be produced.

### Agro-Technique<sup>2</sup>

#### Nursery Technique

- **Raising Propagules:** Before plantation, a nursery of the plants is raised in polybags. The polybags are filled with FYM: sand: Soil in the ratio of 1:1:1, seeds are sown in the filled bags in 2 cm deep, 8-15 days the germination occurs. After emergence of the seedling, the plants are watered regularly to maintain optimum moisture level. The seedlings raised from seeds are not true to type, vegetative propagation is the best technique to establish the Bael.
- **Stem Cutting:** 10-15 cm length young shoots were excised from 2- 4 months old tree. The cuttings are treated fungicide, IBA, IAA solutions (5000 ppm IBA, 100 ppm IBA & IAA). The processed cuttings are placed in polybags or tunnels to produce roots. The 75-80% of rooting is observed in 5000 ppm IBA treatment, 45% and 40% of rooting are observed in 100 ppm IBA and 100 ppm IAA respectively.
- **Micropropagation:** Disease free plants can be produced. The juvenile part of the plant namely, apical bud, node, inter node can be carefully excised from mother tree and sterilised in different chemical agents and they were inoculated in media in aseptic conditions. Media with BAP growth regulator will give rise to micro plantlets with IBA containing media will give rise rooted plants. These plants can be hardened and planted in the field.

#### Planting in the field

- **Land preparation and Fertilizer Application:** Land should be ploughed well followed by harrowing and levelling, make the soil porous, friable and weed free. The land should be gently slope to avoid water logging. Pits preferably, 1 m x 1 m x 1 m, are dug and exposed for solarisation, filled with 20-25 kg FYM after drenching of chlorpyrifos 3 mL/ litre to avoid of termite.
- **Transplanting and Optimum Spacing:** Seedlings and stem cuttings are transplanted in February-March or July-August. A spacing of 8 m x 8 m or 10 m x 10 m is considered appropriate. An optimum of 156 plants/hectare is achieved with this spacing.
- **Intercropping System:** Bael with cluster bean, cowpea, bottle gourd, bitter gourd, sponge gourd, pumpkin, cucumber found the ideal crop. Apart from that aonla, karonda, drumstick, chironji, fig, custard apple, khirni, phalsa and wood apple can also be showed the successful intercropping models. Intercropping in the newly established fields had no adverse effects on plant growth up to 5 years.
- **Interculture and Maintenance Practices:** 5 kg of FYM, 50 g, 25 g and 50 g of N, P, K is required for one year old plants. This dose should be increased every year in the same proportion up to the age of 10 years. Along with this foliar sprays with 0.6% mixture containing zinc sulphate, borax, and ferrous sulphate during July, October and November is found beneficial.
- **Irrigation Practices:** Irrigation to the young plantation should be given 10-15 days interval in summer and one month interval in winter. In bearing orchard, generally irrigation is not required. However, for bearing tree, first irrigation should be given just after manuring and fertilization. In water scarcity areas pitcher irrigation have also been found successful.

<sup>2</sup> Agro-technique study carried out by

Institute of Forest Genetics and Tree Breeding (IFGTB), Forest Campus, Coimbatore-641 002, Tamil Nadu and Medicinal and Aromatic Plant Department, Horticulture & Agriculture Forestry University, Narendra Dev Krishi & Development University, Kumar Gunj, Faizabad.



- **Disease and Pest Control:** Termite and caterpillar attack is very common in the new sampling. Spraying of chlorpyrifos 3ml/ liter and dimethoate 2 ml /liter at 15 days interval control the attack. Apart from this Canker (200 ppm Streptocycline – 15 days interval), fruit drop (0.1% Carbendazim – 15 days interval), Dieback (0.3% copper oxy chloride- 15 days interval), internal rot (1% Borex - foliar spray at small size fruit), fruit rot, black leaf spot (0.1% bavistin) is found the common diseases and the treatment procedure are mentioned in the parenthesis.

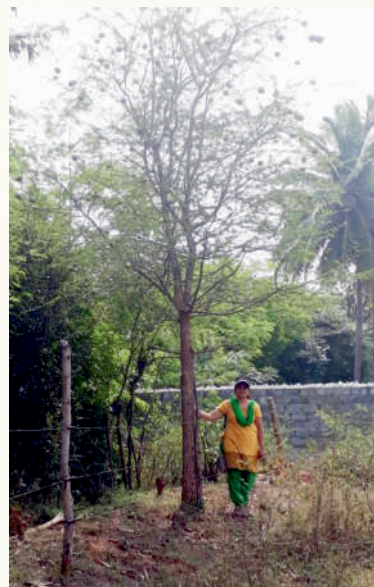
### Harvest management

- **Crop Maturity and Harvesting:** Mature fruits are harvest individually in April – May when shell changes its colours from deep green to yellow green. Fruit formation will vary 30-45 at the age of 6-7 years, whereas seedling plants yields 500- 800 fruits in the 30-40 years. This variation is due to genotype, soil and climatic conditions.
- **Post-harvest Management:** Fruits are different shape and size, it should be graded accordingly. Fully matured fruits are packed in gunny bags or baskets or wooden crates with straw paper or newspaper it can be stored for 15 days. Fruits can be stored up to 3 months at 9°C with 85-90% humidity.
- **Chemical Constituents:** The Bael fruit contains marmelosin, luvangetin, aurapten, psoralen, marmelide and tannins, Luvangetin, apyranocoumarin compounds are isolated from seeds. Leaves contain alkaloids, mermesinin, rutin, phenylethyl cinnamides, anhydromarmeline, and aegelinosides sterols, and essential oils. Stem barks contains coumarin as aegelinol, fagarine and marmin. Roots has psoralen, xanthotoxin, coumarins, tembamide, mermin, and skimmianine.
- **Yield and Cost of Cultivation:** Above 10 years old tree yield approximately 100 fruits per tree, it yielding about 100-150 quintal/ha. An expenditure of Rs. 20,000/- is incurred for crop cultivation/ hectare. An amount of Rs. 30,000-40,000/ha can be obtained in every year by selling the fresh fruits.

### Therapeutic Uses

Roots of Bilva are used to cure diarrhoea, dysentery, and dyspepsia. Root decoction and stem bark decoction is used to treat malaria, fever, jaundice, and skin disease such as ulcers, urticaria, and eczema. It is an ingredient of Dashmoolarishta of Ayurvedic medicine. Leaves are used as mild laxative, ophthalmia, diabetes and asthmatic complains. Unripe fruit powder and decoctions showed effective against intestinal parasites and it acts as an astringent for diarrhoea and stomach ache. Ripe juice is bitter and pungent it lowers the blood sugar.

Various bioactivities such as anti-diabetic, hepato-protective, antimicrobial, analgesic anti-inflammatory and antipyretic, antifungal, anticancer, radio protective, antiulcer, anti-thyroid, insecticidal and antioxidant property have been reported in all parts of Bilva tree.



*Aegle marmelos* seedlings/Saplings





Fruits of *Aegle marmelos*



Variability in fruits of *Aegle marmelos*



#### Market Trend (2019/2020)

- **Market price:** Rs 60-80 per kg of fruit
- **Market demand:** 2000 tonnes or more



## *Artemisia annua* Linn.

Family- Asteraceae

Ayurvedic Name	Agnidamani, Damanaka Bahukantaka,
Hindi Name	Dona, Davna
English Name	Wormwood, Sweet sagewort
Unani Name	Arthamasias, Baranjasif
Trade Name	Artemisia
Parts used	Whole plant

*Artemisia annua* Linn.

### Morphological Characteristics

*Artemisia annua* plants are erect, glabrous, and strong scented annuals. It is an erect aromatic plant with glabrous and ribbed branches, 0.5-3.0 m tall, leaves are 3- Pinnatisect or decompose. Plants roughly have four phases in their life cycle. In the first phase, there is no elongation of main stem and a plant produced a number of leaves on the shoot axis, forming rosette mass of leaves. In the second phase, quick vertical growth of main stem occurred such that the leaves were progressively smaller towards the top. In the third phase, the stem produced inflorescence branches and the whole plant flowered at a time. In the last phase, plants matured and produce achenes. The time of planting has pronounced effect on the characteristics of the plants at each of the phases described.

### Floral Characteristics

Its inflorescence is panicle (compound raceme) with capitulum as basic unit; capitula are 1.5-3.0 mm in diameter. Involucre is imbricate with several rows of bracts. Capitula contain single row of marginal ray florets and several rows of central disc florets. Ray florets are pistillate, 1.5-1.7 mm tall, corolla inconspicuous, 2-toothed. Disc florets are bisexual, 1.0-1.5 mm tall, and corolla 5-toothed. Corolla surface of both florets possesses oil glands. Stigma are bifid, disc florets possess brushing hairs on the stigma, which are absent in ray florets. Anthers are found only in disc florets, 5 in number and form a hollow cylinder around the stigma. Ovary is inferior; unilocular and possesses single, basal, anatropous ovule. Achenes are oval to oblong, lack pappus, 0.6-1.1x0.3-0.5 mm in size, grayish yellow in colour with longitudinal striations on the surface.

### Distribution

The plant grows as a weed in Central Asia and Europe. It is now cultivated on large scale in China, Vietnam, Turkey, Iran, Afghanistan and Australia. In India, it is cultivated in parts of Uttar Pradesh, Madhya Pradesh and Gujarat.

### Climate and Soil

Plant is predominantly found in the temperate regions of the world. Takes about a year to complete its life cycle in the subtropical climate under cultivated conditions. The flowers get the maximum opportunity for fertilization when the temperature is around 35°C. Beyond 40°C there is no achene

formation and unfertilized, nonviable seeds are obtained. The expression of artemisinin synthesis and its accumulation in the leaves progressively increases with the onset of summer in March/April and becomes high by May/June (summer).

Plants can be grown in loam to sandy loam soils with proper drainage. However, light textured soils are ideal for its cultivation. The crop can tolerate the drought conditions. It is very much sensitive to water logging and it cannot be taken in low-lying areas prone to water logging. Plant can grow well in full sunlight as open field crop in subtropical to semi temperate conditions.

### Propagation material

seeds

### Agro-Technique<sup>3</sup>

#### Nursery Technique

The plant is propagated through seeds that are generally sown between 15th December to 15th January. About 50 gm seeds are sufficient for raising seedlings required for planting one hectare of crop.

For raising the seedlings, the seeds are sown in the raised nursery beds. While preparing beds, well-decomposed farmyard manure (FYM) or vermicompost should be mixed with top layer of the soil. Seeds of *Artemisia* are tiny therefore, they are mixed with ash or soil dust to increase the volume to facilitate uniform distribution of seed on the nursery beds. Seeds mixed with ash/soil dust are spread on the surface of the bed and then mixed with the upper layer by using fingers. Then it covered with a thin layer of soil. The beds are irrigated using hand sprayer.

The beds are kept moist until the seeds have germinated. For the first 4-5 days the seedbeds are light watered once or twice a day by using hand sprayer. Later the beds are flooded with water at weekly intervals.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The field should be kept free from weeds especially at early stage of crop growth. About 3-5 number of light hoeing(s) and weeding will be required for the crop. About 10-15 tones per hectare of properly decomposted farm yard manure (FYM) or vermicompost should be applied in the field at the time of preparation of field. *Artemisia* is a fertilizer responsive crop and it responds well to commercial fertilizers. The recommended doses of NPK for sandy loam soils are 150:50:50 and for loam soils it is 80:40:40. The complete dose of phosphorous (P) and potassium (K) should be applied in the form of basal dose (mixed in the soil just before planting). The nitrogen (N) is applied in three equal splits; one in the form of basal dose along with the P and K. The rest of two doses of N are applied in the form of top dressing (granules are sprayed in the standing crop) just after the I<sup>st</sup> and II<sup>nd</sup> harvesting of the crop. Nano urea can be used in standing crops instead of granules.
- **Transplanting and Optimum Spacing:** About 55-65 days old seedlings having 7-10 leaf stage, are transplanted in the main field. A day before transplanting the field should be irrigated. After transplanting of seedlings at recommended distance the field should be irrigated using hand sprayer (Hazara) or similar mechanical device(s) for a couple of days. Then field is irrigated as and when

<sup>3</sup> Agro-technique study carried out by  
Central Institute of Medicinal and Aromatic Plants, Lucknow.  
ICAR – Directorate of Medicinal and Aromatic Plants Research Boriavi, Anand – 387 310, Gujarat



required by the flooding or sprinkler methods. The beds have to be irrigated a day prior to transplanting. The seedlings which are 6-8 weeks old, healthy and uniform should be transplanted at a spacing of 30-60 cm between rows and 45-60 cm between the plants. However, planting at a spacing of 45 × 45 cm is the best to obtain maximum biomass, essential oil and artemisinin yield. Usually transplanting is done in the evening hours to avoid transplantation shock. The plots are given light irrigation after transplanting. Gap filling should be done within 8-10 days of transplanting. It is advisable to plant two seedlings per hill to avoid seedling mortality.

- **Intercultural and Maintenance Practices:** *A. annua* is sensitive to water logging and it causes root rotting. In the rainy season, the channels and furrows should be cleared regularly. Keeping the crop weed free during early period of establishment is essential to get good harvest. The crop requires 2-3 weeding and hoeing during the growth period. The first inter-tillage and weeding should be done about 20 days after transplantation. The second weeding is needed before the major branching stage, followed by hilling. No inter-tillage weeding is necessary once the field is entirely covered by the plant. The manage weeds before they start competing with the main crop for nutrients and light. Use mulch to maintain moisture in the soil and to inhibit growth of weeds. Do not use chemical herbicides to eradicate weeds
- **Irrigation Practices:** Frequent irrigations are required especially during the summer months. Total 5-6 irrigations are generally needed during the whole crop duration. The irrigations must be given periodically. However, any water stagnation must be avoided, as crop is sensitive to water logging.
- **Weeding:** The first inter-tillage and weeding should be done about 20 days after transplantation. The second weeding is needed before the major branching stage, followed by hilling. No inter-tillage weeding is necessary once the field is entirely covered by the plant. Manage weeds before they start competing with the main crop for nutrients and light.
- **Disease and Pest Control:** *A. annua* is prone to few insect pests and diseases. Aphids suck sap from young leaves and shoots and can be seen on lower side of leaves. Spraying Azadirachtin 10,000 ppm @ 5 ml/l is effective to control the pest. White ants attack plants mostly during seedling stage which lead to withering and complete death of the plant. Its menace can be minimized by mixing 10 kg of 1.5% chlorpyrifos per hectare into the soil at the time of land preparation. Leaf blight is more common on mature plants of more than 50 days old. The initial symptom is the appearance of minute, brown lesions on the leaf tip. As the spots grew in size, the leaves often curled upward. Once the necrotic area covers majority of the leaf lamina, the leaf shows a blighted appearance. In cases of severe infection, small branches and inflorescences also become blighted. The disease can be controlled by spraying of Bordeaux mixture 1%. Damping off usually occurs in young seedlings which rot, collapse and die rapidly. Disease can be overcome by adjusting the planting time, to get bright weather during the early stages of establishment of crop. Root rot is withering of the whole plant. Later root turns black and rotting occurs. Increase organic matter content in the soil, remove sick plants and apply Trichoderma to that site; follow crop rotation. In virus affected plants new leaves appear wrinkled and shrunken and have reduced leaf size. For managing viral disease control the aphids which are the vectors by spraying botanical pesticide [Azadirachtin 1%(10,000 ppm) @ 5 ml/l].

### Harvest Management

- **Crop Maturity and Harvesting:** The plants are harvested in their vegetative state, because 90% of artemisinin is in the leaves and fine stem and it offers the best economy in chemical extraction of

artemisinin. Crop may be harvested once, twice, thrice or four times. If the crop is harvested once it will be done in first week of June. The twice harvested crop may be harvested first in June and finally in third week of September just before the onset of flowering.

Plants generally attain a height of 1.5 m or above by the first week of June. The foliage above 70 cm or so should be harvested using sickles leaving 3-4 lower growing green branches intact in each of the plants. The same method is adopted for second harvest. In the last harvest either plants are harvested from the ground level or alternatively only foliage is harvested and the woody stems left behind are uprooted later which can be used as fuel wood.

To obtain seeds, a part of the crop should be retained as unharvested. These plants are generally harvested in late December or in early January by which time the flowers and seeds would have matured and plants are dried. A special attention needs to be paid towards collection of seeds. Since seeds are very light and tiny, they have to be collected as soon as they attain the maturity (becomes yellowish in color) otherwise seeds will be flown and dropped in the field even with a very light movement of air.

- **Post-harvest Management:** The harvested crop needs to be shade dried to about 5-10% moisture content and leaves are separated by threshing before its chemical extraction. The dried collected leaves are processed for extraction of artemisinin. The crop harvested in the months of May-June (summer) can be shade dried easily without any additional efforts. Whereas, specially aerated chambers or other suitable alternate facilities may require for drying of crop harvested in the rainy season (July-September).
- **Chemical constituents:** Artemisinin, Arteannuin B, Artemisinic acid, DHA, Artemether, Artesunic acid, Scopoletin, Arteether and Artelinic acid.
- **Yield and Cost of Cultivation:** Improved varieties of *Artemisia* developed by CSIR-CIMAP e.g. CIM-Sanjeevani, CIM-Arogya when grown using improved agro technology package will yield about 40-50 tons of fresh herb per hectares from three harvests. The dry herb obtained from this will be 4-5 tones per hectares. These amounts of dry herb will leads to the production of upto about 25-30 kg of artemisinin.

### Cultivation Calendar

S.No.	Activity	Time to do
1.	Nursery preparation and sog	December 21st to December 28th
2.	Field preparation and transplanting	February 21st to February 28th
3.	First harvesting	May 28th to June 5th
4.	Second harvesting	July 27th to August 3rd
5.	Third harvesting	September 10th to September 16th
6.	Seed harvesting	December 20th to January 5th

### Therapeutic Uses

- It is used as a strong anthelmintic especially for round worms. It has no effect or less effect against hook worm and tape worms. Plant have activities like anti-inflammatory, analgesic, antioxidant, antitumour, and nephroprotective. The species is of growing importance in the cosmetics industry.



## *Azadirachta indica* A. Juss

**Family-** Meliaceae

Ayurvedic Name	Nimba, Arishta, Nimbaka
Hindi Name	Nim, Nimb, Neem
English Name	Indian Lilac, Margosa tree
Unani Name	Neem
Trade Name	Nimba, Neem
Parts used	Whole plant



*Azadirachta indica* A. Juss

### Morphological Characteristics

Neem (*Azadirachta indica*) is one of the most suitable and valuable tree species found in India. It can grow on wide range of soils upto pH 10 which makes it one of the most versatile and important trees in Indian sub-continent. Due to its multifarious uses, it has been cultivated by Indian farmers since Vedic Period and it has become now part of Indian culture. In India, it occurs throughout the country and can grow well in every agro-climatic zones except in high and cold regions and dam sites. In fact in India, Neem trees are often found growing scattered in the farmer's fields and on the boundaries of fields without much affecting the crops. Farmers practice this system just to meet the local demand for timber, fodder, fuel wood and also for various medicinal properties. Due to its deep tap root system, it does not compete with annual crops for scarce soil moisture.

The plant is used as a medicinal plant for longtime and provides almost all the requirements of rural areas for timber, fuel wood, fodder, oil, fertilizers, pest repellent or the ubiquitous 'datun'. Today, it has been recognized as the most potential tree of India due to its even green nature (deciduous in drier areas) and ability to grow in even the most arid and nutrient deficient soils as well as for its many commercially exploitable by-products and environmentally beneficial characteristics.

### Description

A large evergreen tree, 12 to 18 meter in height and 1.8 to 2.4 meter in girth with a straight bole and long spreading branches forming a broad crown as much as 20 meters across, commonly found throughout greater parts of India.

**Bark:** Grey or dark reddish brown with numerous and scattered tuber scales. The bark exudes a gum known as East India gum. Leaves alternate 20 - 30 cm long, leaflets 8- 19 alternate or opposite, ovate, glossy, bluntly serrate.

### Floral Characteristics

**Flowers:** white or pale yellow, small, scented, numerous on long axillary panicles, have a honey like scent and attract many bees. The flowering season of neem varies from place to place. Generally it flowers from January to May and the ripening time of fruits is from May to August.



**Fruit:** Fruit is an ovoid bluntly pointed, smooth drupe green when young and turns yellow with a very thin epicarp, mesocarp with scanty pulp and a hard bony endocarp, enclosing one seed. The fruit pulp is edible.

### Distribution

It is grown from the southern tip of Kerala to the Himalayan hills in the tropical to sub tropical and semi arid to wet tropical regions and from the sea level to about 700 m elevation. It has been widely cultivated in India and African countries. In India, it occurs throughout the larger parts of the country in the states of Uttar Pradesh, Bihar, West Bengal, Orissa, Delhi, Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu. In the international and national provenance trials raised by Arid Forest Research Institute, Jodhpur it was observed that all neem trees had branches near the base because of frost damage. It coppices well and produces root suckers and withstands pollarding well.

### Climate and Soil

It generally performs well on areas with annual rainfall varying from 400-1200 mm. it thrives under the hottest conditions where maximum day temperature reaches 50°C. But it cannot withstand freezing or extended cold. Neem grows on almost all kinds of soils including clayey, saline and alkaline soils but does well on black cotton soils. It has a unique property of calcium mining which changes the acidic soil into neutral. Neem also grows well on some acidic soil. It is said that the fallen neem leaves which are slightly alkaline are good neutralizing acidity in the soil.

### Propagation Material

Seeds

### Agro-Technique<sup>4</sup>

#### Nursery Practices

##### Raising Propagules

**Nursery Site:** Nursery could be either a temporary or permanent one. Site in either case should have perennial water source and located on a flat ground with well-drained soil. On a hilly site, a moderate slope preferably on the northern aspect has to be chosen.

### Planting Techniques

Neem can be easily raised through direct sowing, entire/polypot seedlings or root-shoot cuttings. For degraded areas direct sowing is more successful and economical provided adequate protection is given during early stages. Entire / polypot seedlings or root-shoot cuttings are more relevant for agro-forestry/silvi pasture and road side avenue plantations. Direct sowing is done either by dibbling in bushes, broadcast sowing, line sowing, sowing on mounds or ridges, sowing in trenches in sunken beds in circular saucers or by aerial sowing. The choice varies with edaphic, climatic, biotic and economic conditions of the site. Planting in pits is carried out by using 20 to 45 cm tall seedlings. Taller ones promise better survival. Planting of stumps prepared from a year old seedlings in crowbar holes also gives good results.

<sup>4</sup> Agro-technique study carried out by

National Bank for Agriculture and Rural Development and Utthan – Centre for Sustainable Development & Poverty Alleviation, Allahabad.

### **Dibbling in Bushes**

Neem seed is successfully dibbled in *Euphorbia* bushes. For this purpose, small pits are made and 3 to 5 seeds sown in each pit and covered.

### **Broadcast Sowing**

This is generally done on ploughed land. Very good results are obtained by ploughing of the ground twice. In Tamil Nadu, early ploughing during pre-monsoon showers gives better results than ploughing after monsoon has set in. In arid areas ploughing is done in early spring when the soil is just moist after winter rain.

### **Sowing in Lines**

In Maharashtra, Neem is grown along with Babool in line sowings in combination with field crops. Here Neem is used as a buffer species to control the insect attack to which Babool is susceptible.

### **Sowing of Seeds**

Germination rate of Neem varies between 15% (stored seeds) and 85% (fresh seeds). Hence, to ensure higher viability of the seeds, their immediate sowing in nursery is recommended. Pre-soaking the seed for 24 hours in cold water and removal of the endocarp or cutting of the seed coat at the round end with a sharp knife also increase its germination capacity. Examination of seeds at the time of sowing is also necessary. Seeds are cut across with sharp blades and the cotyledons are examined. If the cotyledons are found green, then seeds are suitable for sowing and if they are yellow or brown, then seeds are not suitable for sowing.

Sowing of seeds in nursery beds made up of fine river sand is done in drills 15 c/m apart. Seeds are sown 2.5 cm deep at distance of 2 to 5 cm in the lines and lightly covered with earth to safeguard against birds and insects which often eat radicles of the germinated seeds on the surface. The beds are sparingly watered to prevent caking. Alternatively seeds can be sown directly into pots. Germination occurs in 1/2 weeks' time. Once the hypocotyl is erect the seedling is transplanted into the containers. Seeds are sown 3/4 months before planting date. Potting mix comprises of 50% sandy loam, 40% river sand and 10% compost by volume.

### **Pricking**

Seedlings are pricked out at 15 cm x 15 cm when about 2 months old. When the seedlings are 7 to 10 cm tall with tap root about 15 cm long, these are transplanted with balls of earth around them. In dry areas, it is necessary to plant larger seedlings of at least 45 cm height since smaller ones are unable to tide over the drought period. This is the reason why seedlings are kept in the nursery beds for another year before planting in the next range.



Seedlings of Neem



### Planting in the field

- **Land Preparation and Fertilizer Application:** Plough the field and break clods and clumps. Apply 50 gm of VAM fertilizer, 20 gm of Azospirillum and Phosphobacteria to be applied regularly.
- **Transplanting and Optimum Spacing:** This is prescribed for heavy soils. The plant is sowing on mounds (about 70 cm high 60 cm diameter at the top and 2 m diameter at the base) in poor soil on trap formation has given satisfactory results. The plants reached 90 cm height in 16 months after sowing. In Karnataka, sowing on mounds 3.7 x 1.2 m x 46 cm in rows 2.7 m apart on black cotton soil has been successful with plant attaining a maximum height of 1.4 meter in one year after sowing. On dry sites for conserving moisture continuous or interrupted trenches are made on which direct sowing is successful in this case. In Tummala method of Tamil Nadu, the trenches are aligned at an angle of 45° to the contours. Similarly, sunken beds are in vogue in Karnataka and Saucer Method in Andhra Pradesh and Tamil Nadu.
- **Entire/Poly Pot Planting:** Seedlings which have attained 20-25 cm height by the beginning of the rainy season are planted out in pits of 30 cm at a spacing of 3x3 m or any other spacing depending on the purpose of plantation. Pruning of leaves except at the tip and roots have been proved successful in Nagpur district of Maharashtra. In Tamil Nadu, plants of 45 cm height are used for this purpose, since smaller plants are found incapable of bearing the stress of drought period. Planting is, however, done during the rainy season.
- **Planting Root-shoot Cuttings:** The stumps are prepared from 12-13 months old seedlings, keeping 2.5 cm of shoot portion and 23 cm of root and are planted in crow bar holes at the break of rains. In Tamil Nadu stumps from two years old plants have given higher survival and better height growth than one year old root stock. 53% success from root-shoot cuttings has been reported from Maharashtra. The success of root-shoot cuttings depends upon rains, prolonged drought may affect survival to a great extent.
- **Farm Forestry Plantations:** For raising a block plantation under farm forestry a closer space of 5m X 5m accommodating 400 trees per ha may be followed. This may vary from field to field and also depending upon the objective. The wider space of 7mx7m accommodating about 200 trees per hectare may be on the broader side where Agro-forestry can also be practiced.
- **Intercropping System:** The tree component in the agro-forestry systems is preferred to be of local use, easily marketable with good economic value. Although Neem is not considered as the best tree species under agro-forestry systems nevertheless, in many parts of India it has been found to be suitable as agro-forestry species. Plant can be grown with suitable grasses and legumes and several other tree species.

In Maharashtra, Neem is grown along with *Acacia* in lines in combination with agricultural crops like cotton, sesamum, arhar, etc. Neem is uses as a buffer to control insect attack on *Acacia*. Neem tree is also planted on farm land in Karnataka, Andhra Pradesh and Tamil Nadu. It has been reported that reduction in grain production under Neem during 2nd and 3rd year varied from 13 to 33% while this reduction under babul varied from 66 to 99% for 3rd year. Under semi-arid conditions, grain yield of Sorghum was the maximum obtain under Neem plantation. Neem is known to increase the soil fertility and water holding capacity.



- **Intercultural and Maintenance Practices:** Proper watering and weeding are very essential during the first two years for proper establishment. Apply irrigation, after each weeding and hoeing. In case of water scarcity, do spot application of water, once in 10 days will help the crop to survive in drought conditions. Do mulching around the tree basins, it will help to conserve water.
- **Irrigation Practices:** In desert areas of Rajasthan, Neem has been planted along with canal area and watered for the first 5-7 years. Under Saudy-Arabian Arid condition, Neem is usually watered for the first 10-12 years, after which it taps ground water.
- **Weeding:** Strip weeding of young plantations has a positive effect on health and survival. Two weeding are sufficient in the first year and one weeding during the second year. First mechanical thinning in the case of transplanted seedlings is done at the age of 5 years. In arid region Neem planted along the canals are watered for the first 5-7 years.
- **Disease and Pest Control:** Tip borer (*Laspeyresia koenigiana*), Tea mosquito bug (*Helopeltis antonii*) affect seedlings and young plants. *Pulvinaria maxima* is a scale insect now regarded as key pest & *Heliethrips haemorrhoidalis* a potential pest of neem. Neem seedlings get severely affected by damping off *Rhizoctonia* leaf web blight, leaf spot & blights induced by *Colletotrichum*, *Alternaria* & *Pseudocercospora*.

### Harvest Management

- **Crop Maturity and Harvesting:** The rate of growth of Neem in plantation varies with the quality of soil. It is fairly rapid upto the age of 5 years after which it slows down. The plant attains a height of 4 m at 5 years and 10 m at 25 years. The mean annual girth increment is 2.3-3.0 cm. More rapid growth is attained under favorable conditions. In Karnataka naturally grown Neem trees of 10 years age give an average height of 6.58 m and girth of 68.1 cm. In alkaline soils of Uttar Pradesh Neem attains an average height of 170 cm at the end of first season and 264 cm at second season. Seven month old root suckers give the average height of 65.7 cm.
- **Post-harvest Management:** Only fruits at the yellow green colour stage are pricked from the branches by hand or by using ladder. After collection, the fruits are depulped immediately. Soaking in cold water for a few hours helps in removing pulp. Fruits are then rubbed over a coffee weir and floated in water to separate seed from pulp. Storing neem seed for 5 months at 40% natural moisture content at 16 degree centigrade is possible. For short storage the seeds are closed in polythene bags and exposed to air once in a week to keep them viable. Long term storage of Neem seeds for more than 10 years is done at 4% moisture content and -20°C temperature. For this purpose seeds are dried very quickly i.e. within a few hours after depulping in a mono layer at temperature more than 20°C to prevent chilling damage under a fan. Shade drying and storage of seed in cloth bags at a temperature upto 4°C is also done to improve seed viability. Storage of seed in earthen pot containing wet sand (30% moisture) helps to retain viability upto 60% at the end of 3 months. On an average 5000 seeds weigh one kilogram.
- **Chemical Constituents:** Main active constituent of neem is Azadirachtin.
- **Yield and Cost of Cultivation:** Neem starts bearing fruits after 3-5 years and comes to full bearing at the age of 10-12 years. Fruit yield is 10-25 kg per tree per year in the initial years. A mature tree

produces 35-50 kg fruit/year. Oil yield varies from 40-43% of seed on dry weight basis. Highest oil content has been reported from Banswara region of Rajasthan (43.2%), while the lowest oil yield of 32.4% has been reported from Jaisalmer region. It has been observed that as rainfall in an area increases oil content also increases. Among the International provenances tested, Bangladesh provenance has yielded maximum oil content (48.6%). However we presume a conservative yield of 5,7,10,15, 20 kg/tree respectively from 5th year onwards. Yield generally stabilises from 9th year. Sale price of the seed may be considered @ Rs.3/kg. Irrigating the young stock, keeping the field clear from competing weeds & soil loosening have been reported to produce good results in neem.

### Therapeutic Uses:

Neem has proved effective against certain fungi that infect the human body. Neem oil has antibacterial, Antiviral, antimalarial, antipyretic & anti-inflammatory activities. Neem may also be a ready source of low cost analgesic (pain relieving) or antipyretic (fever reducing) compounds. Ancient practice and initial testing of neem derivatives against various livestock pests indicated that this is an area of particular promise for the future. Insects of veterinary importance are obvious targets for neem products. Powdered leaves are a major component of atleast one widely used facial cream. Purified neem oil is also used in nail polish & other cosmetics. Neem oil is non drying and it resists degradation better than most vegetable oils. In rural India, it is commonly used to grease cart wheels. Neem has demonstrated considerable potential as a fertilizer. Neem cake is widely used to fertilize cash crops particularly sugarcane & vegetables. Neem has multiple uses. The wood is used as timber for construction, furniture etc. Neem leaves are good fodder for sheep's and camels. Neem seed yields 20-30% oil content. Neem oil yields azadirachtin which is used as insect repellent.



## *Carum carvi* Linn.

**Family-** Apiaceae

Ayurvedic Name	Krsnajiraka
Hindi Name	Kala Jira, Shiahjira, Sushavi
English Name	Caraway
Unani Name	Zeera siyah
Trade Name	Kala Jira
Parts used	Seeds/ roots



Flowers of *Carum carvi*

### Morphological Characteristics

An annual or biennial glabrous herb, 30-100 cm in height. Root fusiform and thick. Stem slender, branches grooved and hollow. Leaves pinnately dissected 15-20 cm long, leaflets ovate, laciniately cleft into linear, entire or denatate lobes. Flowers white in dense umbels; schizocarp oblong-oval, yellowish brown in colour. Mericarp is aromatic, 4-6 mm long, hard and sharp, mostly curved, light or dark brown with five prominent ribs. It is native to Europe and West Asia. In India, six species of *Carum* are reported, out of which *C. carvi* is used and cultivated.

### Floral Characteristics

The bracts, which are formed after flowering, cover the tiny, white, or pink flowers. both partial and general umbels. Each of the lateral branches and the main trunk end in a complex flowering umbel with eight to sixteen umbel rays. There is hardly any evidence of the epicalyx or calyx. The tiny, reddish or white florets are of varying sizes. The fruit is an elliptical, glabrous, oblong schizocarpic. It comprises 3 to 6 mm long, brownish, sickle-shaped mericarps with five lighter, angular main ribs.

### Distribution

Plant is cultivated widely in northern and central parts of Europe, Turkey, India and North Africa. It occurs wild to a limited extent in the temperate and subtropical regions of the Western Himalayas from Jammu and Kashmir to Uttarakhand. Cultivated in the hills of northern and southern India as a summer crop, and in the plains as an annual winter crop for its aromatic seeds. In Garhwal, it is cultivated in the kitchen gardens of the Niti and Mana valleys in Chamoli district. It can be cultivated between altitudes of 1800 and 2500m in hill regions. It is also available in Canada, United States, Morocco, Germany, Russia, Norway, and Sweden.

### Climate and Soil

In temperate and high altitude regions, with warm summers followed by cold winters and snowfall, is the best climate for its optimum growth. Loam and sandy loam is appropriate for cultivation, especially for the better production of bulbous root, but any soil is adequate, although waterlogging increases the mortality rate.

### Propagation Material

Mainly through seeds or sometimes-through bulbous roots. Multiplication through bulbous rootstock is



also very successful. For this, rootstock from plants at least two or three years old are used. The rootstock sprouts in March/April and bears flowers & fruits in May/June. Larger rootstock tend to yield seeds. The rootstock once planted continue to flower and fruit for ten years.

### Agro-Technique<sup>5</sup>

#### Nursery Technique

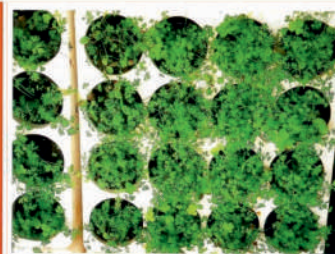
**Raising Propagules:** About 38,000 plants or 6-8 kg seeds are required for one acre of land, when plants are placed 40 cm apart.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The land is dug up or ploughed twice or thrice until a fine tilth, soil is obtained. This crop requires a large quantity of organic manure, especially in sandy soil. Normally, 25 qt manure is required for one hectare of land. Mulching with manure in November and December encourages early and better sprouting. In the plains, where manure or litter are not available, an application of nitrogen (25-30 kg) and phosphorus at 10-12kg per hectare is beneficial. Manuring should be done before seed sowing or rootstock transplanting.



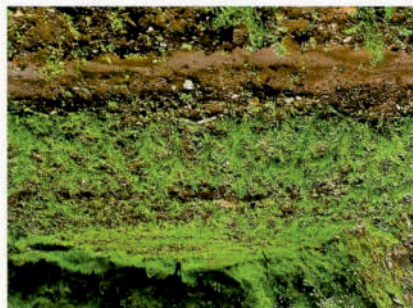
Seedling development stages



Full grown seedlings in styrofoam trays

- **Transplanting and Optimum Spacing:**

The appropriate sowing time as well as multiplication through rootstock happens during October and November in the hills. The seeds are sown in lines 20-30 cm apart. Germination takes



Cultivation of *Carum carvi* at 2200 m



Dry seeds of *Carum carvi*

place after February when the snow melts at high altitudes or the temperature begins to rise. For early germination, however, seeds can be sown inside a greenhouse or in Styrofoam trays. After germination, plants form small rootstock during the first year and remain dormant until the following February or March. When the plants are 5-7 cm tall and are thinned to 20 cm apart in the line. The aerial parts again dry up during the winter. This cycle is repeated for four growing seasons, after which flowering and fruiting takes place. Floral primordial are well developed after heavy snowfalls followed by the beginning of good flowering and fruiting during May and June when occasional showers dampen the air as well as the soil.

<sup>5</sup> Agro-technique study carried out by Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.

- **Intercropping System:** In Himachal Pradesh, it is also recommended as an intercrop in orchards.
- **Intercultural and Maintenance Practices:** Mulching with manure in November and December encourages early and better sprouting. In the plains, where manure or litter are not available, an application of nitrogen (25-30 kg) and phosphorus at 10-12 kg per hectare is beneficial.
- **Irrigation Practices:** The crop is irrigated once a fortnight during the dry months. During the dormancy period, irrigation, once a week is sufficient.
- **Weeding:** Thinning once during the growing season increases growth. The fields are weeded with a shallow scraper every fifteen days during the growing season. During flowering and fruiting, the mustard aphid, butterfly and caterpillars attack the crop. Applications of Aldrin at the time of weeding is beneficial.
- **Disease and Pest Control:** During flowering and fruiting, the mustard aphid, butterfly and caterpillars attack the crop. Applications of Aldrin at the time of weeding is beneficial.

### Harvest Management

- **Crop Maturity and Harvesting:** Flowering occurs from the end of May to June, and seeds are formed in mid-June, 30-35 days after flowering in the hills. Harvesting is done when seeds turn brown. Mature seeds are harvested for sowing. The best harvesting time is in the morning, which prevents the loss of seeds due to the shattering of fruits.
- **Post-harvest Management:** The essential oil content varies with the degree of seed maturity. The best harvesting time for essential oil is when seeds turn brown, ten to twenty days before full maturity. Storage also affects the oil contents of seeds. In hilly regions the maximum oil content is obtained when a dry summer is followed by a cold winter with ten to fifteen days snowfall. Based on these observations, altitudes of 1800 to 2500 m in the Garhwal Himalayan region seem best for its cultivation.
- **Post-harvesting Techniques:** The plants are cut and dried. The fruits are threshed with sticks. Seeds are marketed either whole or ground. Whole seeds are in greater demand than ground as sometimes this is adulterated with cheaper seeds of a similar flavour. Complete drying is necessary before storage as moist conditions cause fungal infections, which cause the quality to deteriorate.
- **Chemical Constituents:** When ground, caraway seeds yield up to 7.5% of volatile oil, mostly D-carvone, and 15% fixed oil of which the major fatty acids are oleic, linoleic, petroselinic, and palmitic acids. Phytochemicals identified in caraway seed oil include thymol, o-cymene,  $\gamma$ -terpinene, trimethylene dichloride,  $\beta$ -pinene, 2-(1-cyclohexenyl), cyclohexanone,  $\beta$ -phellandrene, 3-carene,  $\alpha$ -thujene, and linalool. Seeds contain 5.8-8.1% essential oil, of which carvone and limonene are the chief constituents. Other chemical constituents are pinenes a and b, p-cymene, carveol, discetyl furfural, methyl alcohol, acetic aldehyde, thiamine, riboflavin and ascorbic acid. Seeds have a pleasant aromatic odour which contains protein, crude oil, resin and several trace elements.
- **Yield and cost of cultivation:** The yield of seeds is estimated at nearly 600-750 kg/ha. The total crop including bulbs and aerial parts is estimated at some 2000 kg/ha. However, yield of 200kg seeds/ha is possible after first harvesting.

### Therapeutic uses



Seeds of *C. carvi* are widely used as a spice for culinary purposes. It is used for flavouring bread, biscuits, cakes, candies, curries, in confectionery and liquors in Europe. It acts as a carminative, mild stomachic, aromatic and diuretic in medicine. In Garhwal, vapour from the seeds is used in the treatment of lumbago and rheumatism. The oil is used in the manufacture of Kummel. The fruit has a dose dependent antispasmodic effect and larvicidal activity against the mosquito. It is also used in gargle preparations, toothpaste flavours and in chewing gum. The mixture of caraway oil with alcohol and castor oil is used for the treatment of scabies. It has anti-bacterial and anti-fungal properties. De-carbonised oil is sold in the market for perfuming cheap soaps. Seed cakes (fruits) are used as cattle feed as they contain a high percentage of crude protein and fat. Roots are eaten after cooking. The young leaves are eaten as salad.

### Market trend (2019/2020)

- **Market price:** Rs. 5-10/gm approximately

## *Chrysanthemum cinerariifolium* (Trevir) Boccone Syn. *Pyrethrum cinerarifolium*

Family- Asteraceae

Hindi Name	Pyrethrum
Trade Name	Pyrethrum
Parts used	Flowers



Flowers of *Chrysanthemum*

### Morphological Characteristics

Plant is a glaucous perennial herb upto 60-70 cm in height. The leaves are long petiole finely cut and silky beneath with distant segments. The term "Pyrethrum" is now applied to dried flower heads of this plant which are considered to be the main source of the active insecticidal ingredients marketed throughout the world. Pyrethrins are highly toxic to a wide variety of insects such as fleas, flies, lice, mosquitoes and numerous species of economically important agricultural insects damaging fruit, vegetable, field crop, forestry and ornamental plants.

### Floral Characteristics

The plants bear numerous flower heads which measure 6-9 mm (closed) and 9-12 mm (open). The involucre consists of 2 to 3 mm of yellowish or greenish yellow, lanceolate hair bracts. Each flower head bears a receptacle 4 to 8 mm in diameter. The receptacle is nearly flat and bears numerous yellow disc florets and single row of cream-coloured ligulate ray-florets, 12 mm in length with three rounded teeth. The cream coloured florets look like that of field daisy (*C. leucanthemum* Linn.) but differ from the latter in having the central teeth of ray florets shorter than the adjacent one.

### Distribution

The cultivation of *C. cinerarifolium* is limited to the hilly areas of Kashmir and Tamil Nadu states in India. However, demand for *Chrysanthemum* is very high as it is a natural insecticide against domestic and field insects with low mammalian toxicity. Considering all these it has become imperative to increase the acreage under commercial cultivation. A prerequisite for commercial cultivation of *C. cinerarifolium* in the subtropical north Indian plains is to determine the optimum planting time under such conditions. It has now been established that middle of October to first week of November is the ideal time for planting of *Chrysanthemum*.

Considering its economical importance, *Chrysanthemum* cultivation needs special attention for extending the areas in Indo-Gangetic plains and Uttarakhand.

### Climate and Soil

*Chrysanthemum* plants grow well in climates with a short mild winter and cool summer. Flower



initiation requires low temperature which must fall below 17°C for five to six weeks. Low temperature treatment has a positive correlation with pyrethrin content and flower yield.

Fertile and well-drained soil is the best for growing of this plant. The yields are considerably low in poorly drained soils. Light and medium loam soil, derived from volcanic rock with good water holding capacity are ideal for the crop. In north Indian plains, *Chrysanthemum* needs organic matter rich sandy loam soil for good crop. Limiting (1 ton/ha) acidic soils which are prevalent in certain Pyrethrum growing areas results in 25 to 30% increase in the flower yield. *Chrysanthemum* grows well in those areas where total annual rainfall is about 100 mm or more. An average rainfall of about 100 mm per month is ideal for growth and flowering. Very high rainfall accompanied by persistent clouds is highly unsuitable for *Chrysanthemum* cultivation as shade reduces the yield considerably. Areas of long period of mist, fog or frost are also unsuitable for cultivation of this plant. Bright sunshine with intermittent as rainfall the ideal condition. Short period of drought are essential for interculture, weed control and harvesting of flowers. In India, Kashmir valley and Himachal Pradesh in North and Nilgiri and Palni hills in South are suitable places for cultivation of this crop. However, Pyrethrum has been introduced recently in Indo-Gangetic plains as winter annual crop and in Uttaranchal hills as perennial crop.

### Propagation Material

*Chrysanthemum* is generally propagated by seed as well as the crop can also be raised vegetatively by splits. It is successfully grown in plains through seedlings prepared by seeds in nursery. Seeds collected from matured flowers are used for sowing in the next season. Upper portion of the flowers are removed and lower portion which has a compact disc, contains seeds. 500 g of seeds should be sown in about 50 square meter land for growing nursery for one hectare of land (about 50,000 seedlings).

### Agro-Technique<sup>6</sup>

#### Nursery technique

**Raising Propagules:** Two to three harrowing are enough for preparation of seedbeds. All weeds and stubbles should be removed from the soil. It is better to make ridges 45-50 cm apart if the land is flat. In case of undulating lands as occur in hilly areas, the land should be terraced. Nurseries are raised during spring (April-May) or autumn (Oct.-Nov.) in traditional *Chrysanthemum* growing areas. In areas where irrigation is available nursery can be raised any time from March to November. In north Indian plains nurseries are raised during August-September. Raised beds of 15-20 cm are prepared and well rotten farm yard manure or vermicompost are thoroughly mixed with top 5 cm soil.

The seeds are sown through broadcasting and covered with rice straw, wheat straw or dried grass as a mulch. Mulching helps in maintaining soil moisture and temperature. The beds are watered at regular intervals. The seeds germinate in 5-10 days depending upon the temperature during the sowing period. After the seeds are sprouted, the mulch is removed. In areas like Nilgiri, it is better to provide partial shade during the early phase of growth of the seedlings especially during the months when sunlight is maximum. In temperate conditions no shading is required. In north Indian plains seed germination is difficult at ambient temperature in August-September. It is generally done under controlled condition at 15-25°C temperature. Seeds take 8-10 days to germinate. Seeds treated with gibberellic acid (GA) showed early and high rate of germination. The seeds should get proper sunlight and should be protected from rain.

<sup>6</sup> Agro-technique study carried out by  
Central Institute of Medicinal and Aromatic Plants, Lucknow.

**Vegetative Propagation:** In some cases, *Chrysanthemum* is vegetatively propagated. For vegetative propagation, healthy plants are up rooted from the ground, splited into pieces having 2-3 nodes and are planted similarly as seedlings. In certain areas it is better to plant the splits first in a nursery before planting in the field. The seedlings are planted at a distance of 30-45 cm in rows and 45-60 cm apart. Ridge planting is always better than flat planting as it facilitates intercultural operation and irrigation and avoid water logging.

### Planting in the field

- **Land preparation and Fertilizer Application:** For field preparation one-two ploughing with mould board plough followed by 2-3 harrowing and planking are required to get a fine tilth. Farmyard manure, compost and basal doses of inorganic P and K may be mixed with the soil during final harrowing or using cultivator. Suitable layout is done as per the field condition and irrigation facilities.
- The plant can be grown without fertilizer in soil but soil should be rich in organic matter and available nutrients. Under optimum soil fertility, nitrogen requirement for *Chrysanthemum* seldom exceeds 50 kg N per hectare. However, the crop responds well to increasing level of P up to 60 kg per hectare ( $P_2O_5$ ) or even more in some soil conditions. In Kashmir valley, the optimum levels of N, P and K are 60, 50 and 80 kg per hectare. Phosphorous and potash and 50% of nitrogen should be applied as basal dose before planting in first year and above mentioned dose should be applied every year after harvesting and mixed properly by hoeing in case of perennial cropping. Rest of the nitrogen (remaining 50%) should be applied in two or three split doses at vegetative growth stage, bolting stage and bud forming stage. In Gangetic plains, fertilizer application is necessary to obtain good flower yield. It has been found that 80-100 kg N/ha, 60 kg  $P_2O_5$ /ha and 60 kg of K/ha give good growth and flower yield of *Chrysanthemum*. One-third of nitrogen and full dose of phosphorous and potash should be applied as basal dose before planting and mixed properly in the soil. The remaining amount of nitrogen should be applied in 2 equal split doses at the time of vegetative growth and bolting stage.
- **Intercropping System:** No intercrop has been carried out with this crop.
- **Intercultural and Maintenance Practices:** *Chrysanthemum* crop requires weed free condition particularly in the initial stages of establishment. In large areas, weeding can be done either manually or mechanically. Hoeing can be done by power tiller or mini tractor-drawn cultivator for *Chrysanthemum* grown in rows. In terraces or small field it can be done manually by khurpi. In perennial crop, the first hoeing is done in autumn after the last crop is harvested.
- **Irrigation Practices:** Water requirement of *Chrysanthemum* is comparatively low. However, irrigations are required as the crop passes through dry period both in hills and north Indian plains. Perennial rain fed *Chrysanthemum* takes a long period to flower. Good flower yield can be obtained after one year if the crop is irrigated frequently during the dry months. In north Indian plains *Chrysanthemum* requires irrigation every fortnight from planting to harvesting (October-April) if rainfall is not proper. About 8- 10 irrigations are required during the growth period for good flower yield.
- **Weeding:** Two hand weeding and one hoeing is required in spring. In north Indian plains 5-6 hand weeding and two hoeing are required to obtain good crop stand and flower yield.



- **Disease and Pest Control:** *Chrysanthemum* cultivation has been found to be affected by several pest and diseases, but three most common diseases such as leaf blight, root rot & wilt and basal stem rot & wilt caused by fungal pathogens have been noticed in the commercial fields of *Pyrethrum* in different parts of the country and elsewhere. The **Leaf blight** disease caused by *Alternaria tenuissima* can be controlled by prophylactic spray of Diethane-M-45 (Mancozeb) @ 0.2-0.3% at the interval of 15 days. Treatment with fungicides (Benomyl) can be used to control **Root rot and wilt** disease caused by *Fusarium*. **Basal stem rot and wilt** caused by *Rhizoctonia solani* can be controlled by fungicides, like Bavistin, Ridomil, Mancozeb, have been suggested to minimize the incidence of this disease under field conditions.

### Harvest Management

- **Crop Maturity and Harvesting:** In Nilgiris hills, three harvests of flowers are obtained as the flowering continues for 9 months. The crop gives poor yield during the first year and the optimum yields are obtained only during 2nd and 3rd year. In temperate areas like Kashmir, the first harvest is obtained in the end of June or 1st week of July. In Indo-Gangetic plains, when crop is planted in last week of October, flowers are picked from 15th March to 15th May when about two-third of the disk florets are open and the ray-florets are horizontal.
- **Post-harvest Management:** Harvesting of immature or over mature flowers decreased their pyrethrins content. The flowers should be dried immediately after picking. In India the flowers are dried in sun in thin layers. These should be turned frequently in order to avoid decomposition. The ideal method of drying of flowers is hot air drier method. The temperature should not exceed 80°C. In larger farms use of air drier is essential in order to dry the harvested flowers in time and avoid damage due to decay of moist flowers.
- **Chemical Constituents:** *Chrysanthemum* are composed of six related insecticidal compounds that occur naturally in the *Chrysanthemum* flowers. These are pyrethrin I, pyrethrin II, cinerin I, cinerin II, janolin I, and janolin II.
- **Yield and Cost of Cultivation:** Flower yield and pyrethrins content in flower depend on agro-climatic conditions and cultural practices. In Kashmir and Uttarakhand hills dry flower yield ranges between 225- 250 kg/ha/year. However, in Nilgiris hills in Tamil Nadu the flower yield is higher and it ranges between 400-450 kg/ha with *Chrysanthemum* content 1%. Although several genotypes have been introduced to Kashmir valley from different countries, the local selection C-761 has *Chrysanthemum* content as high as 1.46%. As mentioned elsewhere *Chrysanthemum* has been successfully introduced and acclimatized in north Indian plains as annual crop of about six months duration. The yield of dry flowers under such conditions is about 8-10 q/ha. The average *Chrysanthemum* content is about 0.7% to 0.8% in selected clones.

### Therapeutic Uses

*Chrysanthemum* has a combination of six esters which show insecticidal properties. *Chrysanthemum* are extracted in the form of concentrated oleoresins by a number of petroleum solvents including petroleum ether, hexane and ethylene chloride. The concentrated extract as such or after refining is used in a number of insecticide formulations. There is no substitute of *Chrysanthemum* in comparison to other insecticides, is its very low mammalian toxicity. Due to this quality, *Chrysanthemum* is the only safe insecticide to be used where synthetic insecticides pose a serious health hazard for human, domestic

animals and wild life. *Pyrethrins* easily degenerate in presence of sunlight and are not harmful as other insecticides which have high residual toxicity. In addition to direct toxic action, pyrethrins have repellent activity which keeps away a number of insects.

*Chrysanthemum* is the only insecticide against which insect's species do not develop the resistance very easily. Large scale development of strains of insects-pest resistant against pyrethrins has not been reported, except in isolated cases. It is also one of the few insecticides which have broad-spectrum activity against a very wide range of insect species. *Chrysanthemum* is used as an insecticide in a number of ways, in the form of powder, sprays, aerosol, coils, creams and ointments.

### Market Trend

- **Market Demand:** World demand for the natural product still exceeds the available supply and major producing countries are increasing their produce rapidly. Current annual production of *Chrysanthemum* in India is about 10 tons and the anticipated potential demand is estimated at 300 tons.



## *Chrysopogon zizanioides* (Linn.) Roberty Syn.: *Vetiveria zizanioides* (Linn.) Nash

Family- Poaceae

Ayurvedic Name	Usira
Hindi Name	Khas-Khas/Khus
English Name	Vetivergrass
Unani Name	Khas
Trade Name	Ushir
Parts used	Root



*Chrysopogon zizanioides* in the field

### Morphological Characteristics

Vetiver or Khus (*Chrysopogon zizanioides* (Linn.) Roberty) is a densely tufted, perennial aromatic grass belonging to family "Poaceae". Roots of vetiver are the source of valuable essential oil, which is used in essential oil industry. Indian vetiver oil, especially of North Indian origin is considered to be the best in the world market. Plant culms are stout, over 2.0 m tall, and form an aromatic roots. Leaf blades are linear, acute 30-90 cm long, 4-20 mm wide, erect, rigid, firm or spongy, glabrous, rarely hairy downwards on the upper surface, pale green. Panicles are oblong up to 30 cm long; usually contracted; rachis stout and smooth. Whorls of branches 6-10 with up to 20 rays; branches oblique to sub-erect, filiform and slightly rough.

### Floral Characteristics

Raceme 5, rarely 12 cm long, very slender; joint about as long as the sessile spikelet or sometimes distinctly exceeding them in length, smooth or more or less rough, minutely and unequally ciliate at the slightly oblique tips; pedicels smaller but shorter sessile spikelet, linear-lanceolate to almost linear acute or sub-acute, 4.0-4.5 mm long, yellowish, olive, violet brown or purplish to almost black, callus obtuse, less than 1 mm long glabrous, glumes acute, coriaceous, lower muriculate, 5 nerved, lateral nerves close, very fine upper glume spinulose muricate on the keel. Lemma of the lowest floret as long as the glumes acute, retrorsely ciliate; lower floret hermaphrodite; lemma up to 3 mm, long narrow, oblong, lanceolate mucronulate, ciliate. Anthers 2-3 mm long. Pedicelled spikelet almost smooth; lemma of upper floret entire, acute. The length of root varies from 10 cm to 35 cm or more according to the condition of growth, soil, climate, availability of water in soil at different depth, etc.

### Distribution

In India, vetiver grows in Uttar Pradesh, Rajasthan and some parts of southern and Peninsular India.

### Climate and Soil

Well drained, loamy soils of pH 6-8 are considered ideal as the roots produced in such soils are thick and contain more essential oil with the improved varieties like (IM-Vriddhi & KS-1) etc. *Vetiver* cultivation can also be done successfully on the riverine coastal areas. *Vetiver* crop requires subtropical climatic conditions for better growth and oil recovery. The crop grows luxuriantly with a rainfall of 100-200 cm and temperature of 22-43°C. *Vetiver* is tolerant to a wide range of temperature ranging from -15 °C to

+55°C, depending on growing region. The optimal soil temperature for root growth is 25°C. Root dormancy occurs when temperature goes below 5 °C.

### Propagation Material

#### Agro-Technique<sup>7</sup>

#### Nursery Technique

- **Raising Propagules:** This plant is propagated vegetatively mostly through slips. Propagation through seeds is restricted to breeding purpose only for development of new varieties. For obtaining planting material (slips); shoots of 6-8 month old clump are cut 25-30 cm above the ground and clumps are dug and split into slips (a stem with some portion of roots remained intact on it). Slips thus obtained are kept moist and stored in shade. Planting slips having only hard wood should be avoided.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** Fine tilth is essential for cultivation of *Vetiver* for better root production. At the time of planting the field should be deep ploughed, a harrowed and brought to a fine tilth. Proper levelling of soil is to be done to avoid water stress and water logging. The land is laid into plots/beds of conventional size for irrigation. About 10-15 ton/ha FYM / Compost or 5-7.5 ton/ha vermi compost should be mixed well with soil before 15-20 days of planting if soils are poor in nutrient. This will help in proper root growth and makes the digging of root easy. Due to its high shoot biomass, *Vetiver* requires a high amount of major nutrients. However, because of its dense and deeper root system it can uptake nutrients from much deeper soils. Therefore, application of major (NPK) nutrients is necessary for optimum growth and root yield. In such conditions application of 100 Kg N, 60 Kg P and 50 Kg K per hectare has been recommended. Nitrogen (one-third) should be applied at the time of transplanting and remaining at an interval of 30 and 90 days after plant establishment. Combined supply of organic and inorganic nutrients helps increase productivity as well as soil fertility.
- **Transplanting and Optimum Spacing:** In general conditions, the slips from healthy and disease free clumps are planted during June-July with the onset of monsoon vertically about 10 cm deep at a spacing of 30x30 cm/60x30 cm / 60 x 45 cm / 60 x 60 cm based on soil fertility status, climate, variety and irrigation facility. *Vetiver* crop produce higher yields if slips are transplanted on ridge at a distance of 45cm. Plant population varies from 27,800 to 1,10,000 plants/ha. If irrigation facilities are available, it is better to plant during March-April. Late planting results in the production of coarse roots which yield inferior quality oil. In South Indian conditions where temporal and diurnal variation in temperature is not significant and monsoon sets in early, the ideal planting time is February to April. But for the rainfed areas, monsoon planting only is considered to be the most ideal.



<sup>7</sup> Agro-technique study carried out by  
Central Institute of Medicinal and Aromatic Plants, Lucknow.



On sloppy undulating and problematic soils also, it should be planted in rainy season only. Interspaces between row to row and plant to plant are determined by type of soil, fertility status, climate, irrigation facility and variety grown.

- **Intercropping System:** In the early part (March-May) of the crop growth, the interspaces can be utilized for suitable intercropping of some other important crops like *Mentha Piperita* and *Mentha arvensis* which would generate additional revenue and help in better utilization of resources (irrigation water, fertilizer) and better profits to the farmers.
- **Intercultural and Maintenance Practices:** In case of newly established crop, 2-3 weeding and earthing-up at an interval of one month are needed during initial period of plant growth. Once the crop is established, weeds are kept under check because of *vetiver's* thick and dense shoot cover. Aerial portion is trimmed at 20-30 cm above ground level twice during the entire cropping period.
- **Irrigation Practices:** In the absence of rainfall, soil moisture status should be maintained by irrigation from planting to establishment. In the areas where rainfall is good, well distributed over the year and humidity is high, in dry areas about 8-10 irrigations will be required to get the optimum yield. Apply mulch to conserve soil moisture. Irrigation should be discontinued 7-10 days before harvesting.
- **Weeding:** *Vetiver* is a fast growing well competitive plant and once established, it does not allow weeds to grow. However, some weeds like *Cynodon dactylon*, *Cyperus rotundus*, *Argemone mexicana* and *Parthenium hysterophorus* do infest *vetiver* field and can adversely affect the root growth. To suppress weed growth two to three weeding and two hoeing are recommended for optimum growth of plants and root development. Weed growth can also be checked by use of herbicide atrazine or simazine @1.5 kg/ha as pre-emergence.
- **Disease and Pest Control:** *Vetiver* is a quite hardy plant, therefore, resistant to severe disease and insect pest attack. Some minor infections like leaf spot caused by *Curvularia trifolii* may be observed during rainy season. *Fusarium* occurrence is also seen only during rains. The damage caused by such infections is very minor. Insects like scale insects and termites can do some damage to the crop in the early stage of growth. Timely spraying of Metasystox 0.4% and application of chloropyriphos at the rate of 600- 800 mL/ha with irrigation water are recommended to check the damage caused by scale insects and termites, respectively. A beetle (*Phyllophaga serrata*) has also been reported to be infesting *Vetiver* crop. This can be controlled by broadcasting 65% Lindane (1.25Kg/ha) before final ploughing. Sometimes rats/rodents damage the roots of *Vetiver*. Proper measure should be taken for the rodent control.

### Harvest Management

- **Crop Maturity and Harvesting:** Digging of roots after 10-12 months is recommended for winter planted crop. November/ February period has been found to be the right time for harvesting, as the oil content is maximum during that period. Digging after February may result in lower recovery and poor quality of oil. Low soil moisture at the time of digging helps in the separation of roots as the soil adhered to it can be shaken off easily. In case of moist soil or heavy textured soil where the water table is high and soil remains wet for a longer period, the root after digging are left in the field for 2-3 days to dry out the soils for easy separation of roots. A tractor drawn mould board plough or a single disc

plough can be used for efficient digging of roots up to 35-40cm depth. Finally, roots are washed with clean water followed by shade drying until excess moisture is reduced.

- **Post-harvest Management:** Distillation is an important process for extraction of essential or volatile oil from *Vetiver* roots, known as *Vetiver* oil or 'Khus oil'. The process of distillation consists of soaking and cleaning of the root mass prior to packing in the distillation unit. Before distillation, khus roots should be soaked in water for 12-14 hours for the faster oil extraction. Chopping of roots has an additional advantage that a large quantity of roots can be packed in to a still. The distillation period is usually 12-16 hrs. Distillation for period less than the prescribed hours gives up lower recovery of oil. Similarly prolonging the distillation period result in recovery of undesired fraction causing poor odour value of oil. The still operates on the principle of water and/or steam distillation. The distillation of Khus roots is a refined technique owing to the viscid nature of the oil, low volatility and high boiling point. The separation of the oil from water is to be done carefully due to the fact that the specific gravity of the oil is almost equal to that of water. The distillation unit is usually made of mild steel or stainless steel. Traditionally copper stills are also commonly used as they are durable and produce good quality of oil. CIMAP has developed improved processing technology and distillation unit for better recovery and quality of vetiver.
- **Chemical Constituents:** The oil contains both cadinane and eudesmane sesquiterpenes of unusual antipodal configuration, including khusol, Khusimol, Khusitone, leavojuneol etc. Presence of laevorotatory khusimol (a rare C-14 class of terpenoid) is a unique feature of north Indian khus oil. On the other hand oils from the southern India, dextrorotatory, contain more of hydrocarbons and less of oxygenated constituents and are therefore, of inferior oils factory value. Ketone sesquiterpenes and the ester vetivery, vetivenate chiefly attribute odour of the oil.
- **Yield and Cost of Cultivation:** Depending upon growing conditions, climate, nature of soil and management practices, root yield varies from 25-30 quintal/ha and oil yield 25-30 kg/ha. Oil recovery on commercial scale ranges from 1.0 to 1.2% depending upon the variety and process including efficient design of distillation unit.



Crop in the field

### Therapeutic Uses

The oil is widely used in perfumery industry, herbal cosmetics, soaps and perfumes. The oil is a high grade fixative and blends well with sandal wood, lavender, patchouli and rose oil. In India, vetiver finds extensive use in tobacco, pan masala and cold beverages industries. Raw roots knitted into the home fans and water soaked roots placed against fans impart pleasant fragrance to air.

In addition to above, Khas which is also known as "Ushir" in Sanskrit is also used in Ayurvedic and Unani system of Medicine for the treatment of many diseases. Its roots are diuretic, cardio tonic, thirst, antiemetic, antidiarrheal, wound healer and have galactagogue properties. The syrup prepared from it is used as a drink for giving cooling effects.



The *vetiver* roots have brain cooling, bitter, alexitric, soporific, stomachic and astringent properties. They are useful in severe headache, bilious fevers, sweats, foul breath, strangury ulcers and blood disease. Vetiver oil is also used in remedies against snake bite, cancer, bacterial and fungal infections.

The roots are also widely used for making common articles like screens, mats, handicrafts, fancy hand fans, bags and ornamentals baskets and incense sticks.

The *vetiver* leaves, rachis and whole plant have several additional uses. Young leaves are browsed by cattle and sheep (as fodder). Dried leaves are used for thatching of huts. The plants is often planted on sloppy lands to check soil erosion. It also help to reduce silt build up downstream. In addition, *vetiver* hedge might prove excellent as wind breaks in decertifying areas.

### Market trend (2019/2020)

- **Market price:** Rs. 16,500 – 17,000 /kg (current market price)
- **Market demand:** The world production of *vetiver* oil is around 300 tons per annum of which India contributed about 20-25 tons only. The global *vetiver* oil market demand was estimated at 408.8 tons in 2019. It is expected to expand at a volume based CAGR of 7.8% from 2020-2027. The Indian consumption at present is about 100 tons and more than 80% is met by import.

## *Gloriosa superba* Linn.

**Family - Liliaceae**

Ayurvedic Name	Langali
Hindi Name	Kalihari, Agnishikha
English Name	Glory lily
Unani Name	Garbhapatini
Trade Name	Glory Lily, Malabar Lily
Parts used	Rhizome and Seed



*Gloriosa superba* Linn.

### Morphological Characteristics

*Gloriosa superba* is a perennial climber up to 1.5 m tall. The slender stems are produced annually and are upright to scrambling and can grow up to 4 m long. Tubers sprout in spring, and a tuber sends up 1 to 2 stems. The leaves are shiny, bright green, and are tipped in a tendril, which will cling to anything it touches. The stems die back in late summer and the tubers are dormant during winter.

### Floral Characteristics

The flowers are large and showy (4.5-7.0 cm across) with six 'petals' (*i.e.* perianth segments or tepals) that are red, orange, and yellow in color. These elongated petals (5-8 cm long and 7-15 mm wide) have wavy (*i.e.* undulating) margins and are strongly bent backward (*i.e.* reflexed). They are actually derived from three petals and three sepals which are almost identical in appearance. They are most commonly scarlet red or reddish-orange with yellow bases, and as they age they become entirely dull red or purplish in color. The flowers also have six very conspicuous stamens, with large anthers (7-10 mm long) that are borne on stalks (*i.e.* filaments) 3-7 cm long. They also have a large style (3.5-5.5 cm long), which splits into three short branches near its tip. These flowers are borne on stalks (*i.e.* pedicels) 4-20 cm long that emanate from the upper leaf forks (*i.e.* axils). Flowering occurs mostly during summer to autumn (*i.e.* from May to October).

### Distribution

Tropical South Africa, Madagascar, India, China and Malaysia.

### Climate and Soil

Well-drained sandy loamy porous soils are well suited for the cultivation of *Gloriosa superba*. The ideal pH should be 6.0-7.0. This can be cultivated in tropical and subtropical parts of India up to 2100 m from mean sea level with an annual rainfall of even 70 cm. Warm and humid climate in early period of growth are ideally suited for this crop.



### Planting Material

Tubers and Seeds

### Agro-techniques<sup>8</sup>

#### Nursery Techniques

The plant can be propagated by both seed and rhizomes. Seeds are used to produce tubers in the nursery. However, commercial plantation is raised using tubers. The best time for seed sowing in the nursery is March-April. Seeds can be treated using hot water along with different chemicals i.e. Thiourea,  $\text{KNO}_3$ , also seeds are treated with growth

#### Propagule rate and pre-treatment

About 2000-3000 kg tubers are required for planting one hectare. Before planting, tubers are treated with 0.1% carbendazim or organo-mercurial fungicide to protect them from fungal attack.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The land should be ploughed, harrowed, and planked to good tilth. The field should be leveled properly and divided into beds of convenient size. Proper arrangements for drainage should be kept to avoid water logging during the rainy season. About 15-20t/ha of well rotten FYM should be mixed in the soil at the time of land preparation. A fertilizer dose of 120 Kg N, 50 kg P, and 75 Kg K per ha is applied for good crop yield. Half of N and the complete dose of P and K are applied as basal dressing. The remaining dose of Nitrogen is applied after one and two months of planting.
- **Planting and Optimum Spacing:** Deep furrows, 6-8 cm are opened at a spacing of 45-60 cm. Tubers are planted in the field during June-July with 60 cm x 45 cm spacing between plant to plant and row to row. In order to avoid rotting of the tubers before sprouting, only healthy tubers should be selected for planting.
- **Intercrop**
- **Intercultural and Maintenance Practices:** Periodic manual weeding and hoeing are required for proper growth. However, in the initial stage, it requires frequent weeding. Manual weeding is good for plant growth. Chemical weeding should be avoided. Since, its stem is very tender, the provision of some kind of support is necessary. The stems should be staked with bamboo sticks or allowed to trail on the wooden or iron frame. When the plants are about 30-40 cm tall, they should be staked or tied to wires or allowed to climb on some sort of frame. There are two types of structures adopted by farmers. One method is planting of four feet wooden sticks alongside of the furrows with the spacing of about 15 feet between sticks. 3-4 steel wires are tied parallel to the tip of wooden sticks. Sorghum straw is inserted in between steel wires. This facilitates the plant to climb. In the other method, the farmers use iron rods (3'x3'x3'), instead of wooden sticks and rest of the support system is same as in the case of wooden support system. The main disadvantage of wooden system is that wooden sticks are to be replaced frequently due to termite attack.

<sup>8</sup> Agro-technique study carried out by

Division of Forest Products and Utilization, Faculty of Horticulture & Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu 180009 (J&K)

- **Irrigation Practices:** Light irrigation is applied immediately after planting of tubers and later on 4-7 days intervals or as and when required. There should be no hard pan formation during the sprouting and emergence of the growing tip. Irrigation should be withheld after the flowering is over to prevent the rotting of the tubers. Frequent or heavy irrigation may cause rotting of tubers.
- **Weeding:** During the initial stages of crop establishment, frequent weeding is required to avoid competition of weeds with the main crop. While weeding, utmost care is to be taken to avoid any damage of growing tip of rhizomes as once the growing tip is damaged, it does not sprout again during the season. Chemical weeding is avoided.
- **Disease and Pest Control:** Major pests of *Gloriosa* are Lily Caterpillar and Green Caterpillar. The caterpillars feed on almost all parts of the plant and damage the growing tips. They can effectively be controlled by spraying 5% Neem seed Kernel Extract as and when required. Following major diseases are reported in *Gloriosa*:

**Leaf Blight:** The affected leaves first become light yellow and later turn into black spots which ultimately spread over the entire leaf. The disease can be controlled by spraying 0.3% Mancozeb.

**Tuber Rot or Basal Stem Rotting and Wilting:** The soil-borne *Sclerotium* spp. affects the underground tubers and causes the death of the plant. In the initial stage, infected tubers start becoming soft and the foliage exhibits a yellow appearance in advanced stages, the whole tuber gets infected and the plant dies off. Drenching the soil with Carbendazim @ 0.2% in the root zone of the plant controls tuber/basal/stem rotting.

### Harvest Management

- **Crop Maturity and Harvesting:** The crop raised through tubers, planted in the month of June starts bearing after 50-60 days and continues to flower and set fruit till October. The fruit requires about 105-110 days to change its color from dark-green to light yellowish-green, and appear shrunken and light in weight. At this stage, the fruits are harvested, and kept in shade for 7-10 days to facilitate the capsules to open up. The seed and pericarp are separated manually and dried for a week in the shade.
- **Post-harvest Management:** The fruits harvested after 105-110 days are dried in shade for 10-15 days. After digging out, the tubers are rubbed with dry cloth and cut into pieces. The tubers should not be dipped in water for cleaning because colchicine easily dissolves in water. The tubers should be cut into small pieces which are dried in shade. Seeds and tubers are stored in air-tight containers separately to increase their shelf-life.
- **Chemical Constituents:** Colchicine, Gloriosine, Lumicolchicine, Colchicoside.
- **Yield and Cost of Cultivation:** 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 and one ton of tubers may be harvested.

### Therapeutic Uses

The seeds and tubers contain alkaloid colchicine which is widely used for the treatment of gout and rheumatism. In Indian System of Medicines, it is used for the treatment of gout, infertility, open wounds,



snakebite, ulcers, arthritis, cholera, colic, kidney problems, typhus, itching, leprosy, bruises, sprains, hemorrhoids, cancer, impotence, nocturnal emission, smallpox, sexually transmitted diseases, and many types of internal parasites.

### **Market Trend (2019/2020)**

- **Market price:** seed- Rs1000-1500/kg Tubers- Rs.300-400/kg

## *Hippophae rhamnoides* Linn.

**Family** - Elaeagnaceae

Ayurvedic Name	Badriphal
Hindi Name	Badriphal
English Name	Seabuckthorn
Unani Name	-
Trade Name	Sea Buckthorn, Leh Berry
Parts used	Fruit



Fruit of *Hippophae rhamnoides* Linn.

### Morphological Characteristics

Seabuckthorn (*Hippophae rhamnoides*) is a thorny, temperate bush. Plant is a hardy, deciduous shrub that can grow between 2 to 4 m high. Root is tap root, much branched, having primary, secondary and tertiary roots covered with root hair, found more prominently in the apical portion. The stem is hard, woody, erect, generally multiparous, rarely uniparous or biparous, cylindrical, perennial, spiny, waxy at young stage and rough when mature. The young stem is generally silvery white and smooth in nature covered with white scales and multicellular hair which disappear as stem matures. It has a rough, brown or black bark and a thick, grayish-green crown. The leaves are alternate, narrow and lanceolate, with silvery-green upper faces. The oval or lightly roundish fruits grow in compact grapes/occurs varying from pale yellow to dark orange. Individual fruits weigh between 270 and 480 mg. The plants have a very developed extensive root system, and the roots live in symbiosis with nitrogen-fixing *Frankia* bacteria. The roots also transform insoluble organic and mineral matters from the soil into more soluble states.

### Floral Characteristics

Inflorescence is solitary axillary clusters or racemose type. The male inflorescence is built up of four to six apetalous flowers, while the female inflorescence normally consists of only one apetalous flower and contains one ovary and one ovule. Fertilization occurs solely via wind pollination, so male plants need to be close to female plants to allow for fertilization and fruit production.

#### Male Flower:

Male flowers are minute, solitary, axillary, in clusters of 14-15 flowers, arranged in two whorls of 7-8 flowers each. Average length and width of male flower is 2.11 and 1.62 mm respectively. Flowers are bracteates, actinomorphic, perianth 2 and stamens four in number. Flower bud initiation starts in last week of March and pollen matures in first week of May.

**Female Flower:** Inflorescence is solitary, axillary clusters or racemose. Flower bud initiation starts in last week of March. Flowers are bracteates, actinomorphic, minute, unisexual, numerous, perianth two, flowers in one whorl of 5-6. Perianth is in two whorls, free above and joined below. Gynoecium is monocarpous, monomerous, carpel stylate, apically stigmatic. Ovary superior, unilocular, with single basal ovule, shortly funicled, ascending, anatropous, bitegmic and crassinucellate. Fruits are small drupe (Utricle). Seed are Dark brown, ovoid to elliptical in shape having crustaceous, shiny testa.



### Distribution

Plant is widely distributed throughout the dry temperate regions of Europe and Asia. In India, it is found in abundance in Lahaul-Spiti, Kinnaur and Chamba in Himachal Pradesh, Kumaon and Gharwal hills of Uttaranchal and in the Ladakh region of Jammu & Kashmir besides Sikkim and Arunachal Pradesh in NE region. Seabuckthorn is said to be a native of Himalayas. It has been found growing wild in Ladakh since time immemorial. In Ladakh, it grows naturally in all five valleys viz. Indua, Suru valleys found growing along the rivers, agricultural fields and also in wasteland, rocky and salt affected soils. It grows naturally in various parts of Leh valley mainly in Stakna. In Nubra valley, it grows along the banks of Nubra and Shylok rivers and along irrigation channels. A thick population of plants has been noticed on the sand dunes between Warsi, Sumur and between Khalsar and Thoise.

### Climate and Soil

In nature, *H. rhamnoides* is found growing profusely on a wide range of soil types, but soil with a light physical structure, rich in nutrients with a pH 6.5–7.5 is better for the plant growth. Best growth occurs in deep, well-drained, sandy loam with ample organic matter. *H. rhamnoides* is considered drought resistant but it is a moisture sensitive plant especially in the spring when plants are flowering and young fruits are beginning to develop. Planting in arid or semiarid areas is possible, if water is supplied for establishment. It can bear fruits at altitudes up to 2000 m above sea level. The plant can withstand temperatures from  $-43^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ . It flowers at temperatures 10 to  $15^{\circ}\text{C}$  and requires total effective temperatures, spring to harvest time, of  $14.5^{\circ}\text{C}$  to  $17.5^{\circ}\text{C}$ , depending on latitude, elevation and species. Frost hardiness is the highest in deep dormancy in November and December. During this period, negative temperatures of  $-50^{\circ}\text{C}$  may be tolerated. Whereas in the post-dormant period in January to March, the critical temperature drops in air temperature for the male to  $-30^{\circ}\text{C}$  to  $-35^{\circ}\text{C}$  and for the female,  $-40^{\circ}\text{C}$  to  $-45^{\circ}\text{C}$ .

### Propagation Material

Vegetative reproduction of the plants occurs rapidly through root suckers. Propagation through seeds is not commonly used in orchards because the species is dioecious. With vegetative propagation, the cuttings will bear fruit 1 to 2 years earlier than seed propagated trees and the genetics and sex are known from the mother plant. Sea buckthorn can be propagated by using both hardwood or softwood cuttings, root cuttings, layering and suckers.

### Agro-Technique<sup>9</sup>

#### Nursery Technique

The large morphological diversity is a good indication for opportunities in selection of desired characteristics for a given region. Seabuckthorn has been growing wild under natural conditions and planted by local farmers or by Forest Department for protection of flood/soil erosion on river banks, sand dunes fixation or for fencing the new plantation or agricultural fields. However, for commercial cultivation, it is imperative that the crop is multiplied from the best material which has been selected for its fruit yield. Seabuckthorn can be propagated by various methods.

**Seeds:** Seabuckthorn can be propagated successfully by seed which are viable for a period of two years, after two year seeds lose viability rapidly. Seeds are smaller with brown and hard seed coat. About 100-

<sup>9</sup> Agro-technique study carried out by  
Defence Research & Development Organisation (DRDO), Leh (Ladakh), J&K

105 seeds are obtain in one gram yield of seeds. The freshly harvested seeds have a short physiological dormancy and thus, cannot germinate immediately after harvesting. May is the best time for sowing of seeds in nursery beds. Before sowing the mature seeds should be stratified for about 20-25 days by keeping in a box in alternate layers of moist sand. These boxes are kept under cool and shady condition. Seeds can also be sown directly in nursery beds in the month of November where cold treatment is given before germination under natural conditions.

**Suckers:** Seabuckthorn has profuse suckering habit and has been reported to yield 13-65 suckers per plant depending upon the growing conditions and age of the plants. These suckers are true to the type which can be separated along with the roots from the mother plants and planted directly at the planting site. The best time for separation of suckers and planting in March before buds break. Care should be taken to identify and tag plants during the fruiting season in order to avoid mixing of male and female suckers. This method being an asexual method of propagation produces true to type plants. However, the major disadvantage is difficulty in operation due to thorny plant structure.

**Cuttings:** Seabuckthorn can be propagated successfully by stem cuttings and this method has been recommended for commercial propagation. It helps in development of a scientific structure of the plant and maintenance of male/female ratio in the orchard. One to two year old stem cuttings having pencil thickness are ideal for its propagation. The stem cuttings are taken from identified male and female plant to get elite planting material. The best time for taking cutting is in the month of March. The side branches and thorns are removed and 30 cm long cuttings are made. The cuttings are then placed in running water by dipping 2/3 to 1/2 lower portion of cutting in water for a period of 2-3 days. This helps in removal of anti-rooting compounds present in the cuttings and activates the cells for absorption of rooting hormone which is applied before planting. The cuttings should be placed in shade away from the sun. If the cuttings are not to be planted immediately or transported to a longer distance both upper and lower cut ends should be sealed with wax to reduce the water loss and minimize the attack of microorganisms. The wax must be removed before planting in the nursery. Seabuckthorn cuttings are not easy to root on their own, thus the quick dip in rooting hormone Indole Butyric Acid (IBA) is applied @ 500 ppm before planting it in the nursery beds. The best time for planting of cuttings has been found to be the month of April. Properly treated cuttings should be planted soon after treatment in well prepared nursery beds. Planting should be done in rows 30-45 cm apart and proper spacing between the cuttings. While planting the cuttings in nursery beds, 2/3 part of cuttings having at least 3 nodes embedded in the soil. Cuttings are planted slanting at an angle of 45° which helps in better rooting. Nursery beds are irrigated immediately after planting and kept moist by light and frequent watering. The conditions ideal for rooting are highly porous soil with high temperature and humidity conditions. Moisture stress at any stage and low temperature at the time of rooting reduces success. Seabuckthorn normally takes 60-75 days in rooting depending upon the soil and climatic conditions. About 85% success has been recorded in rooting of stem cuttings under Ladakh conditions.

**Micro Propagation:** Micro propagation is the most modern method of propagation and fast multiplication of elite planting material. This is preferred under controlled conditions. It helps in production of disease free planting materials throughout the year and in conservation of valuable, exotic and indigenous materials under laboratory conditions. Modern tissue culture laboratory has been established at Field Research Laboratory (DRDO), Leh for micro propagation of Seabuckthorn. Shoot



proliferation has been achieved by using Murashige and Skoog (MS) nutrient media having 30g sucrose, 08 gm agar and plant bio regulators viz 0.01 ppm IBA & 2.0 ppm BA and 1.0 ppm NAA for shoot proliferation and rooting respectively. These plants will be hardened in greenhouse, for commercial cultivation.

### Nursery Management

**Selection of site for Nursery Bed:** Light and well drained soils are ideal for nursery area. The selected site should be in a sunny location with assured irrigation facilities. Nursery bed should be rich in organic matter and other nutrients.

**Preparation of Nursery Beds:** Before sowing seeds in nursery the bed should be ploughed deep. Well-rotted FYM @4kg/m<sup>2</sup> should be incorporated in the soil 20-30 days before sowing/planting. Beds should be dug properly and should be free from stones, pebbles, roots, weeds, etc. Soil should be light and organic manure should be mixed properly. The bed should be 2 meter wide and any desirable length, as per the slope and method adopted for irrigation. Before planting the cuttings or sowing of seeds, the bed of fine tilth should be prepared and adequate arrangements rogation and protection of the beds from animals. In heavy soils, additional FYM and sand should be added to make the soil light.

**Varieties:** Most of Seabuckthorn plantation world over is under wild and natural conditions and planned orchards are being developed from natural selections. However, some countries like Germany, Russia, etc. have developed a few Seabuckthorn cultivars having desirable traits like early or late ripening, big size of the fruits, high juice content, higher nutritive value, high oil content in pulp and seed, precocity and prolific bearing, less thorns and stress tolerance, etc. In India, efforts have been made by Field Research Laboratory (DRDO) in Leh to develop promising varieties of Seabuckthorn having high juice and oil content, large sized fruit (2-4cm long), high content of vitamin C and  $\beta$ -carotenoides, strong and scientific plant structure, ease in harvest and better shelf life of the fruits by using different breeding approaches viz selection, polyploidy and irradiation.

### Planting in the field

- **Land Preparation and Fertilizer Application:** Before planting the field should be leveled properly and stones should be removed, because this helps in proper layout of the orchard. After leveling of field the proper layout should be done and planting sites should be marked with the help of lime, rope or peg. The pits are dug at the marked points for planting of Seabuckthorn. The pits should be of 60 cm diameter and 60-80 cm deep to remove the stones, roots etc from root zone. The best time for digging of pits is end October or early November. If they are not dug during this period, it must be dug at least 45 days before planting. Any big stone/ rock near the pit should be removed else it will hinder the expansion of roots after planting. After digging of pits the soil should be cleaned properly and well-rotted FYM @ 2kg per pit should be mixed properly before filling the pits. In heavy soils, sand should also be mixed to make soil light and porous. The pits should be opened for solarisation for about 10-15 days and thereafter, they should be filled properly with the prepared mixture. The soil mixture should be pressed and should be filled 10 cm above the ground.
- **Time of Planting:** One to two year old root cuttings are most suitable for planting in the fields. Seabuckthorn can be planted in autumn (Oct-Nov.) and spring (March-April) after onset of dormancy and before sprouting of buds, respectively. Spring planting has been found to give better results with regards to plant establishment and its survival. Rooted cuttings are uprooted carefully with minimal

damage to roots, and minimum time gap between uprooting and planting of cuttings should be ensured. If rooted cuttings have to be transported over a long distance or need to be stored for long duration the roots of the cuttings are wrapped in moist moss grass with some soil to prevent drying of roots by air and wind. The roots of cuttings are wrapped in gunny bags and kept in moist or buried in soil. The cuttings should be stored in moist and cool place away from sun and windy site. In any case, the uprooted cuttings should not be stored for more than 20 days.

- **Method of Planting:** At the time of planting, a small hole is made in the centre of pit at the marked point, as per the layout plan and rooted plants are planted by spreading the roots properly in their natural direction. It must be ensured while planting that root is not coiled since it may lead to the death of the plant. Soil should be filled by pressing with a pole to remove the air pocket near the roots and should be irrigated immediately after planting. The most important point to be kept in mind is that seabuckthorn is a dioecious plant, where male and female plants are separate, and it is generally pollinated by wind. Thus, at least 10% male plants must be planted in the orchard, distributed uniformly all over the orchard to ensure pollination of the female plants. Recommendations have also been made to plant the male plants around the orchard but this method may pose problem because a large number of male plants will be required to be planted which will reduce the yield per unit area. Pollination of female plants in centre of the orchard may not be possible in this method.
- **Transplanting and Optimum Spacing:** Generally plant may be planted in hedge row system providing more space in between the rows and lesser space between plants. Single or double hedge row system can be adopted which provides enough space to approach each plant easily for pruning, harvesting and other cultural operations. In single hedge row system the distance between row to row is maintained at 2-4 m for pure cultivation, south-east sloping terrain is recommended to facilitate the maximum sunlight exposure and rows should be oriented in a north– south direction to provide maximum light and 4-5 m for intercropping. *Hippophae rhamnoides* needs a period of 4 to 5 years from the appearance of the first shoots from the seeds to the beginning of fruit and peaks at the 7–8th year of plant life, remaining productive for 30 years with intermittent pruning.
- **Interculture and Maintenance Practices:**
  - Pruning:** The basic aim of pruning is to strike a balance between the roots and shoot (vegetative) growth of the plant by heading back or thinning out the excessive vegetative growth of the plant. It is also practiced to induce fresh growth, encourage regeneration to remove diseased or dried branches to promote flowering/fruiting reduce crop load, to improve the quality and colour of the fruits, provide shape and strong structure to the plant and remove undesirable growth and interfering branches. Data on pruning in Seabuckthorn is not available, since no systematic study has been conducted. However, it is essentially required for canopy management, removal of profuse suckers and induction of new growth which is essential to induce flower buds in next season. Seabuckthorn should be pruned regularly for ease in harvesting and exposure of plant to sun for production of quality fruits. The best time for pruning of Seabuckthorn in Ladakh is the month of March, before sprouting of the plant in spring. Pruning should be done with a sharp secature or saw. However, 50% growth of 3-4 year old shoots should be removed.
- **Irrigation Practices:** It has also been observed that the plant needs frequent and light irrigation at initial stage for establishment. Light and frequent irrigation should be given regularly to newly



planted plants to obtain maximum growth. In established plants moisture stress at the time of bud break, fruit setting and fruit growth is detrimental for its fruit growth and yield. Seabuckthorn is highly sensitive to water logging and high moisture conditions, thus, water stagnation at any stage should be avoided. Autumn irrigation has been reported to be beneficial for the plant since it enables the plant to face sub-zero temperatures. If sufficient water is not available in the soil, the first irrigation should be given in mid March before bud break. Thereafter, orchard should be irrigated at an interval of 10-15 days. Newly established plants and plants in nursery beds need more frequent irrigation for the initial two years. In light, sandy and rocky soils efforts should be made for moisture conservation. Heavy irrigation should be given to the field after filling of pits, which helps in proper setting of newly filled pit soil and in complete mixing and decomposition of FYM in the pit. It is advisable to complete this process at least 30 days before planting of Seabuckthorn. It is also suggested that a peg should be placed in the centre of filled pit so that plants are planted at right place as per the layout.

- **Mulching:** Mulching in Seabuckthorn, especially in newly planted orchard or nursery beds, has been found to be beneficial since it reduces the water requirement of the plant by 2/3 and conserves the moisture by reducing moisture loss. Under Ladakh conditions, dry weeds, grasses, stones, pebbles or black polythene, etc can be used as mulch materials. Beneficial effect of mulching has been noticed under soils having poor water holding capacity and in crisis of irrigation water. It has been found to enhance the plant establishment, growth, fruit yield and fruit quality.
- **Weeding:** Weed control is important, especially during the early growth stages of *H. rhamnoides*, since it grows slower than weeds due to its less vigorous root system. Weeds should be removed before planting by preparing the land adequately, and they should subsequently be controlled during the first four to five years, until the shrubs are high enough to shade out the weeds. Weed control is done both mechanically and manually. Weeding should however not be too deep so as not to damage the root system of *H. rhamnoides*.
- **Disease and Pest Control:** In Asia and Europe, Seabuckthorn losses occur notably due to environmental stress, wilt disease and insect pests. To control the disease include removing and burning infected branches, not replanting *H. rhamnoides* at the same site for 3–5 years, and avoiding to make cuttings from infected plants. Antagonistic fungi like *Trichoderma* sp. or *Penicillium* sp. can be used to combat wilt disease in plants infected by *Plowrightia hippophaes*. Additionally, four strains of *Cladothrix actinomyces* were found to be usable as antagonistic fungi in *H. rhamnoides* plants infected by *Fusarium sporotrichioides*. Cultivars of *H. rhamnoides* that were relatively resistant to wilt disease have also been identified. Seabuckthorn is affected by several insect pests, of which green aphids (*Capitophorus hippophaes*) are one of the most damaging. They are usually found in the new growth on shoot tips where they stunt growth and cause yellowing of the leaves. Another serious pest is the seabuckthorn fruit fly (*Rhagoletis batava*), whose larvae feed on the fruit flesh, rendering the fruits unsuitable for use. Seabuckthorn is also affected by the gall tick (*Vasates* spp.), which causes gall formation on the leaves and thereby leads to deformation of the leaf surface. Both the leaf roller (*Archips rosana*) and the gypsy moth (*Lymantria dispar*) chew on *H. rhamnoides* leaves. The leaf roller occurs from May to July, while the gypsy moth occurs later in the summer. Further insect pests include the comma shaped scale (*Chionaspis salicis*), which sucks sap from the bark and can cause important damage by leading to the death of the plant, and the larvae of the sea buckthorn moth

(*Gelechia hippophaella*), which penetrate into fresh buds and feed on them. Thrips, and occasionally earwigs have also been observed as affecting *H. rhamnoides*.

Insecticides such as dylox are used to control insect pests in the soil, and insecticide soap can be employed against green aphid infestations.

### Harvest Management

- **Crop Maturity and Harvesting:** Seabuckthorn is a non-climacteric fruit which ripens on the plant and cannot ripen after harvesting. Ripening of fruits generally sets in by mid to end August under Ladakh conditions depending upon the altitude. Fruits at lower altitude ripen earlier than those growing at higher altitudes.

The harvesting of Seabuckthorn generally starts soon after ripening. The ripe fruits of Seabuckthorn are strongly attached to the plants and are difficult to harvest. It has been observed that harvesting of fruits is comparatively easier and effective in early morning hours before sunrise, since subsequently fruits developed turgidity and it became difficult to harvest after sunrise. Seabuckthorn can be harvested by various methods viz. shaking/vibratory/mechanical chopping etc. It can also be harvested by exogenous application of plant bio regulators which make the harvesting easy. Mechanical harvesting/shaking will need power or sufficient space in the orchard. One person can harvest about 2.0 kg of ripe fruits per hour.

The harvesting of ripe fruits of Seabuckthorn is the most difficult operation. The plant being highly thorny and fruits being soft, small, delicate and highly perishable and attached strongly to the plant poses difficulty in the operation. Wild population of Seabuckthorn has developed a thick growth which poses the problem of poor accessibility of fruits. It is because of this reason that presently only about 20% fruits are being utilized and the remaining 80% are wasted. In order to overcome, this problem, it is essentially required that a planned orchard should be developed and adequate spacing should be provided between row to harvest the potential of the existing resource. Wild plantations can also be made manageable if space is created by removing the plants.

- **Post-harvest Management:** Vegetatively propagated Seabuckthorn plants normally start bearing fruits at the age of 4 years after plantation, while seedlings take 5-6 years to come into fruiting. Seabuckthorn orchard starts commercial production only 8 years of plantation. The fruits ripen in the fall and frequently cling on the shrub until the following March/April. Estimate of orchard planting with 2,500 trees per hectare with a ratio of 1:6-8 male and female, and 4 meters between rows with 1 meter between plants should yield approximately 10 tone. Plants will produce up to 7 kg annually. In Asia the fruits are harvested by hand; this process requires about 1500 person-



Fruits



hours/ha. Fruit harvest is the most time consuming operation in growing *H. rhamnoides*.

Difficulties in harvesting are the major barriers of orchard production and development of the plant's potential as a cash crop. Harvesting the fruit is problematic because the fruit does not easily release from the stem. Different mechanical harvest methods were developed in the late 20th century, such as shaking, vacuum and quick freezing, but with the disadvantages of fruit and bark damage and low efficiency, as of 1990. Except when frozen on the shrub, fresh fruit mechanical harvesting is still in the development stage during the early 21st century. This is mainly due to the difficulty in separating the stem (pedicel) from the berry (pericarp). Mechanical harvesting – with the sequence of cutting a branch from the tree, freezing it, then shaking the branch to release the berries – eliminates the necessity for maintenance pruning, leaving a hedge that has been uniformly cut back, with high-quality berries. Fruits of Seabuckthorn are very soft, delicate, juicy and small. Fruits are highly perishable and cannot be transported over long distances. Thus, after harvesting fruit needs to be processed as soon as possible. Ripe fruits should be processed within 24 hours of harvesting. Fruits are collected in plastic baskets which should not have a capacity more than 10 kg in order to avoid the damage to fruits by pressure. During harvest leaves, thorns etc. are collected alongwith the ripe fruits. Moreover, the ripe fruits of Seabuckthorn have a musky odour which must be reduced before processing. Thus, proper cleaning and washing of fruits before processing is important. Washing with cold water helps in reducing the odour of fruits. Care should be taken that cleaning of fruits should be done with clean water under hygienic conditions. Data on storage of Seabuckthorn fruits is not available. However, for storage and distance transportation of ripe fruits the recommended temperature is 4-6°C to reduce post-harvest losses. Quick freezing of fruits and storage at -20°C has also been found effective for long term storage of fruits.

- **Chemical Constituents:** Fruits contain high amounts of vitamin C, vitamin E, carotenoids, flavonoids, Vitamins, Organic acids, Carotenoids, Flavonoids, Steroid, Betaine, 5-Hydroxy ptamine (5-HT), Chlorogenic acid, Coumarines, Ursolic acid (trierpene),  $\beta$ -amyrinoleylcohol acid, and health-beneficial fatty acids, as well as higher amounts of vitamin B<sup>12</sup> than other fruits.
- **Yield and Cost of Cultivation:** An orchard planting can yield 10 tonnes of berries per hectare. Yield of Seabuckthorn plant varieties according to the age, manage mental practices adopted, variety, etc. Cultivated varieties have been reported to yield about 10-15 ton/hectare fruit under scientifically managed orchard conditions. However, under Ladakh conditions, yield of ripe fruits ranges from 0.6-2.0 kg per plant, since plants are growing wild under natural conditions. About 200-300 quintal of the fresh leaves can be harvested per year after 8 years of plantation. The average fruit weight ranges from 152 mg to 362 mg per fruit. The ripe fruit yields about 70% juice after pulping and seed yield ranges from 6-8%.

### Therapeutic Uses


Traditionally Amchies (traditional doctor/Vaidya) use Seabuckthorn (they call it Tarbu) fruit, pulp and bark in treatment of various ailments such as skin diseases, boils, blisters, asthma, jaundice, stomach or gastric disorders, weakness, etc. It has also been extensively used as an expectorant for improving lung functioning, dispersing dampness, strengthening spleen and stomach and promotion of blood purification and circulation. It is believed by the locals that regular consumption of sea buckthorn fruit

which has a prophylactic action against cold, cough and provides resistance to body against several diseases. Various parts of Seabuckthorn are being used for protection against cancer and flavonoids in wound healing. The plant has been used in Tibetan system of medicine for more than 1300 years and is officially listed in Chinese pharmacopoeias.



## *Jurinea macrocephala* (DC. ex Royle) Benth. ex C.B. Clarke

Family - Asteraceae

Ayurvedic Name	Jaatukanda, Gugguluka.	
Hindi Name	Dhooplakkar,	
English Name	Incense	
Trade Name:	Dhoop, Guggal Dhoop	
Parts used	Rhizome	

*Jurinea macrocephala* with flowering head

### Morphological Characteristics

Plant is prostrate, perennial, stem less herb with a dense central domed cluster, large purple flower heads. Leaves in rosette, lobed with purple mid-vein, oblong blunt, pinnately lobed rising from stout tap root. Generally, found in pastures and morainic alpine areas between 3400 and 5000 m altitudes.

### Floral Characteristics.

Flowers on short stalk in umbel-like head, involucre with outer bracts lanceolate, hairy. Achenes curved, compressed, four to five angled, tubercled, ashy-grey with brown pappus.

### Distribution

The plant is found from Himalaya region, Kashmir to Kumaon.

### Climate and Soil:

A good depth of sandy, porous soil is considered best, since the plant develops a long thick root.

### Propagation Material

By seeds and rootstock segments.

### Agro-Technique<sup>10</sup>

#### Nursery Technique

- I. **Raising Propagules:** Seeds are collected during October. Seeds are sown 30 cm apart during May and June at alpine sites for seedling establishment. When the plants are two years old, they are thinned to 45 cm apart. The aerial parts dry up during the winter. This cycle is repeated for four to five growing seasons after which flowering and fruiting takes place. Generally, between five and twenty-five flowering heads are found in this species. A twenty-flowering head plant is considered best for Dhoop



Plant of *J. macrocephala* with flowering head

<sup>10</sup> Agro-technique study carried out by Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.

and plants are also known as Bishkandara locally. At lower altitudes, seeds are sown during October and November inside a greenhouse and by the end of March, seedlings are well developed and ready to transplant.

### Planting in the field

- **Land Preparation and Fertilizer Application:** In nature, it is observed that, where sheep and goats graze during the summer, *Jurrinea* grows well. For better growth and yield, farmyard manure approximately, 60-80 qt/acre is most useful.
- **Transplanting and Optimum Spacing:** Since plants need porous soil for healthy growth, raised beds are preferable at lower altitudes especially during the rainy season to prevent waterlogging. For cultivation in one acre of land nearly 33,000 plants are required.
- **Intercropping System:** Intercropping with *Tanacetum longifolium* Wall. ex DC. (Kitam) is recommended.
- **Intercultural and Maintenance Practices:** The field should be weed-free the first weeding is done one month after planting and the second after another 30 days. One hoeing after two months of planting is sufficient. Manual weeding/hand weeding is required time to time.
- **Irrigation Practices:** Irrigation from March to May every three to four days is sufficient.
- **Weeding:** Weeding is required frequently during the early stages of plant sprouting and at the seedling stage. After the second year of growth, weeding every month is sufficient.
- **Disease and Pest Control:** No serious pests and disease were observed.

### Harvest Management

- **Crop maturity and Harvesting:** After completion of the vegetative growth for three or four years the plant produces flowers and seeds from July to October in alpine sites. The reproductive phase commences earlier at lower altitudes. Harvesting should be done after that period. Yield can be obtained, however, from plants of more than two years old throughout during the growing season.
- **Post-harvest Management:** Harvesting of root is done by digging up the fields. After harvesting, roots are divided into slices and allowed to dry completely in the sun before packing.
- **Chemical Constituents:** Roots afforded six compounds namely b-sitosterol, lupenone, physcion, ptiloepoxide, 20, 21a-poxytaraxastan-3b-ol and chlorogenic acid. High quantity of chlorogenic acid (6, 130 mg/g) lupe-none (2, 33.4 mg/g) and amyris (a,b) (170.6 mg/gm) were detected in ethyl acetate and chloroform fractions.
- **Yield and Cost of Cultivation:** Estimated yields are approximately 5-6 qt/acre per annum after three to four years of growth.

### Therapeutic Uses

Roots are considered to be a stimulant and given in fever. A decoction of the root is given for colic pain, and bruised roots are applied to eruptions. The aromatic roots form the chief ingredient of Dhoop/Havan Samgiri and are used as incense in homes and religious ceremonies.

### Market Trend (2019/2020)

- **Market Price:** Rs. 700-1000/kg approximately



## *Ocimum sanctum* Linn.

Family - Lamiaceae

Ayurvedic Name	Tulasi
Hindi Name	Tulsi
English Name	Holy Basil
Unani Name	Tulsi
Trade Name	Tulsi
Parts used	whole plant



*Ocimum sanctum* Linn.

### Morphological Characteristics

*Ocimum sanctum* is an erect, herbaceous, much-branched, softly hairy biennial that grows up to height of 30-60 cm, with simple opposite green or purple leaves having scented and hairy stems. Leaves are opposite, exstipulate, petiolate, ovate, up to 5 cm long, and usually toothed. Apex is acute or obtuse, almost glabrous except at veins, aromatic with pungent taste, venation pinnately reticulate with 5-7 lateral alternate pair of veins, adaxial side dark green, abaxial, side dull green and veins prominent on both surfaces. Fruits are sub-globose or broadly ellipsoid, slightly compressed, nearly smooth, pale brown or reddish with small black markings.

### Floral Characteristics

Flowers are purplish in elongate racemes in close whorls. Pedicels of the flower are longer than the calyx, and the calyx is ovoid or c, 3-4 mm bilipped; upper lips are broadly oblong or suborbicular, shortly apiculate, while lower lips is longer than upper have four mucronate teeth, the central two largest; corollas are about 4 mm long, pubescent and aromatic; having aromatic odour and pungent flavour; and a nectar. Sub-globose or broad-elliptic and slightly compressed; pale brown or reddish, with minute black marks at the thalamus, aromatic and powerful in flavour are the four nuts in this fruit. It is brown, mucilaginous, 0.1 cm long, slightly notched at the base, and has a pungent, mucus-like flavour when soaking in water.

### Distribution

The plant is native to the Indian subcontinent and widespread as a cultivated throughout the Southeast Asian tropics.

### Climate and Soil

Sandy loam soil with good organic matter is considered ideal for the cultivation of the *Ocimum sanctum*. Well-drained soils help in better vegetative growth. The plant can be grown in tropical and sub-tropical climates.

### Propagation Material

Seeds

### Agro-Technique<sup>11</sup>

<sup>11</sup> Agro-technique study carried out by  
CSIR-Central Institute of Medicinal & Aromatic plants, Bangalore ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand Gujarat

### Nursery Technique

**Propagule Rate and Pre-treatment:** Seeds of Tulsi can be soaked in water before planting. Seeds can also be pre-treated with  $\text{KNO}_3$  for better germination. Seeds are to be sown in the nursery beds. Before the sowing of seeds, application of farm yard manure is required. For the sowing of one hectare, about 300 gm of seeds are required. Seeds are to be sown during May to June (Onset of Monsoon). Saplings are to be ready for transplanting in 45 days.

### Planting in the field

- **Land Preparation and Fertilizer Application:** The land is brought to one tilth and laid out into plots of convenient sizes. It is preferable to add 15 t/ha of farm yard manure and recommended fertilizers as basal dose during the preparation of land. Regarding the inorganic fertilizer application of 120:60:60 kg/ha of NPK is recommended. The chemical fertilizer dose for *Ocimum* is 120 kg N, 60 kg of  $\text{P}_2\text{O}_5$  and 60 kg of  $\text{K}_2\text{O}$  per hectare for optimum herbage yield. Half dose of N and entire dose of  $\text{P}_2\text{O}_5$  and  $\text{K}_2\text{O}$  should be given as a basal dose, whereas, the remaining N is applied after one month.
- **Transplanting and Optimum Spacing:** Saplings of tulsi is transplanted in the field during July at a spacing of 45x45 cm between plant to plant and 60 × 60 cm spacing between row to row. The field will be irrigated immediately after transplanting.
- **Intercropping System:** *Bacopa monnieri* can be grown as an intercrop with *Ocimum sanctum* for a more profitable option.
- **Intercultural and Maintenance Practices:** The field should be weed-free the first weeding is done one month after planting and the second after another 30 days. One hoeing after two months of planting is sufficient. Manual weeding/hand weeding is required time to time.
- **Irrigation Practices:** Irrigation is required once in a week just after the transplantation. With the onset of monsoon, the rains meet the water requirements of the crop fully till September. The crop needs irrigation once or twice a month thereafter. About, 12-15 irrigations are enough during a cropping season.
- **Weeding:** Inter-spaces should be maintained weed free and the first weeding is done after one month of planting and the second after another 30 days. Afterwards, no further weeding is required as the plants become bushy and cover the soil and thereby smother the weeds. However, after each harvest, weeding should be done so as to avoid weed growth in the inter-spaces, if any.
- **Disease and Pest Control:** *Ocimum sanctum* is found to be infested with a few insect pests and diseases. *Ocimum sanctum* is a hardy crop and no serious pests and diseases have been reported. In waterlogged conditions root-rot may occur in plant. To avoid this, proper drainage system has to be maintained. If the problem becomes serious drenching has to be done with 3% neem seed kernel extract. The following diseases are commonly found in Tulsi plant.
- **Leaf Rollers:** Leaf rollers stick to the surface of the Tulsi leaves, fold them backward lengthwise web them together.
- **Tulsi Lace Wing:** *Cochlochila bullita*: The adult and nymphs feed on leaves and younger stems, sometimes gregariously, and leave their excreta making it unsuitable for use. Due to feeding, the leaves initially get curled and later the whole plant gets dried up.



**Control:** Spray Azadirachtin 10,000 ppm @ 5 ml/l to control this insect.

### Harvest Management

- **Crop Maturity and Harvesting:** The first harvest is done after 90 days of planting and subsequently it may be harvested at every 75 days interval. The crop is harvested at full bloom stage by cutting the plants at 15 cm from ground level to ensure good regeneration for further harvests. The yield and oil content are more in plants harvested during sunny days. An average of 13-14 tons of herbage can be obtained per hectare.
- **Post-harvest Management:** After harvesting, drying of leaves is to be done. For transportation it is packed in airtight bags. Leaves should be stored in dry places. Then steam distillation is done to obtain the essential oil.
- **Chemical Constituents:** Oleanolic acid, Rosmarinic acid, Ursolic acid, Eugenol, Linalool, Carvacrol,  $\beta$ -elemene,  $\beta$ -caryophyllene and, Germacrene.
- **Yield and cost of cultivation:** On an average, about 10,000 kgs of fresh herbage per hectare may be obtained. The herb contains about 0.1 to 0.23 per cent oil and about 10-20 kg of essential oil per hectare. Irrigated tulsi gives higher herbage yield (upto 20 ton and oil yield (upto 40kg/ha).

### Therapeutic Uses

Tulsi is useful for the treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, insect bite etc. Ocimum also possesses anti-diabetic, anti-fungal, anti-microbial, hepatoprotective, cardio-protective, anti-spasmodic, analgesic and adaptogenic activities.

## *Paris polyphylla* Smith.

**Family - Melanthiaceae**

Ayurvedic Name	Satwa, Dudhiya buch
Hindi Name	Dudhiya buch, Satwa Bada
English Name	Love Apple
Trade Name	Daiswa paris
Parts used	Rhizome



*Paris polyphylla* Smith.

### **Morphological Characteristics**

It is a perennial rhizomatous herb, up to 40 cm tall. Leaves four to nine in a whorl, elliptical with short stalk. Rhizome thick, creeping. Plants show a wide range of morphological variations.

*Trillidium govanianum* (D.Don) Kunth is generally known as “Chhota Satwa” in the trade, and used as a substitute for *Paris polyphylla*. It is a perennial, rhizomatous herb, from 5 to 15 cm tall. Leaves are broadly ovate, acute with conspicuous stalks. Flowers are brownish purple, borne at the apex of the stem and surrounded by leaves. Fruit a globular red berry. Generally found in scrub at elevations between 2700 and 3500 m.

### **Floral Characteristics**

Flower is solitary, terminal, short stalked, greenish and relatively inconspicuous, with four to six lanceolate long pointed green leaf like perianth segments, which are 5-10 cm long. There is an inner ring of long purple or yellow perianth segments, which look like spider legs. Ten short stamens are arranged again in a ring. The ovary is in the superior position, with numerous ovules. The fruit is a berry or berrylike capsule, in which the seeds are enclosed in a red succulent aril when ripe. The species is extremely polymorphic. Flowering occurs in April-May.

### **Distribution**

Plant is found generally in temperate regions between 2200 and 3200 meter altitudes. Plant is mainly found in Himalayas, from Pakistan to West China, at altitudes of 2000-3000 meter. *Paris polyphylla* is an Asian species of flowering plant native to China, Taiwan, the Indian Subcontinent and Indochina. It is used as an ornamental plant for woodland gardens.

### **Climate and Soil**

Shaded and moist locations in well drained situations are preferable. Sandy loam, with rich humus content is suitable for its cultivation.

### **Propagation Material**

Propagated by division of bulbous rhizomes and seeds.



### Agro-Technique<sup>12</sup>

#### Nursery Techniques

- **Raising Propagules:** The plant is early growing in nature. Underground perennial rhizomes are generally used for multiplication. Cuttings are planted during October or in March to April 45 cm apart after digging the field thoroughly. Seeds are sown 5 cm apart during October inside a greenhouse or during March and April directly in the fields. After one year of growth, plants are thinned to 45 cm apart.
- **Rhizomes:** Bulbous rhizomes are to be lifted and replanted, however, when absolutely necessary.



Plant in the field



Dehiscence of pod and mature seeds

#### Planting in the field

- **Land Preparation and Fertilizer Application:**  
Top dressing, without mixing the well decayed manure with soil, during the winter or before sprouting is beneficial. Additions of forest litter approximately, 30-35 qt/acre above 2500 m and 40-50 qt/acre at 1800-2200 m is also beneficial. Mulching annually with decayed manure or forest litter is excellent
- **Transplanting and Optimum Spacing:** Underground perennial rhizomes are generally used for multiplication. Cuttings are planted during October or in March to April 45 cm apart after digging the field thoroughly. Seeds are sown 5 cm apart during October inside a greenhouse or during March and April directly in the fields. After one year of growth, plants are thinned to 45 cm apart. Bulbous rhizomes are to be lifted and replanted, however, when absolutely necessary.
- **Intercropping System:** Intercropping with *Skimmia anquetilia* N.P. Taylor and Airy Shaw or other shade providing species is recommended.
- **Irrigation Practice:**
- **Weeding:** To control weeds dry leaves can be spread thickly over the fields.
- **Disease and Pest Control:** no specific disease has been carried out till date.



Cultivation of *P. polyphylla* at 2,200 m.

#### Harvest Management

<sup>12</sup> Agro-technique study carried out by Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.

- **Crop Maturity and Harvesting:** Flowering and seed formation happens after three or four years. Plants raised from vegetative propagation, however flower and set seeds even during the same year. Harvesting of *T. govanianum* can be done during August just after the seeds mature, while in *Paris polyphylla* seeds ripen in October and their rhizomes should be harvested after that period.
- **Post-harvest Management:** *P. polyphylla* yields may be further increased under cultivation, when compared to the natural conditions.
- **Chemical Constituents** Plant rhizome contains sugar and two glucosides i.e. aparidine and aparistapnin. Plants also contain Polyphyllin C, Polyphyllin D, Saponin-1, Stigmasterol which is a steroid, and Stigmasterol-3-O- $\beta$ -D-glucoside.
- **Yield and Cost of Cultivation:** Six to eight qt/acre yield is obtained under natural conditions.

### Therapeutic Uses

It is useful in the treatment of heart diseases, asthma and bronchitis. Himalayan Paris is traditionally used against analgesic, antibacterial, anti-phlogistic, antispasmodic, antitussive, any poisonous bites, burn, cut or injury, depurative, detoxification, diarrhea, dressing, dysentery, febrifuge, fever, gastric problems, intestinal wounds, narcotic, poisoning, rashes or itching, scabies, skin diseases, sleeplessness, snake bite, stomach pain, typhoid, ulcer and wounds. It is a much sought after plant, making it an endangered species because of over-exploitation.

### Market Trend (2019/2020)

- **Market Price:** Rs. 2000-3000/kg approximately



## *Phyllanthus emblica* Linn.

Family - Phyllanthaceae

Ayurvedic Name	Amalaki
Hindi Name	Amla
English Name	Indian Gooseberry
Unani Name	Amla
Trade Name	Amla
Parts used	Fruits



Fruits of *Phyllanthus emblica* Linn.

### Morphological Characteristics

The tree is small to medium in size, reaching 1-2 m in height. The branchlets are finely pubescent 10–20 cm long and usually deciduous. The leaves are simple, sub-sessile and closely set along branchlets, light green, resembling pinnate leaves. The flowers are greenish-yellow. The fruit is nearly spherical, light greenish yellow, quite smooth and hard on appearance with six vertical stripes or furrows. Ripening in autumn, the berries are harvested by hand after climbing to the upper branches bearing the fruits. The taste of Indian gooseberry is sour, bitter and astringent. The fruit is quite fibrous.

### Floral Characteristics

The flowers are greenish-yellow, borne in axillary fascicles, and give way to globose fruit. The fruits are depressed globose in shape, 1–2.5 cm in diameter, fleshy, and obscurely six-lobed, containing six trigonous seeds. They are green when unripe, and turn light yellow or brick red when mature.

### Distribution

Amla is native to south-eastern Asia and grows well under various agro-climatic and agro-edaphic situations. It is geographically distributed in Bangladesh, China, India, Nepal, Malaysia, Pakistan, Sri Lanka, China (South), Malaysia to Australia (North) and Thailand.

### Climate and Soil

Amla is a subtropical fruit, it grows well in tropical humid conditions as well. The Amla plants can tolerate freezing temperatures (0°C) to high temperatures as 46°C. Further, the plant can tolerate severe drought conditions in summer and water logging conditions during rainy seasons.

### Propagation Material

Amla is commonly propagated through seeds in well-prepared nursery beds. However, propagation can also be done through stem cuttings for the fast growth of plants. Propagation through stem cuttings required treatments before planting in nursery beds. Well-decomposed farm yard manure should be mixed with a top layer of the soil while preparing the nursery beds.

### Agro-Technique<sup>13</sup>

<sup>13</sup> Agro-technique study carried out by

1. Institute of Forest Genetics and tree breeding, Coimbatore and Forest Research Centre (ICFRE), Hyderabad

### Nursery Techniques

**Propagule rate and pre-treatment:** Amla seeds are soaked in tap water for 24 hours to overcome dormancy. Further, seeds were treated with GA3 500 ppm for 12 hours and thiourea (3%) to break the dormancy of seeds and 10 cm thick long branch after sterilization with fungicide can be taken for rooting. Cuttings can be treated with auxin, IBA and NAA individually or in combination for fast root growth.

### Planting in the field

- **Land Preparation and Fertilizer Application:** Land to be levelled and well ploughed for better aeration. Application of farm yard manure vermi-compost may smooth and bring better aeration in the soil before transplantation of Amla. 15 kg well-decomposed farmyard manure (FYM) and 0.5 kg phosphorus should be applied to each pit before planting. Application of 30 grams of Nitrogen each year during September – October up to 10 years for each tree is recommended. The land is brought to one tilth and laid out into plots of convenient size. It is preferable to add 15 t/ha of farm yard manure and recommended fertilizers as basal dose during the preparation of land and should be mixed well in the soil.
- **Transplanting and Optimum Spacing:** Seedlings of Amla can be planted in the field at a spacing of 4.5 m x 4.5 m in the month of May-June.
- **Intercropping:** Amla can be intercropped with Black gram, cowpea, horse gram, and green gram up to 4-5 years. Cultivation of short duration medicinal and aromatic plant crops such as ashwagandha, coleus, kalmegh, lemon grass, palmarosa etc can be cultivated as intercrop.
- **Intercultural and Maintenance Practice:** Weeding and hoeing are required in the initial years of transplanting for better root initiation and elongation. The growth of shoot should be pruned to develop a low-headed and more branched tree.
- **Irrigation Practices:** Amla plants hardly require irrigation during monsoon. Young plants require irrigation during summer months at 15 days interval till they fully establish. Watering of mature fruit bearing plants is necessary during summer months at bi-weekly intervals to increase fruit set and to reduce fruit drop. The crop responds very well to drip irrigation. After the monsoon rains, during the October-December 25-30 litres of water per day per tree through drip may be given. Mulching of black polythene also reduces the water requirement of Amla.
- **Weeding:** Soil working and weeding may be done twice a year.
- **Disease and Pest Control:**

**Amla Aphid** *Schoutedenia emblica*: The damaged leaflets fall down and only the midrib remained on twig. Infection of aphid *Schoutedenia emblica* can be controlled by spraying of Neem seed kernel extract (NSKE) containing 1500 ppm of Azadirachtin. Application of Dimethoate 50 EC and profenophos 30 EC can also give control aphid infestation. Further, clipping off and removal of affected leaves and shoots can also prevent aphid infection.

**Leaf Roller** (*Gracillaria acidula*): Leaflets turn pale brown or dark brown and in severe attack, the leaflets are twisted up to form cocoons. Application of dimethoate 0.03% and quinalphos 0.025% is found effective against leaf roller.

**Gall Insect** (*Betuso stylophora*): Adult emerges with the onset of monsoon and gall initiation in the stem takes place. Galls formed by the shoot gall insect are pruned and destroyed and spraying of



0.05% chlorpyrifos at the initial stage can help to avoid further pest attacks.

**Bark-eating caterpillar (*Indarbela sp.*):** The caterpillar of the bark-eating caterpillar is nocturnal in nature and eats on the bark under the shelter of a web and bores into the trunk and branches.

**Control:** Removing and destroying dead and severely affected branches of the tree for reducing the impact of caterpillar. Application of Kerosene 2 ml per hole, DDVP 76 EC 2 ml per hole may control caterpillar infection.

### Harvest Management

- **Crop Maturity and Harvesting:** Fruit of Amla is highly perishable in nature and available for 2 to 3 months. Thus, storage of fruit is essential at an appropriate temperature (low, controlled) to keep fresh and juicy in the long term so that farmers can get a better price in the market. For better results, Amla must be stored in cold storage minimum for one week at 0-2°C while maintain 80-90% relative humidity.
- **Post-harvest Management:** Storage facilities such as cold storage and controlled/modified atmospheric storage are very expensive and not in the direct reach of normal farmer.
- **Chemical Constituents:** Fruits of Amla contain Ascorbic acid (vitamin C), Emblicanin A, Emblicanin B, Punigluconin, and Pedunculagin.
- **Yield and Cost of Cultivation:** The average yield can be around 100 kg per tree in a fully grown (after ten yrs) Amla tree.

### Therapeutic Uses

- The fruit of Amla used in Ayurveda as a potential source of Rasayana and in traditional medicine for the treatment of diarrhoea, jaundice and inflammation. Various studies show that Amla possesses anti-diabetic, hypo-lipidemic, anti-microbial, anti-inflammatory, antioxidant, hepato-protective and anti-emetic activities. Fruits of Amla are used as ingredients in various compound formulations like Chyavanaprasa, Dhatri-loha, Amalaki Rasayana, Dhatriyarishta etc. Amla fruit is useful in memory-enhancing, ophthalmic disorders and lowering cholesterol level. It is also helpful in neutralizing snake venom and as an antimicrobial.

## *Plantago ovata* Forssk.

Family -Plantaginaceae

Ayurvedic Name	Sheetabeeja & Ashwakarna
Hindi Name	Isabgol
English Name	Psyllium
Unani Name	Qasliyoos and Barghosh, Bazr-e-qatuna
Trade Name	Isabgol
Parts used	Husk



*Plantago ovata* Forssk.

### Morphological Characteristics

The *Plantago* genus comprises 200 species of which 10 occur in India. *Plantago ovata* is an annual herb, which attains a height of 30-40 cm. The stem is underground and covered with fine hairs. The leaves are in rosette or alternate, clasping the stem, strap like curved, 7.5 to 25.0 cm long, narrow varying from less than 6.0 mm to 12.5 mm in width tapering to a point, three nerved, entire or toothed, coated with fine hairs.

### Floral Characteristics

Flowers are white, minute, four parted, arranged in erect, ovoid or cylindrical spikes 12.5 to 37.5 mm in length. Capsule is ovate, 8 mm long, 2-celled, the top half lifting up when ripe, releasing the smooth, dull, ovate seeds, 1.8 to 3.8 mm long, pinkish-grey brown or pinkish-white with a brown streak on the convex surface. Each seed is encased in a thin white, translucent mucilaginous membrane known as husk. The inflorescence is a spike with about sixty florets clustered at the top of the fragile peduncle in about 3.0 cm length. The flowers are protogynous with floral maturity occurring in acropetal succession. Thus, the gynoecium of the bottommost flower matures first, protruding its stigma through the tip of the unopened flower. The androecium matures later.

### Distribution

It is a plant of Western Asian origin and is believed to have been introduced into India during the middle age. India continuous to rank first in Isabgol production and trade in the world market. At present, Gujarat, Madhya Pradesh and some parts of Rajasthan, especially on Malwa tract and northern belt are the major Isabgol growing areas in India. India produces about 13,000 tonnes of Isabgol seeds and 3,200 tonnes seed husk annually, of which about 90% is exported. The crop is cultivated in north Gujarat, districts of Mehsana, Banaskantha, Kutch, Jamnagar, Ahmedabad, Rajkot, Junagarh, Bhavanagar and Kaira. Isabgol is also cultivated in small areas of Sirohi (Rajasthan), Rewari (Haryana) and Sasaram (Bihar).

### Climate and Soil

*Plantago ovata* can be grown on a variety of soils. It however, does well on light well drained-sandy loam



to rich loamy soil. It is considered one of the suitable crop for marginal lands particularly the sandy soils. The crop performs well on neutral soil (pH-7.2 to 7.9), but can withstand mild salinity levels. Other species like *P. major* have higher salinity tolerance limits.

*Plantago* thrives well in warm-temperate regions. In India, the crop is grown in winter. In general, cool and dry weather is favourable to the crop.

### Propagation Material

Seed few varieties are available for commercial cultivation. Gujarat Isabgol-1 & 2, HI-5 are suitable for cultivation in Gujarat, Rajasthan and adjoining areas. Niharika and Mayuri varieties recently developed by CIMAP is suitable for north Indian conditions.

### Agro-Technique<sup>14</sup>

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The nutrient requirement of the crop is low. Normally, 25 kg Nitrogen (N)/ha and 25 kg Potash ( $P_2O_5$ )/ha are required to be applied as basal doses at the time of final preparation of land and 25 kg N/ha is top dressed 30-40 days after sowing. The crop has low nitrogen requirement and unless the soil is highly deficient in available nitrogen (120 kg/ha), Isabgol crops need not be fertilized. Under low fertility status of soil, the Isabgol crop may be followed with green manure or in sequence with a leguminous crop to restore fertility thereby requiring minimal use of fertilizers.

Seeds are pretreated with TMTD (tetramethol thrium di sulphide) or any other mercurial seed dresser at 3 g/kg seed to protect the seedlings from the possible attacks of seed-borne diseases. During the winter or rabi crop season the land is ploughed, harrowed and brought to a fine tilth.

- **Transplanting and Optimum Spacing:** The land is divided into flat beds of convenient size, depending upon the source of irrigation. The seeds are sown from mid-October to mid-December at the rate of 6-13 kg/ha. In rows, spaced 22.5 cm apart or broadcasted. The line sowing facility the intercultural operations. After sowing, seeds are covered with some soil, by lightly sweeping the soil surface with a broom. Germination begins in 5-6 days after sowing. If soil moisture level is low, a good irrigation schedule is needed to avoid delayed germination.
- **Intercropping System:** One row of isabgol alternating with one row of lentil, one row of isabgol alternating with cowpea, one row of sorghum- three rows of lentil can be cultivated.
- **Interculture and Maintenance Practices:** The first weeding is generally done after 20-25 days of sowing. Only 2-3 weedings are required within the first two months of the crop age. The application of 0.5 kg/ha isoproturon as pre-sowing or pre-emergence is recommended to keep the weed growth and to obtain better isabgol seed yield. Higher rate (1 kg/ha) of herbicide was found to be phytotoxic and reduced the crop yield.
- **Irrigation Practices:** The crop requires 4-5 irrigations. A light irrigation just after sowing is desirable to ensure good germination and crop stand, depending upon the initial moisture status of soil. The seeds germinate in 6-7 days. If the germination is still found to be poor, a second supplementary irrigation may be given. Last but the most critical irrigation should be scheduled to coincide with the milky stage of the seeds for their plumpy and bold development.

<sup>14</sup> Agro-technique study carried out by  
Central Institute of Medicinal and Aromatic Plants, Lucknow.

- **Weeding:** Generally, two hand weeding are required with in two months of sowing. First weeding should be undertaken after 20-25 days of sowing.
- **Disease and Pest Control:** The crop suffers from several diseases, including the damping off, wilt, downy mildew, powdery mildew and leaf blight disease.
  - i. **Wilt:** Many of the land cultivars of isabgol as susceptible to *Alternaria* and *Fusarium* wilt. Symptoms may be pre-emergence damping off, or distortion of tap root (commercing at the tip). It is better to spray the fungicide 30 days after sowing and two or more sprays at the interval of 15-20 days or when the weather turns favourable for the pathogen to spread: Bordeaux mixture-6:3:10; or Copper oxychloride or Dithane M-45 or Dithane Z-78 or any other copper fungicide at 2.0-2.5 gm in one liter water.
  - ii. **Damping off:** *Pythium ultimum* Trow., *Rhizoctonia solani* is responsible for damping off at the seedlings stage. Pre-treatment of seeds, with metalaxil or fenaminosulf at 5.0 g/kg seeds, protect the seedlings. Treatment of seeds with GCA 48988 provides protection to young seedlings for a longer period.
  - iii. **Powdery mildew:** Powdery mildew caused *Erysiphe cichoracearum* D.C. and leaf blight caused by *Alternaria alternata* (FR) Keisslar are of minor importance. These diseases can be controlled by spraying karathane W.D. (0.2%) as soon as the disease appears.
  - iv. **Insect pests:** Sometimes, white grubs and termites damage the crop by cutting the roots. These can be controlled by broadcasting 65% lindane (1.25 Kg/ha.) before the last ploughing. Aphids also attack this crop which can be controlled by spraying 0.2% dimethoate.

### Harvest Management

- **Crop Maturity and Harvesting:** Flowering begins after two months of sowing and the crop becomes ready for harvest in March and April (after 120-150 days of sowing). The plants are cut 15 cm above from the ground using hand sickles. The flower spikes turn reddish brown at ripening, the lower leaves dry and the upper leaves yellow. This work is performed in early morning, so as to save the seeds from shattering. The plants are threshed and winnowed repeatedly until the entire chaff is removed and the seeds are clean. The seeds may be marketed whole or the husk may be sold separately. The husk is removed by crushing the cleaned seeds in stone or emery grinders. The husk is sieved and screened through different grades of mesh to sort it out according to its texture and fineness. Most of the exported husk is of the grade designated as 70 mesh. The highest quality husk is purely white with no admixture of red kernel particles.
- **Post-harvest Management:** The crop is harvested in the morning after the dew is gone to minimize shattering and field losses. In India, mature plants are cut 15 cm above the ground and then bound, left for a few days to dry, thrashed and winnowed. Harvested seed must be dried to below 12% moisture to allow for cleaning, milling, and storage. Seed stored for future crops has shown a significant loss in viability after 2 years in storage.

The crop requires clear sunny days and dry weather for its maturity. Rains, particularly at the time of harvest, when the seeds are fully mature and dried on the spikes, is disastrous for the crop. It makes the mucilaginous husk to stick with the kernel tenaciously making its separation difficult,



thereby rendering the produce to lose its economic utility. The husk (psyllium) constitutes about 30 percent of seed by weight.

- **Chemical Constituents:** The isabgol husk yields a colloidal mucilage consisting mainly of xylose, arabinose and galacturonic acid. Also present are rhamnose and galactose. Its seeds contain a significant amount of protein (17 to 19%). The dehusked seeds possess 5% yellow semi-drying oil, small amounts of glycosides, aucubin and considerable tannin and an active principle resembling acetylcholine.
- **Yield and Cost of Cultivation:** The average yield comes upto 10-12 q/ha. Adverse climate conditions affect both yield and quality of seeds. Rainy and cloudy weather at the time of maturity and frost at the flowering stage adversely affect both yield and quality of the seeds.

### Therapeutic Uses:

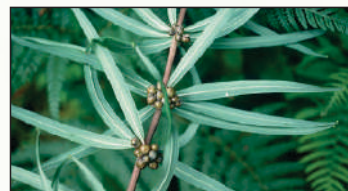
Isabgol seed is in use in medicine since long and isabgol based drugs have gained increasing popularity both in India and abroad. The mucilage of husk (*psyllium*) absorbs toxins from the gut and helps in excreting them from the body. In patients suffering from chronic dysentery the ulcerated surface of the intestinal mucosa is soothed by the demulcent action of mucilage, the mucilage spreads along the inner wall of intestine and protects it against the irritants present in food. The seed husk is also effective in reducing serum cholesterol level. Besides, its medicinal properties in intestinal disorders, psyllium finds use in health care in several other ways. Its use is becoming popular in food products, as an ingredient in chocolates. The industrial applications of psyllium include its use as a sizing material in textiles and in the formation of tablets and in cosmetics. The protein rich seed meal of isabgol makes an ideal cattle feed.

*Plantago ovata* is valued for its seeds and husk which have been used as laxative, that is particularly beneficial in habitual constipation, chronic diarrhoea and dysentery for centuries all over the world.

## *Polygonatum cirrhifolium* (Wall.) Royle

**Family** -Asparagaceae

Ayurvedic Name	Mahameda
Hindi Name	Meda
English Name	Whorled Solomon's seal
Trade Name	Meda/Salam Mishri
Parts used	Rhizome



*Polygonatum cirrhifolium* (Wall.) Royle

### Morphological Characteristics

*P. cirrhifolium* (Meda) is a perennial herbaceous plant which attains a height of 1.2 m with tendril like tips on the leaves. Leaves in whorls of three to six, linear, lanceolate. Rhizome is thick and creeping. Stem angled and grooved, rootstock thick and creeping. Fruit is berry. The plant is found in temperate to alpine regions from 1500 to 3700 m altitudes.

### Floral Characteristics

Flowers white, tinged with purple or green, on short stalks. Flowers are tube-shaped with spreading triangular petals. The species is bisexual and the plant is mostly pollinated by Bees. Leaves are narrow lance-like, in whorls of 3-6, usually with coiled tendril like tip. Tiny flowers, about pedicel 3-8 mm long, are tinged purple or green. Flower of *Polygonatum cirrhifolium* bloom during May to July and the seeds ripen from September to October.

### Distribution

Mahameda is distributed in the temperate Himalayas and Northeast India at the ranging from 1500-3700 above msl. It is also found in South West China and Nepal.

### Climate and Soil

Mahameda is a perennial herb is usually found amongst scrub on humus rich soil, natural blanks etc. in temperate forest.

### Propagation Material

Mahameda can be propagated through seeds and rhizomes. Mainly through vegetative propagation, by rootstock cuttings.

### Agro-Technique<sup>15</sup>

#### Nursery Technique

- **Propagule rate and pre-treatment:** Rhizome of Mahameda can be collected, and multiplied in



*Polygonatum* sps.

<sup>15</sup> Agro-technique study carried out by Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.



various sets of conditions in mist chamber, poly house, shade house, polyhut, etc. Seeds can be treated with cow dung before sowing in the nursery and also can be treated with cold water, hot water and boiling water with subsequent cooling for 24 hours to test seed germinability.

### Planting in the field

- **Land Preparation and Fertilizer Application:** Partially shaded moist locations or woodlands, with rich humus-containing porous soil, are suitable for its cultivation. Large concentrations of well decomposed farmyard manure or forest litter is needed before planting. Manuring should be done during the winter months after the fields are well prepared through digging or ploughing. Approximately 60 quintal manure is required for one acre of land.
- **Transplanting and Optimum Spacing:** Seeds of *Polygonatum* species show dormancy (epicotyl) and require chilling for germination. Germination without any treatment is poor and takes 30-45 days. Hormones and chilling give slightly increased germination up to 30 or 40%. Seeds are sown during March and May at lower and alpine sites respectively, after chilling for 24-45 hrs. The best method for multiplication is vegetative propagation through rhizome/ rootstock cuttings. For propagation, rhizomes are divided into slices 0.5-0.8 inches in size and transplanted immediately in the favourable growth seasons in March to May. Roots sprout within twenty to thirty days. Nearly 42000 to 45000 plants or cuttings are required for one acre of land. Plants/ cuttings should be 30 cm apart.
- **Intercropping System:** To provide shade for good growth, intercropping with *Foeniculum vulgare* or *Megacarpaea polyandra* is beneficial.
- **Interculture and Maintenance Practices:** Manuring every after three years is recommended.
- **Irrigation Practices:** During the dry months of the first year, watering every 48 hours is needed. After the second year, weeding every fifteen to twenty days is sufficient.
- **Weeding:** Intense irrigation and weeding is required during the initial phase of plant growth.
- **Disease and Pest control:** No serious pest and disease were observed.



Crop in Field

### Harvest Management

- **Crop Maturity and Harvesting:** At lower altitudes where plants get a six to eight month growing season, they mature after three years of vegetative growth. Flowering occurs during May - July and seeds mature by the end of September. After that the aerial parts wither and the rhizome may be harvested for commercial purposes.
- **Post-harvest Management:** After harvesting, rhizomes are washed and dried in the sun or in warm air, and divided into small slices of 0.5 inches diameter and 0.5-0.8 inches long. After drying these are packed into bags for trade.



Rhizomes of *Polygonatum* sps.

- **Chemical Constituents:** Chemical composition:  $\alpha$ -L-rhamnopyranosyl,  $\beta$ -D-lucopyranoside, dauvosterol,  $\beta$ -sitosterol, 6- nonadecenoic acid, 6-stearic acid.
- **Yield and Cost of Cultivation:** The estimated production of species is 4-6 qt/acre after 3 years of cultivation.

### Therapeutic Uses:

Mehameda is one of the eight constituents of Ashtha Verga in Ayurveda. Used as a tonic, it promotes body heat, dried up serious fluids, carminative and antitussive. Used against loss of vigour, pain in the kidney and hips, swelling and fullness in the abdominal region, accumulation of fluids in bone joints, skin eruption and cough. Also recommended for tuberculosis, and as a remedy for menstrual problems. A paste of seeds and leaves is applied to itching and chapped skin. Leaves are eaten as a vegetable and a root infusion with milk used as an aphrodisiac and blood purifier, pasted on cuts and wounds, also useful for tumours and piles. Rhizome of *Polygonatum* are cardi tonic, stimulant, antitussive and, carminative. Rhizomes are used in the treatment of loss of vigour, pain in the kidneys, swelling and fullness in the abdominal region, accumulation of fluids in bone joints, skin eruptions and coughs.

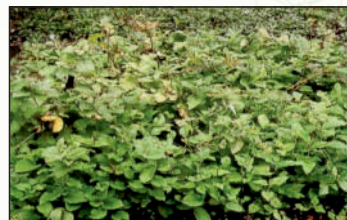


## *Polygonum rumicifolium* Royle ex Bab.

*Syn. -Koenigia rumicifolia/Aconogonon rumicifolium* (Royle ex Bab.) Hara

Family -Polygonaceae

Ayurvedic Name	Bakroyala
Hindi Name	Kanthala
English Name	Dock leaf knot weed
Unani Name	Anjabar
Trade Name	Not in trade
Parts used	Leaf, stem and rhizome



*Polygonum rumicifolium* Royle ex Bab.

### Morphological Characteristics

The plant is robust, very leafy perennial herb. Leaves large, dock like, fleshy, broadly ovate to sub ovate, heart shaped, blunt or almost acute. Leaf stalk short, thick. Stem thick, unbranched and 15-20 cm long.

### Floral Characteristics

Flowers are tiny green in dense axillary and terminal cluster. Flowers bisexual, rarely unisexual; bracts and bracteoles membranous. Perianth persistent, 5 or 4 parted. Stamens 7 or 8 sometime 4 stamens. Styles 2 or 3, deciduous, mostly elongate. Fruit is achene and trigonous or biconvex, rarely biconcave.



Flowering Stage



Natural Habitate

### Distribution

Plant is found occasionally in alpine regions between 3500 to 4500 altitudes near rocks, between boulders and on open grassy slopes.

### Climate and Soil

Moist sites with a rich humus content and slightly acidic soil with pH 5.5-6.0 is suitable for plant cultivation. Cultivation of this species can be done successfully upto 1800 m altitude.

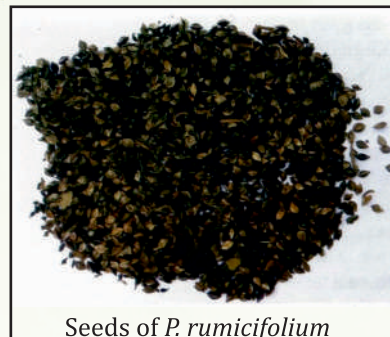
### Propagation Material

Through seeds and rhizome cuttings.

### Agro-Technique<sup>16</sup>

#### Nursery Techniques

- a) **Raising Propagules:** Approximately 44000 plantlets or 2.5 kg seeds are needed for one acre of land. Seedlings are planted 30x30 cm apart. After the second year stoloniferous rhizome segments are removed for extension of the crop.
- b) **Vegetative Propagation:** through rhizome segments is also most successful and nearly forty percent of cuttings sprouted. Further, combinations of 10 ppm of IBA, IAA, GA<sub>3</sub> and Kinetin increase root sprouting of 60-65%. Cuttings are generally planted during September and October.



Seeds of *P. rumicifolium*

#### Planting in the field

- **Land Preparation and Fertilizer Application:** It requires rich organic matter for good growth and yield especially at lower altitudes. Approximately 60-80 qt/acre farmyard manure is required. Manuring should be done every two years, and before the commencement of vegetative growth during the winter. Seed production potential is very high (215 seeds/plant). Seed viability is only fifty percent due to its high moisture content. Seed germination can be increased with GA<sub>3</sub> (100 ppm) treatment. Furthermore, excised seeds have more than eighty percent germination. Since the seeds have a low viability, sowing should be done during October and November inside greenhouses. Germination happens within fifteen days of sowing. Seed loses viability very rapidly, and only five percent germinated after eight months, even when stored in cold chambers.



Vegetative propagation through rhizome segments



Cultivation of *P. rumicifolium*

- **Transplanting and Optimum Spacing:** Three to four months after germination, seedlings are transplanted during May at alpine sites. By the end of the second growth season, rhizomes start multiplying and during the third year, between two and five new plants emerge from these stoloniferous rhizomes.

<sup>16</sup> Agro-technique study carried out by  
Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.



- **Intercropping System:** Intercropping with *P. marcophyllum* and *P. amplexicaule* can be done.
- **Interculture and Maintenance Practices:** Manuring should be done every two years and before the commencement of vegetative growth during the winter. Approximately 60-80 qt/acre farmyard manure is required.
- **Irrigation Practices:** High moisture content (60-80%) is needed. Irrigation is required every 24 hours during May and June. During the winter watering once a week is sufficient.
- **Weeding:** The fields should be weeded with a shallow scraper every fifteen days during the first year's growing season. After the formation of mats of rhizome during the second year onwards, initial weeding at sprouting time followed by weeding once every month is sufficient.
- **Disease and Pest Control:** No serious pests and disease are reported.

### Harvest Management

- **Crop Maturity and Harvesting:** After three to four years of vegetative growth, the plant produces flowers and seeds during August and September at lower altitudes and during October and November at alpine sites. Harvesting should be done after seeds mature. After establishment of cultivation, harvesting can begin after two years. Young leaves and tender stems, are harvested during July and August for vegetables.
  - **Chemical Constituents:** Eight compounds were isolated and identified as friedelin, beta-sitosterol, simiarenone, angelicin, psoralen, palmitic acid, (-)-epicatechin, and quercetin.
- a) **Yield and Cost of Cultivation:** At natural sites production is estimated at approximately 15-20 qt/acre.

### Therapeutic Uses

Rhizomes are used as an antidote against aconite poison. It is considered a blood purifier, also used in skin disease and joint pain. Young leaves and shoots are acidic and eaten as rhubarb, or boiled and eaten as a vegetable. Number of common foods such as sorrel and rhubarb contain oxalic acid and the leaves of most of the members of this genus are nutritious and beneficial to eat in moderate quantities. Cooking the leaves will reduce their content of oxalic acid. People with a tendency to rheumatism, arthritis, gout, kidney stones or hyper acidity should take especial caution if including this plant in their diet since it can aggravate their condition.



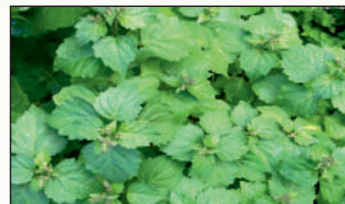
Mature Plant

## *Pogostemon cablin* (Blanco) Benth.

Syn. *P. patchouli* Pellet

**Family** -Lamiaceae

Hindi Name	Patchouli
English Name	Stink weed
Trade Name	Patchouli
Parts used	Leaves



*Pogostemon cablin* (Blanco) Benth.

### Morphological Characteristics

Patchouli (*Pogostemon cablin* (Blanco.) Benth.) belonging to family Lamiaceae is the source of an essential oil. Patchouli is a perennial aromatic herb with erect stem and large pale to purplish green leaves. Leaves are simple, ovate to oblong-ovate, coarse, tip acute to obtuse, margins crenate-serrate both surface are more or less densely tomentose, petiole 0-8 cm, stem densely tomentose, swollen at the nodes.

### Floral Characteristics

Inflorescence in terminal and auxiliary spikes, paniced dense sometimes interrupted, 2.5-6.5 cm long. Patchouli flowers only in its natural habitat that is unexploited areas of natural forests. Calyx 5.0 - 6.5 mm long, corolla lobes obtuse 6-9 mm in size, pink purple or white violet blotched on all segments, stamens filaments violet, bracts as long as calyx. Seed setting is quite rare.

### Distribution

Patchouli, a native of Philippines, grows wild in Malaysia, Indonesia and Singapore. This plant species was introduced to India almost 60 years ago in Madhya Pradesh. Presently the crop is being cultivated in Maharashtra, Gujarat, Karnataka and in some North Eastern states of India. There is a good scope of its cultivation expansion in coastal areas; southern as well as western India.

### Climate and Soil

Patchouli is hardy plant, adapting itself to wide range of soil and climatic conditions, it flourishes in areas with high average temperature (25-35°C) and high relative humidity (75%), but can be successfully grown wherever similar conditions can be achieved by partial shade and irrigation. For a rainfed crop an annual rainfall of 2000-3000 mm well distributed throughout the year is optimum but even lower ranges of 1750-2000 mm is acceptable. Patchouli can also be cultivated where rainfall is below 1500 mm if irrigation is available. Bright sunny days are favorable for maximum leaf oil content although plants perform well under partial or intermittent shade also. It is relatively soil exhausting crop and therefore, flourishes well in soil of high fertility status. The crop cannot tolerate severe frosts, hence crop is recommended in areas with an elevation up to 900-1000 msl. Light, porous, well drained soils rich in organic matter with pH 5.5-7.0 are optimal, but can be grown successfully in soils having pH around 8.0.



### Propagation Material

Generally, there is no seed setting in patchouli and hence the crop is normally propagated vegetatively by root/stem cuttings. Since the crop is highly susceptible to nematode attack, it is advisable to adopt phyto-sanitary measures from nursery stage itself.

The first strain was introduced to India from Singapore in 1935. It was named as Singapore strain identified as *Pogostemon cablin* (Blanco) Benth. Malaysian and Java strains were also introduced later. Currently CSIR-CIMAP is actively involved in the variety development of this plant. The uniform and stable varieties of Patchouli are available namely CIM – Shreshtha, CIM-Utkrisht and CIM Samarth.

### Agro-Technique<sup>17</sup>

#### Nursery technique

**Raising Propagules:** Since planting material is costly, growers should multiply the planting material at their own farm after purchasing a small quantity from authentic source as nucleus material from reputed organisations working on patchouli. Within 6 months, planting material can be multiplied vegetatively 30-50 times under optimal conditions.

The crop is propagated by root cuttings raised in nursery. The nursery is generally raised during rainy seasons. Transplanting of cuttings can be carried out throughout the year except for peak summer and winter months and during heavy rains.

Nursery is raised under shade and cuttings are prepared preferable in the morning or the evening to minimize desiccation. Cuttings are taken from healthy and vigorously growing plants. Terminal stem cuttings 10-12 cm in length with 3-4 nodes are considered ideal for propagation. Cuttings are trimmed by removing all leaves except first 3-4 leaves from terminal end. The basal end of the cutting should be neatly cut in oblique fashion from just below the node with sharp blade. Application of a commercial rooting hormone preparations, containing IBA to the basal end of the cuttings promotes quick rooting. The cuttings should then be planted in nursery beds or polythene bags with a suitable dibbler. A nursery area of about 200 sqm is sufficient for planting one hectare crop. The soil/nursery beds can be treated with carbofuran @1.0 kg/ha, before planting cuttings.

Under moderate climatic condition of some central parts of India, the planting can be carried out throughout the year. However, ideal time of planting for subtropical climates of north Indian plains is July-September. In North Eastern parts of the country crop should be planted from June to August. Patchouli can be planted under the shade in various plantation and orchard with assured irrigation facilities. Rooted cuttings are carefully dug out of nursery or taken out of polythene bags and immediately planted. Aeration, partial shade and regular watering are essential for early rooting. The cuttings take about 30-35 days for rooting in nursery and become ready for transplanting. Generally the transplanting of cuttings is done in evenings followed by a light irrigation.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The main field for transplanting is thoroughly divided and tilled. Suitable nematicides, viz. carbofuran at the rate of 1.0 kg per hectare is incorporated along with 5-10 ton of FYM and 0.5 ton of neem cake/Pongamia cake per hectare 10-15 days before transplanting. The plots are then laid into raised bed strips of 75 cm width and furrows (45 cm) with irrigation channels at appropriate intervals for gravity irrigation. If drip system is adopted, drain channels at appropriate intervals are provided.

<sup>17</sup> Agro-technique study carried out by  
CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow.

- **Transplanting and Optimum Spacing:** Transplanting on raised beds is done at a spacing of 50x50 cm and at this spacing about 40,000 cuttings would be needed to plant one hectare. Suitable drain channels along and across the slope at appropriate intervals for removing excess moisture during continuous rainy days is desirable to prevent plant mortality from moisture saturation.

Although the quantities of fertilizers required depend on the fertility of the soil, patchouli generally requires high dose of nitrogen and potassium. For 50 kg Phosphorus ( $P_2O_5$ ), add 313 kg/ha Single Super Phosphate or 108 kg/ha Diammonium phosphate into the soil as a basal dose before planting. For 60kg potash ( $K_2O$ ), may be applied 100 kg Muriate of potash into the soil as a basal dose before planting. 150kg N/ha/year in 3 split doses; 1<sup>st</sup> after planting/harvest and 2<sup>nd</sup> one month after the 1<sup>st</sup> application and the rest after each harrow in equal doses, for 50 kg/ha/year for nitrogen (N), add the 111 kg urea. Any mortality observed should be replaced within 20-30 days of transplanting and plant population should be maintained for proper yields.

- **Intercropping System:** Patchouli may be planted under the shade in various plantations and orchards. As patchouli loves shade, the inter-row shaded areas of orchards/plantation can be economically utilized by growing this crop. Patchouli can be integrated with Poplar, Papaya, Mango, Aonla, Coconut etc. In the Western Ghat areas, patchouli as intercrop in plantation crops and other erect growing trees is recommended for higher economic return per unit area of land.
- **Intercultural and Maintenance Practices:** After each harvest, the density of weeds will be less and careful weeding is necessary since the branches of the crop plant are brittle. Care should be taken to avoid mechanical damages. Also the root zone should not be disturbed with weeding tools. Deep hoeing is not recommended. The raised beds should be reformed after the harvest. Patchouli is also observed to be affected by root rot and wilt generally after first harvest. Excess soil moisture has been found to increase plant mortality due to root rot. Hence, proper drainage of patchouli plots is essential for avoiding plant mortality. Preplanting incorporation of *Pongamia* or neem cake (Karani) @ 1t/ha into the soil has been found effective in reducing plant mortality due to root rot in patchouli.
- **Irrigation Practices:** For getting good yield of the crop, the area should receive good and evenly distributed rainfall. Irrigation is necessary in areas where rainfall is scanty and inadequate. Initially, irrigation once in 3-4 days should be provided for 15-20 days after transplanting; later on at 8-15 days interval is sufficient depending on climatic conditions, soil type and intensity of shade. In any case, water logging should be avoided.
- **Weeding:** Patchouli plantation should be kept weed free. Patchouli, because of its bushy growth can effectively check/suppress weed growth. However, at the initial stages (2-3 months) 1-2 weedings are necessary till the canopy develops. The crop canopy cuts the sunlight and prevents weed growth.
- **Disease and Pest Control:** Root knot diseases caused by *Meloidogyne incognita* (a root knot nematode) can be managed by application of Carbofuran @ 1.0 kg a.i./ha prior to planting both in nurseries as well as in fields. Yellow mosaic disease is caused by a virus. Application of any insecticide checking the insect/ vector population helps in reducing its transmission of virus to other plants. A leaf feeding caterpillar (*Pronomis profusalis*), leaf webber (*Pachyzancla aegrotalis*) and a leaf roller (*Herpetogramma licersisalis*) have been found to attack patchouli in south India. Another plant bug (*Patchypeltis* sp.) is a serious pest on the foliage. Singapore variety is comparatively free from this. These pests can be managed by the application of Emamectin Benzoate @ 0.5 gm (0.05%) or methyl parathion (0.05%) at fortnightly intervals. Two to three sprays are recommended at an interval of 15 days depending on the intensity of pest infestation.



### Harvest Management

- **Crop Maturity and Harvesting:** Patchouli crop takes about 5-6 months to attain maturity. The first harvest of the crop is, therefore, taken after 5 months of transplanting. The stage at which crop has to be harvested is very important for better yield and quality of oil. The crop is harvested when the foliage becomes pale green and slightly brown and starts emitting characteristic patchouli odour. Harvesting is done with sharp sickles leaving juvenile branches for regeneration during cool hours of early morning or evening. Damage to branches should be avoided since they are brittle. The harvested herb must contain 60-70% leaves; woody hard stem portion must be avoided.

Subsequent harvests can be taken at 3-month intervals; intermitting long winters can prolong the interval especially under north Indian plains. There is a decline in the yield as well as quality after first three harvests. However, the crop can be maintained for 2-3 years depending upon the productivity and plant populations. In hot and humid-tropical parts of south India, the crop can be maintained for about 2 years under shade/open, while in sub-tropical condition of northern India, a fresh crop is advisable after obtaining three harvests.

- **Post-harvest Management:** Patchouli herbage is not distilled fresh. It is shade dried for 4-7 days (atleast for 48-72 h) depending on weather conditions. The harvested material is shifted to a rain protected drying shed. The material is frequently turned over for proper aeration and uniform drying. Crisp drying is not desirable. The shade dried material containing 10-15% moisture is baled. This can be stored in a cool place till distilled. It is advisable to avoid fermentation. Proper drying is of great importance for obtaining maximum yield and oil of good quality. On an average, about 20% of air dry material is obtained from the total freshly harvested biomass.
- **Chemical Constituents:** Nine major compounds have been isolated from the oil of *Pogostemon cablin*. The main and important chemical compounds of patchouli are patchouli alcohol, pogostone, friedelin, epifriedelinol, pachypodol, retusine, oleanolic acid, beta-sitosterol and daucosterol.
- **Yield and Cost of Cultivation:** The total biomass produced by patchouli depends upon many factors of which climate in which it is grown is an important one. Patchouli grown in areas with moderate temperature and well distributed rainfall produces about 20-25 tonnes of fresh herbage obtained from 3-4 harvests annually whereas in area like north Indian plains with extreme climates, it may only produce 12-15t (from 2-3 harvests) which on drying reduces to 4.0 -5.0t and 2.5-3.0 t, respectively. On an average the oil recovery can be expected in the range of 2.0-3.0% on air dry weight basis and a yield of 50-100 kg oil/ha/year. Oil yields of 80-100 kg can be achieved in coastal and North Eastern parts of the country while 60-80 kg of oil can be obtained in central parts of India. An yield of about 50-60 kg is considered satisfactory under sub-tropical plains of Northern India.
- **Therapeutic Uses:** The oil of patchouli is used extensively with varied applications. It blends well with sandalwood, geranium, vetiver, Ionone, sandalwood derivatives, clove oil, lavender, bergamot and many others. It is widely used in soap, cosmetics, tobacco and incense. The oil gives one of the finest attars when blended with sandalwood oil. The oil possesses anti-bacterial activity and is also used as an ingredient in insect repellent preparations. The leaves and top are added in bath for their anti-rheumatic action. It is also used as masking agent for alcoholic breath.

### Market Trend (2019/2020)

- **Market price:** Rs. 3500-4000 Kg
- **Market demand:** India imports huge quantities (>100+) of oil to meet its initial demand.

## *Rauvolfia serpentina* (Linn.) Benth. ex Kurz.

Family -Apocyanaceae

Ayurvedic Name	Sarpagandha
Hindi Name	Sarpagandha, Chota chand
English Name	Indian snakeroot
Unani Name	Asrol
Trade Name	Sarpagandha
Parts used	Root



*Rauvolfia serpentina* (Linn.) Benth. ex Kurz.

### Morphological Characteristics

Sarpagandha (*Rauvolfia serpentina*) is an important medicinal plant since ancient times. It is also known as chandrabhang' or 'chota chand' in Hindi. It is a perennial plant belonging to family Apocyanaceae. Six species of sarpagandha viz. *Rauvolfia densifolia*, *R. beddomei*, *R. trifolia*, *R. tetraphylla* and *R. vomitoria* are found in India. Roots of *Rauvolfia serpentina* contain important medicinal compounds. Its fresh roots give peculiar smell and are bitter in taste. Height of the plant is 20-60 cm. Its stem are erect, branches are soft and green in colour. Its root grows 40-60 cm deep in soil.

### Floral Characteristics

Its flowers are white-pink in colour. In most of the fruits of sarpagandha, single seeds are found, however in some fruits more than one seed may occur.

### Distribution

Sarpagandha is found across the various agro-climatic zones of India. It is available as wild in Himalayan regions, Meghalaya, Assam, Eastern Uttar Pradesh, Bihar, Shimla, Uttarakhand, Southern parts of India, Madhya Pradesh and Orissa. The plant is cultivating in various states like Uttar Pradesh, Bihar, Tamil Nadu, Orissa, Kerala, West Bengal and Madhya Pradesh.

### Climate and Soil

Hot and humid climate is well suited for commercial cultivation of Sarpagandha. Apart from this, slightly shady areas occupied by wild and pet animals are also suitable for its cultivation. Sandy-loam or sandy soils rich in organic matter are excellent for its cultivation. The plant requires slightly acidic to neutral soil (pH 6.0-8.5).

### Propagation Material

By seed, stem cuttings and root cuttings.



### Agro-Technique<sup>18</sup>

#### Nursery Technique:

Propagation of sarpagandha through seed is generally not suitable because of 20-25% germination chances. For propagation through seeds, firstly seeds are put in a normal salt solution. The seeds floating on water surface are removed. Treatment with salt solution prevents the crop nursery from 'damping off' disease and germination power of seeds also increases. Seeds should be sown in the month of May in well prepared plots. After sowing, seeds are covered with a thin layer of soil. Plots should be watered as and when required to maintain proper moisture. Around 2.5-3.4 kg seeds are sufficient to raise the planting material for one hectare area. Seeds start germination after 10-12 days and after 60 days, plants are ready for transplantation. In the first week of July, plants become ready for transplantation in the field. However, sowing of seed in southern parts of India should be done only after rains. Nursery plants are ready for transplantation in field after 6 weeks of seed sowing. A nursery of 500 square meter is sufficient to cover one hectare land.

**By Root Cuttings:** Cultivation of Sarpagandha through roots is the best method. Root cutting method is more profitable than cultivation through sowing of seeds. For cultivation, high quality of variety such as CIM-Sheel developed CSIR - CIMAP rich in medicinal compounds should be used. In the month of March-September, 2-5 cm long pieces of roots are placed in 5-10 cm deep furrows adjacent to each other and covered with a layer of soil. This method requires 40-50 kg roots for one hectare.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** For Sarpagandha cultivation, land is initially ploughed for 2-3 times and then farm yard manure (10-15 tonnes/ha) is mixed and ploughed again. After ploughing, land is properly leveled and necessary channels are made for irrigation purpose. Optimum level of different nutrients in soil for Sarpagandha cultivation should be ensured according to fertility status of the soil. Generally 10-15 tonnes of farm yard manure (FYM) per hectare should be thoroughly mixed in the soil, 30-35 days before sowing and followed by a basal dose of phosphorus, potash and nitrogen (60 Kg, 50 Kg and 100 Kg, respectively) per hectare/year. For 60 kg phosphorus in one hectare, 130 kg Diammonium phosphate (DAP) or 375 kg Single Super Phosphate (SSP) can be applied in the first year mix in soil with deep ploughing. In second year, spread in field and mix with soil. For 50 kg/ha Potash, 83 kg Muriate of Potash (MOP) can be applied. For nitrogen, 43 kg Urea spread 10-15 days after plant establishment, between 15th July -15th August, between 15 September -15 October, between 15 Feb. -15 March and between 15 May -15 June for better yield.
- **Transplanting and Optimum Spacing:** The best period of Sarpagandha crop plantation is March-April in agro-forestry system and July-October in open fields. At the time of transplantation, the plant should be 10-15 cm in height and 60-70 days old. Special attention should be given while taking out seedlings from nursery so that roots of the seedlings are not damaged. Seedlings should be kept covered with moist jute bag or a layer of leaves, after taking out from nursery. Transplantation should be done in evening hours. The seedlings are transplanted at a distance of 40 cm plant to plant and 60 cm row to row.

<sup>18</sup> Agro-technique study carried out by  
CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow.

- **Intercropping System:** In the tropical areas, sufficient space in the field remains available for initially 90 days during Sarp Gandha cultivation. Additional income can be generated by utilizing this space for intercropping of the crops which get matured in 70-80 days. Intercropping with tulsi, Kalmegh, Radish and pulses with Sarp Gandha crop planted in the month of June can be successfully done. Besides this, the Sarp Gandha plant goes under dormancy during which entire field becomes devoid of leaves and during this period the pulse crop and vegetables of Dalhani season can be grown to get full and additional productivity.
- **Intercultural and Maintenance Practices:** Initial flush of weeds must be controlled effectively so as to ensure a weed free environment to young plants. The weeding and hoeing cycles should be arranged as to keep the crop free from weeds. The prescribed schedule of all inter-cultural operations such as weeding, hoeing, topping, nipping of buds, pruning, shading and earthing up etc., must be adhered to in a manner to optimize the overall productivity. Use of herbicides should be avoided as far as possible. In case of their inevitable usage, available evidence of safety to the target crop should be considered adequately.
- **Irrigation Practices:** One irrigation must be given immediately after transplantation. Weed problem in Sarp Gandha crop transplanted in March-April is less as compared to plants transplanted in rainy season. To obtain full growth of the crop and high productivity, irrigation must be done during hot and dry periods. The crop transplanted in March-April require more irrigation. One or two irrigation should be given in the period between root planting and sprouting followed by frequent irrigation up to next three months. Thereafter, irrigation should be done at monthly interval. In the northern plains of India, 8-10 irrigations in the first year and 6-7 irrigations in second year are required.
- **Weeding:** By hoeing, the field keep weed free. In initial, first year two weeding are done and in second year one weeding followed by one hoeing is done at growing period of plant. If flowering starts in initial period, flowers should be nipped to raise root growth.
- **Disease and Pest Control:** Very few insects are found to damage Sarp Gandha. Caterpillars roll the leaves and feed inside and it can be controlled by Spray Quinalphos 25 EC (0.01%). The grub attacks seedlings about 2 cm below the hypocotyls as a results seedlings die. It can be controlled by Chlorpyrifos (600-800 ml/ha) with irrigation. Mites cause Chlorotic discolouration of upper surface of leaves and controlled by foliar spray of Oxydemetonmethyl (0.025%). Sarp Gandha is also attacked by some fungal disease like Die-back caused by *Colletotrichium gloeosporioides* Numerous tiny necrotic spots with Chlorotic border appear on the upper leaf surface of infected plants in the month of August-October. As a result premature defoliation and drying of infected leaves occur. Remove infected plants and burn and Spray Diathane Z-78 (0.2%). Sometime there is appearance of dark brown/black necrotic spots all over the leaves, which later enlarge into circular spots of size 2-20 mm diameter. Lower leaves are more attacked than young leaves. Sometimes purple colour blotches appear on ventral surface of leaves which can be controlled by the Spray Captan (0.25%) before monsoon onset and at monthly interval.

### Harvest Management

**Crop Maturity and Harvesting:** Root yield at different age and season have shown that 18 months duration crop produce maximum Root yield. The harvesting period coincides with the shedding of



leaves during the early autumn season next year. At this stage, the roots contain a maximum concentration of total alkaloids. At harvest, the root may be found to go up to 40 cm deep in the soil. Harvesting is done by digging up the roots and these roots are also collected.

- **Post-harvest Management:** Special attention should be paid during root harvesting, because roots of Sarpagandha goes very deep in soil. After digging, the roots are cleaned, washed and cut into 12 to 15 cm pieces for convenience in drying and storage. The dry roots possess up to 8-10 percent of moisture.
- **Chemical Constituents:** More than 90 compounds are found in different varieties of *Rauvolfia*, among which the compounds reserpine, racenomin, ajamalcin and ajamalin are important from medicinal point of view.
- **Yield and Cost of Cultivation:** On an average 10 quintal root are obtained from one hectare.
- **Therapeutic Uses:** Sarpagandha root is being used for treatment of insomnia, insanity and snake bite since ancient times. Reserpine and racenomin are used in modern system of medicine (allopathy) to control high blood pressure, whereas ajamalin and ajamalcin are used in cardiac diseases. Its roots are used for the treatment of insomnia, insanity, epilepsy, asthma and high blood pressure in Ayurvedic system of medicine.

## *Rheum moorcroftianum* Royle

Family -Polygonaceae

Ayurvedic Name	Rewandchini
Hindi Name	Rewandchini, Peetmula, Dolu archa
English Name	Moorcroft's Rhubarb
Unani Name	Rewand Cheeni
Trade Name	Rhubard
Parts used	Rhizome, Root and leaves



*Rheum moorcroftianum* Royle

### Morphological Characteristics

The plant is 60 cm tall. It is a stout herb, leaves are radical, thickly coriaceous, orbicular glabrous or stellate puberulous beneath, peduncles and racemes are together. Leaf-stalks are finely striped, short, 3-6 cm, hairless. Leaves dark below, purple in the margin and green above, ovate, 6-12 x 4-8.0 cm, basal veins 5, leathery, base rounded or slightly heart-shaped, margin entire, palmately divided to pinnate, tip bluntly pointed.

### Floral Characteristics

Flowers are borne in spike-like panicle, axis 2-5, nearly equal to leaf. Flower-stalks are about 2 mm, slender. Tepals are yellow-white or with some red, narrow oblong or oblong-elliptic, inner 3 larger, about 2 mm. Anthers are purple-red. Fruit is ovoid or broadly ovoid, 7-8 x 5-6 mm; wings narrow, 1.0-1.5 mm, with longitudinal veins at middle. Flowers occur during the June-July.



Flowers of *R. moorcroftianum*



Seeds of *R. moorcroftianum*



### Distribution

Plant is found in the Himalaya, from Kumaun, Garhwal, Kashmir to Nepal and Tibet, at altitudes of 3600-4400 m.

### Climate and Soil

The plant is confined to the temperate, sub-alpine, and alpine zones of the Himalayas. Well-drained, porous, humus-rich soil is suitable for its cultivation. It prefers exposed or partially shaded habitat and can be cultivated on altitude above 1800 m. The growth and survival at lower elevations is surprisingly high.

### Propagation Material

Through seeds and rhizome cuttings.

**In Vitro propagation:** In *R. moorcroftianum* rooting and callusing is observed when seedling are grown on MS medium, supplemented with auxin. Rooting is observed better at a higher concentration of BAP+IAA. Combinations of IAA, IBA and BAP growth hormones induced callusing, shoot bud formation and rooting.

### Agro-Technique<sup>19</sup>

#### Nursery Techniques

##### Raising Propagules

- Seeds are collected from nature during September - October and sown during October - November at lower elevations inside a greenhouse. In open beds, seeds are sown during the late February or March. At alpine sites, the best sowing period is May. Under control conditions seed germination is 60-85%. Under nursery bed conditions the germination is recorded as 50-60% at higher altitudes and 30-40% at lower altitudes from March to June. For better germination seeds are sown in Styrofoam trays, containing sandy loam soil treated with manure or forest litter, in greenhouses at 20-25°C. About 600 gm of seeds are required to raise a nursery for planting at a spacing of 50 cm × 50 cm in one hectare of land. Seedlings are obtained from a nursery raised in March in open sites or in February in sheltered places. Seeds are sown in lines 15 cm apart. Germination of the seeds is complete within one month of sowing.

##### Planting in the field

- **Land Preparation and Fertilizer Application:** Treatments of manure and forest litter are favoured for the survival and growth of seedlings. Nearly 60 quintal manure is required for one hectare of land at 1800-2000 m sites, and 40 quintal manure at 2200-2500 meter sites for good growth and yield. Manuring is done either during the winter or at the time of transplanting. Decomposed manure should be used. For its cultivation at lower elevations, beds are prepared during the winter month by digging or ploughing. Manure is added as required on the basis of the soil nutrition status. During the rainy season, trenches one foot deep are dug and manure is placed before planting the rhizomes or cuttings.
- **Transplanting and Optimum Spacing:** Vegetative propagation through rhizome transplantation, or rhizome cutting from nature, are quite successful with this species. Through this method the long juvenile phase can be reduced by one to two years. Slices of rhizome with at least one dormant bud

<sup>19</sup> Agro-technique study carried out by Nautiyal and Nautiyal, High Altitude Plant Physiology Research Centre, H.N.B, Garhwal University.

are transplanted, either during April - May or during October - November, 2.5x2.5 feet apart in rich organic humus-containing soil. Leaves and aerial parts wither away within two or three months but the underground rhizome remains dormant throughout the winter. Rhizomes regenerate new plants during the spring. At this planting, distance approximately 16000 seedlings/cuttings are required for one acre land. For seedling establishment in one hectare of land, approximately 6.50 kg seeds are required.



Cultivation of *R. moorcroftianum*

- **Intercropping System:** Intercropping with *R. emodi* is suitable up to 1800 m, and approximately 8000 plants of each species are required for cultivation.
- **Interculture and Maintenance Practices:** While the entire quantity of FYM is applied as basal dose (10 tone/hectare), half dose of nitrogen and full dose of phosphorus and potash are also applied as a basal dose before transplanting the crop. Rest of nitrogen is applied as top dressing six to eight weeks after transplantation.
- **Irrigation Practices:** *R. moorcroftianum* is a drought-resistant plant. Plants however, need regular irrigation initially for ten to fifteen days after transplanting. During the winter season, irrigation is frequently not needed as the underground parts remain alive with little soil moisture. Excessive watering causes the death of underground rhizomes during this period and increases mortality at lower altitudes.
- **Weeding:** Regular weeding/hoeing operations, at an interval of 15-30 days, during the establishment and initial growth phase of the crop as well as during monsoons have shown better



results in terms of plant growth. To avoid rhizome decay during this period and at the same time retain soil moisture, mulching with decaying leaves on the soil surface is necessary.

- **Disease and Pest Control:** The crop is often infected with *Fusarium sps.* soil drenching with Carbendazim 50 at a rate of 2 gm/litre of water is recommended as a control measure. Insects and aphids, which attack the plant at early stage, may be checked by spraying Ekalux 25 0.5% twice at an interval of 10–15 days.

### Harvest Management

- **Crop Maturity and Harvesting:** In nature, plants become mature after five or six years of the vegetative growth phase. At lower elevations, under cultivation, plants mature after four to five years. Plants raised from rhizome cuttings flower after two or three years. Plants are generally harvested during July - August at lower altitudes and during late September to October at higher altitudes, after the completion of growth phases.
- **Best Period of Harvesting for Bio-active Chemical Ingredients:** Emodin, Chrysophenol and rutin content increase with the maturity of plants in nature. Similar trends are found in plants cultivated at lower altitudes, although active contents decrease at the lower altitude of cultivation. Plants should be harvested before senescence to achieve a large quantity of active contents. To get the maximum amount of bio-active ingredients plants must be harvested during the months of July and August at lower altitudes and in October at higher altitudes.
- **Post-harvest Management:** Rhizomes are dug out, washed and cut into pieces then clean or sun dried and stored in airtight containers for marketing, or kept in dry cold chambers.
- **Chemical Constituents:** Rhizomes and roots possess purgative properties similar to that of *R. emodi*. Also used as a yellow dye for woolen clothes. Four active ingredients are found in *R. moocroftianum* as in *R. emodi*. In wild populations, emodin ranged between 1.44 and 1.95% and rutin 0.30-0.65%, chrysophanol 2.34-2.52% and chrysophenol acid 0.72-1.25%. The plant contains anthraquinone glycosides.
- **Yield and Cost of Cultivation:** Production is estimated at approximately 4.1 tonnes/hectare between 1800 - 2800 m altitudes after three years of cultivation through seedlings, and within two or three years by vegetative propagation. Due to the increasing demands of pharmaceutical industries, intercropping with *R. emodi* seems to have great potential as a cash crop for villagers.



Mature and dried rhizome/root

- **Therapeutic Uses:** The rootstocks are used in 'bile' fever, gastritis, stomachache and dysentery. Root extract is used in the disease due to cold, locally called 'dhumbu' (body pain and swelling). The extract is also applied to fix fractured bone. This species has very similar properties to the Himalayan Rhubarb (*Rheum australe*) and is commonly mixed with that species in trade. The roots contain tannins and, taken in small doses acts as an astringent tonic to the digestive system, relieving diarrhoea. At larger doses, however, the anthraquinones in the root exert their influence as a mild laxative and are a gentle treatment for constipation. The root is taken internally in the treatment of chronic constipation, diarrhea, liver and gall bladder complaints, blood disorders, haemorrhoids, menstrual problems, sore throats and skin eruptions due to an accumulation of toxins. A paste of the rootstock is used in treating scabies and other skin. Combined with other herbs, the paste is applied to fix fractured bones, swellings, sprains etc.

### Market Trend (2019/2020)

- **Market price:** 200-300/kg approximately



## *Sapindus trifoliatus* Linn.

Family -Sapindaceae

Ayurvedic Name	Reetha, Arishtak
Hindi Name	Phenil, Rishtak
English Name	Soapnut
Unani Name	Reetha
Trade Name	Soapnut
Parts used	Roots, leaves, fruits, seeds



*Sapindus trifoliatus* Linn.

### Morphological Characteristics

Soap nut is a medium-sized tree that grows up to 18- 25 m. The bark is 4-6 mm thick and greyish-brown color. Leaves are paripinnate, alternate, estipulate, rachis 4.5-10.0 cm, stout, glabrous, swollen at base; leaflets 4-6, 8-18 cm long, opposite or sub opposite, elliptic-lance shaped with tipping points and slightly oblique based. The leaves margin is entire, glabrous, lateral nerves 6-17 pairs.

### Floral Characteristics

Flowers are polygamous, greenish-white, in axillary or terminal panicles. The sepals are 5, pubescent outside, glabrous within, ovate, unequal, in 2 series, much imbricate. The petals are 5, linear-lanceolate, softly woolly on the inner surface except for the claw, scales minute or absent; disc concave, margin fleshy, hirsute. The stamens are 8, inserted within the disc. The filaments are free, pilose; anthers oblong; ovary superior, tomentose, not lobed, 2-3-celled, ovule 1 in each cell, style terminal, stigma 2-3 lobed. Fruit is a drupe, 16-18 mm across, globose, greenish-yellow, fulvous hairy when young, wrinkled when ripe. The seeds are 2-3, globose, and black. Flowering is observed during December and ripe fruits are harvested in March-April.

### Distribution

Occurs in the semi-evergreen and moist deciduous forests from 200- 1500 msl and also in the plains. It appears as native species of the Andaman Islands, Bangladesh, India, Myanmar, Pakistan, and Sri Lanka and was introduced to the African continent.

### Climate and Soil

Low to medium-high elevations up to 1500 msl are favourable for cultivation. The deep clay loamy soil with an annual rainfall of 200-1000 mm is suitable for the tree. It grows robust in areas with annual daytime temperature ranging from 32-40°C, however, it can tolerate temperatures from 10 - 47°C.

### Propagation Material

Mature seeds are best for the propagation of Soapnut. Vegetative propagation through stem cuttings and ring air layering in juvenile plants below 5 years old is also promising.

## Agro-Technique<sup>20</sup>

### Nursery techniques

#### Raising Propagules

- The seeds were sown in a nursery sand bed and found germinated within 13-21 days. The seeds are categorized under Orthodox type as it was tolerant to both desiccation and chilling temperature conditions. The seeds were found viable for long period and 80% germination was recorded up to 17 months under storage in polycarbonate bottles kept at freezing temperature condition. The raised seedlings were transplanted into polybags after two pair of leaves, in a planting medium containing soil: sand: and cow dung in a ratio of 3: 1: 1. The hardening of poly bagged seedlings was made at mist house conditions ( $28\pm 2^{\circ}\text{C}$ ; 80-90% RH) for 2 weeks and later moved to shade conditions and to open areas.
- Stem cuttings of 10- 15 cm long with 2-3 nodes were prepared for rooting. The cuttings were planted in sand beds of the low poly tunnel. Rooting was recorded after 30 days of planting. The ring air layering was conducted in lateral branches by using coir pith: sand: cow dung as a medium in a ratio of 2:1:1. The auxin such as IAA, IBA, and NAA of different concentrations were applied for rooting. The rooting was observed in a month. The layers in poly bags were kept in the mist house, condition maintained at  $28\pm 2^{\circ}\text{C}$ ; 80-90% RH. The rooted stalks and layers in polybags were kept in the mist house conditions for two weeks for hardening.

#### Propagule rate and pre-treatment

- Seeds with an initial moisture content of 13% exhibited 77% germination. The seeds treated in concentrated  $\text{H}_2\text{SO}_4$  for 1 minute were found enhanced germination percent up to 100%.
- During stem propagation, a maximum rooting sets of 80% was achieved in both control and NAA @1000ppm treated sets. In-ring air layering, a maximum rooting of 100% was achieved in control sets.



*Sapindus trifoliatus* plant stock

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The weed growth is removed from the planted site. Planting pits ( 1.5x1x1' ) size were prepared and filled with organic fertilizers such as cow dung and leaf litter compost to accelerate root establishment and growth.
- **Transplanting and Optimum Spacing:** One-year-old poly bagged plants of 60- 70 cm are suitable for planting. Plants transferred to the field during the onset of South West monsoon (June), were found favour the establishment. The optimum space recommended is 4mX4m between the plants.
- **Intercropping System:** No studies have been carried out.
- **Intercultural and Maintenance Practices:** Weeding at regular intervals to be carried out in the planted sites to avoid suppression of seedlings by the weed growth. Mulching of seedlings during the

<sup>20</sup> Agro-technique study carried out by  
Tree Physiology Department, Kerala Forest Research Institute, Peechi



December - January with leaf litter will be aided to maintain the soil moisture. Casualty planting could be done during the rainy season.

- **Irrigation Practices:** A drip system through drip cables is ideal for watering the growing saplings during summer. Irrigation once a week is optimum for the seedlings.
- **Weeding:** As and when required.
- **Disease and Pest Control:** Nursery-growing seedlings were found infested by the caterpillars. The caterpillar was reared and the adult was identified as a moth, *Serrodus campana* (Lepidoptera: Erebidae). The application of Neem oil is effective against caterpillar infestation. The seedlings were also found severely infested and appears papery white leading to growth retardation or even loss. The adult trees were also found similar infestation however not in a severe state.

### Harvest Management

- **Crop Maturity and Harvesting:** The soap nut berries are produced after 8-9 years. Fruits are the main trading material and fruits are harvested during March- April. Fruits are manually picked from trees when it becomes wrinkled during the mature stage.
- **Post-harvest Management:** Fruits are sun-dried after harvesting and deseeded for packing.
- **Chemical Constituents:** Fruits contain triterpenoid glycoside saponin (10-11.5%), Sugars (10%), and Mucilage. All parts of the *Sapindus trifoliatius* show presence of phenolic acids such as protocatechuic acid, cis-p-coumaric acid, p-hydrobenzoic acid, and cinnamic acid
- **Yield and Cost of Cultivation:** On average, one tree produces 12-14 kg of ripened fruits in a fruiting season. The dried fruits along with seeds are collected @ Rs. 80/ kg. The cultivation cost is comparatively less than other tree crops as the species are suited for planting in degraded forests and outside forest areas.

**Therapeutic Uses:** The soap nut powder is used in cosmetics and contraceptive creams due to its antibacterial and antifungal uses. The soap nut oil helps to relieve joint pains. The seed powder is applied to cure a common cold, arthritis, and constipation. The thick watery solution of the pulpy mesocarp is applied to the nose of the patients for the relief of Hemicrania and for restoring consciousness during epileptic and hysteric fits. The roots, leaves, and bark act as expectorant and demulcent. The plant has anti-inflammatory, anti-ulcer, anti-cancerous, anti-diabetic, anti-oxidant, and anthelmintic activity. The fruit pulp is an effective detergent, and bio-surfactant, and is used as an ingredient in the preparation of hair shampoo, body shampoo, and cleanser due to its action against lice and dandruff.

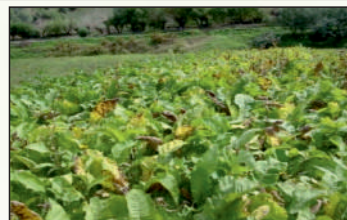
### Market Trend (2019/2020)

- **Market price:** The dried fruits alongwith seeds are sold @ Rs. 82- 150/Kg by the local people in the market.
- **Market demand:** The fruits are high demand in the market. It is a major income source for the tribal and local people.

## *Saussurea lappa* C.B. Clarke

Family -Asteraceae

Ayurvedic Name	Kushtha, Kusht
Hindi Name	Kuth
English Name	Indian Costus
Unani Name	Qust
Trade Name	Kuth
Parts used	Dried roots



*Saussurea lappa* C.B. Clarke

### Morphological Characteristics

*Saussurea lappa* is a perennial herbaceous plant with the plant height of 1-2 m. It is a robust, erect perennial herb. Roots are stout, dark brown or grey, up to 40 cm long. Stout tuberous roots may be 60 cm long and are characterized by a penetrating aroma.

### Floral Characteristics

Flower heads are stalkless, bluish-purple to almost black, hard, rounded, 2.4-3.9 cm across, often 2-5 clustered together in the axils of leaves or terminal. Involucral bracts many, ovate-lanceolate, long pointed, purple, rigid, hairless, receptacle bristles very long. Corolla about 2 cm long, tubular, blue-purple (or) almost black. Anther tails fimbriae. Achene curved, compressed and 8 mm long. Tip narrowed, with one rib on each face. Pappus are brown and double feathery.



Plant



flowers

### Distribution

In natural conditions, the plant is found in Kashmir, Himachal Pradesh and Garhwal region of Uttarakhand where it is distributed from 2500-4000 meter.



### Climate and Soil

Require a cool and humid climate and found at altitudes above 2600-3200 m. Sandy textured loam soil, rich in moisture and organic carbon is best for germination as well as better survival of seedlings and productivity. The plant grows in the temperate and sub-alpine region.

### Propagation Material

Seeds are generally used for propagation purpose. The seeds retain their viability for a year or more.

### Agro-Technique<sup>21</sup>

#### Nursery Techniques

**Raising Propagule:** The seeds are sown in April or May in the nursery. In nature, seeds shed during September and October lie under the snow during the winter and begin to germinate during April or May. Seeds retain viability for one year to eighteen months. For cultivation, seeds are sown in spring directly in fields, or during September and October inside a greenhouse. Greenhouse conditions favour early germination as well as rapid growth.

**Propagule rate and pre-treatment:** Useful pre-treatment for propagation of species is the chilling treatment for a period of 50 days at low temperature (3-4°C) as well as treatment of seeds with lower concentration of gibberellin.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** The higher quantity (60 quintal/acre) of farmyard of litter manure is required especially in cultivated fields. Under a tree canopy, where litter and humus content are already high, no manure is needed. 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.
- **Transplanting and Optimum Spacing:** Seedlings are transplanted at a spacing of 90cm x 90cm when they are one year old. Seedlings can be transplanted after good root development (six to nine months) when roots are 10-12 cm long. For direct sowing, small shallow pits are prepared and the seeds are sown 30cm apart. After six months' growth, plants are 60cm x 60cm thinned apart to encourage healthy growth. This method is successful on moist sites, however, where irrigation is not needed for planting seedlings.
- **Intercropping System:** Approximately 1.5 kg seeds or 20,000 seedlings are required for cultivating one acre land, planting 2x2 ft apart for better growth and yield. A canopy of *Betula utilis* (Bhojpatra), *Quercus semecarpifolia* (Kharasu) and *Abies pindrow* (Silver fir) are suitable for its cultivation. At lower altitudes, however, cultivation under a *Quercus leucotrichophora* canopy is also successful.
- **Intercultural and Maintenance Practices:** Aerial parts wither during the winter and begin growing again during the next season. This process is continued for two to five years before flowering and seed setting. At lower altitudes, however, it takes less time to form seeds. After flowering, plants continue to grow for the next year, but the root quality deteriorates.
- **Irrigation Practices:** Excessive watering is required at the time of germination and the early development stages of seedlings. The land is irrigated when seeds are sprouting. The crop requires 5-6 irrigation between May-September. After one year of growth, the irrigation requirement decreases and plants are watered every four to six days only during the dry months.

<sup>21</sup> Agro-technique study carried out by  
G.B. Pant National Institute of Himalayan Environment, Almora

- **Weeding:** Weeding once every fifteen days is required during the seedling stages and the rainy season.
- **Disease and Pest Control:** Disease is mainly root rot, generally occur at high tem to prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds & leaves), root of chitrak, Dhatura, Cow's urine etc. Disease is mainly root rot, generally occur at high temperature, high moisture conditions and improper drainage condition.

### Harvest Management

- **Crop Maturity and Harvesting:** Crops cultivated through seedlings come to fruiting within two to four years depending on climatic conditions. After flowering, the roots are harvested during September and October before complete seed maturity. The flower heads are harvested and sun dried for a week before threshing. Plants raised through root, however, become mature in a year or two. Roots are harvested during September-October when they achieve maximum growth and come to flower when they are about five years old. It is observed that, after complete maturity of seeds, the root becomes hollow and quality deteriorates. Hence, for good yield as well as quality, roots are harvested after fifteen to twenty days of flowering, or before seed maturity. Furthermore, after seed setting the root quality decreases, hence roots left in the soil for regeneration purposes.
- **Post-harvest Management:** Usually in 2-3 years well grown mature root tubers are developed. However, yield is obtained from 3 years old crop. The root is harvested in early September or October or early spring. The roots are cleaned with water and dried for processing.
- **Chemical Constituents:** Root contains two liquids resins, alkaloids, a solid resin, salt of valeric acid, an astringent and ash that contains manganese. The oil of the root was found to have following approximate composition: Camphene 0.04%, phellandrene 0.4%, terpene alcohol 0.2%, A-costene 6.0%, B-costene 6.0%, aplotaxene 20.0%, costol 7.0%, di-hydrocostus lactone 15.0%, costus lactone 10.0%, costic acid 14%.
- **Yield and Cost of Cultivation:** After 2-3 years of planting about 200-300 kg of dry tuberous roots per hectare can be obtained. Nearly 2.0 to 3.5 tonnes/ha yield is estimated for Kashmir. In Garhwal, nearly 3.5-4.0 tonne/ha yield is estimated at 2200-2500m altitudes. After harvesting, roots are washed with water to remove soil, then cut into small pieces and kept in partial shade for drying. They are either left whole or ground and stored in dry chambers or cotton bags.

### Therapeutic Uses

It has been used successfully by Unani physician in the treatment of hepatitis, jaundice, splenomegaly, cough, asthma, chronic bronchitis, paralysis, tremors, epilepsy, hysteria, arthritis, chronic rheumatism, sciatica, gout, intestinal worms, amenorrhea, fevers, malaria, leukoderma, erysipelas, ring worm, chronic itching, scabies, dysentery, dyspepsia, cholera, melasma, alopecia, chronic ulcer, hair fall and scorpio/ snake bite. Its oil has also been used in perfumery and cosmetics and for prophylactic use.

### Market trend (2019/2020)

- **Market price:** Market rate of *S. lappa* (*S. costus*) during 2019-2020 was Rs. 541.07±46.88 per kg(<https://echarak.in>)
- **Market demand:** 100-200 MT



## *Sida cordifolia* Linn.

Family -Malvaceae

Ayurvedic Name	Bala
Hindi Name	Bala, Kharainti
ॐ ॐ	
Unani Name	Bala
Trade Name	Bala
Parts used	Whole plant



*Sida cordifolia* Linn. in flowering stage

### Morphological Characteristics

It is an erect perennial sub-shrub that reaches up to 2 m in height, with the entire plant covered with soft white felt-like hair that is responsible for one of its common names, "flannel weed". The stems are yellow-green, hairy, long, and slender. The yellow-green leaves are oblong-ovate, covered with hairs, and 3.5 to 7.5 cm long by 2.5 to 6.0 cm wide.

### Floral Characteristics

Flowers are small in size, bright yellow, axillary solitary, trumped shaped, bracteates actinomorphic, pedicellate, bisexual, pentamerous, hypogynous and cyclic. Fruits were schizocarp, capsule, and circular in shape consisting of 12-14 hairy mericarps. The seed were kidney shaped and dark brown in colour.

### Distribution

It is widely distributed in the tropical and sub-tropical plains of India and Sri Lanka up to an altitude of 1000 m. It has naturalized throughout the world, and is considered an invasive weed in Africa, Australia, the southern United States, Hawaiian Islands, New Guinea, and French Polynesia.

### Climate and Soil

The plant grows in subtropical and tropical climate. It grows well throughout the plains of India and Sri Lanka especially in damp climates. Also, found in open spots where there is full sun or partial shade, in loam soil that drains well. These plants prefer frost free conditions.

### Propagation Material

The crop can be raised easily through direct sowing of seeds in monsoon season. The seeds freshly harvested to store up to three years are used for the cultivation. Mature seeds can be collected all year round. In the absence of sufficient seeds, apical shoots, explants and stem cuttings may be used as propagating materials.

### Agro-Technique

#### Nursery technique<sup>22</sup>

#### Raising Propagules

The seedlings can be raised from seeds in the nursery in April. The crop can be raised easily through

<sup>22</sup> Agro-technique study carried out by  
Department of Forestry, Uttar Banga Krishi Vishwavidyalaya, Pundibari, 736 165, West Bengal, India.

direct sowing of seeds in the monsoon season. The seeds are shown in poly bags with a well drain potting mixture. If seeds are sown directly in the main field produce an uneven or dense crop stand. Seeds get matured in September to November.

Different categories of primers with different concentration and duration were compared with control for germination followed by seedling establishment. Soaking the Bala seeds in 0.5%  $\text{CaCl}_2$  solution for 48 hours is recommended for easy, effective and uniform germination, seedling growth and establishment. Maximum growth and yield are obtained when Urea 112.5 mg + SSP 30 mg per plant fertilizer can be applied during the seedling stage.

**Propagule rate and pre-treatment:** Seeds of Bala are reported to exhibit seed coat imposed dormancy posing problems in germination. This can be overcome by soaking the seeds of Bala in water or 0.5 %  $\text{CaCl}_2$  solution for 48 hours.

### Planting in the field

- **Land Preparation and Fertilizer Application:** For planting, the land is repeatedly ploughed to a fine tilth and remove the weeds and pebbles. The seedlings are transplanted at a spacing of 75 cm x 75cm. For a hectare of land, 20-25 tonnes of farmyard/vermicompost to be applied at the time of planting for fertile soils and 15-18 tonnes for moderately fertile soils. Green manuring is effective where irrigation facilities are available.
- **Transplanting and Optimum Spacing:** After emerging, the seedlings of 7-14 days old are transplanted into main field. Maximum growth responses were observed in 75cm x 75cm spacing.
- **Intercropping System:** Not reported
- **Intercultural and Maintenance Practices:** The crop is given 2-3 periodic weeding and hoeing at an interval of one month.
- **Irrigation Practices:** Irrigation is not essential in the rainy season, during summer provides irrigation twice a week. For planting, the land is repeatedly ploughed to a fine tilth and remove the weeds and pebbles.
- **Weeding:** The crop is given 2-3 periodic weeding and hoeing at an interval of 20-30 days.
- **Disease and Pest Control:** Not reported.

### Harvest Management

- **Crop Maturity and Harvesting:** Maximum biomass is obtained in 5-6 months. The optimum stage for the harvest of *Sida cordifolia* is eight months after planting under open condition, at which maximum root yield and ephedrine content was noticed. Further delay in harvesting showed a sharp decline in both root yield and ephedrine content.
- **Post-harvest Management:** The roots are uprooted, washed, cleaned, and dried in shade. The dried produce is packed in gunny bags and stored under humidity-free conditions.
- **Chemical Constituents:** Chemical constituents are ephedrine (chief constituent), pseudoephedrine, fatty acids, saponine, hypaphorine,  $\beta$ -phenethylamine, ecdysterone, indole alkaloids, palmitic acid, stearic acid, and  $\beta$ -sitosterol.
- **Yield and Cost of Cultivation:** The dry weight yield of roots is estimated to be 1.0 to 1.5 tonnes/hectare.



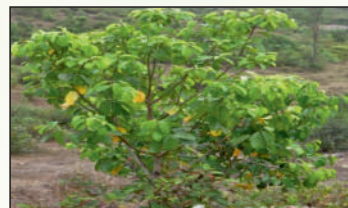
### Therapeutic Uses

In traditional therapy whole plant is used as astringent, analgesic, anti-inflammatory, anti-cancerous, anti-tumor, anti-HIV, immune stimulant, cooling stomachic, hypoglycemic, nervous, urinary and cardiac diseases. In North India, *Sida cordifolia* is commonly used as the drug while in South Indian preparations mainly contains *Sida rhombifolia*. The *Bala* drug is held in great repute by ayurvedic physicians for treating various diseases and it forms chief ingredients of several preparations like Ksirabala, Dhanvantaram, Balarishtam, Rasnadi Kasayam and, Aswagandi Leham.

## *Symplocos cochinchinensis* (Lour.) Moore sp. Laurina Retz. Nooteb.

### Family -Symplocaceae

Ayurvedic Name	Lodhra
Hindi Name	Bholiya, Sodh
English Name	Laurel sapphire berry
Unani Name	Lodhra
Trade Name	Laurel sapphire berry, Chunga
Parts used	Bark and Leaves



Plant of *Symplocos cochinchinensis*

### Morphological Characteristics

It is a medium-sized tree that grows up to 15-20 m. The bark is light grey colour, thin and smooth. The leaves are simple, alternate, spiral, estipulate, lamina 10-17 cm long, elliptic to elliptic-ovate, apex acuminate, base acute to attenuate, margin crenate-serrate, sometimes revolute and lateral nerves 7- 8 pairs.

### Floral Characteristics

Flowering occurs from July to October. The inflorescence is axillary simple or branched spikes, 7 cm long and velvet-hairy. Flowers are bisexual sessile and white. The bracts are solitary at the base of each flower-stalk, calyx tube adnate to the ovary, lobes 5, minute, lobes 1 mm, triangular. The petals 5, ovate, 3 mm, recurved; stamens many, equal, arranged in 5 groups. The ovary is 1 mm, inferior, spherical 2-3-celled, ovules 2 in each cell, style 5 mm, simple, stigma capitate. Fruit is a drupe, 8 mm across, hairless, flask-shaped, spherical ribbed, purple colour, crowned by sepals. The seeds are brown and oblong. Fruits arise from January- May.

### Distribution

Trees are distributed in the tropical and subtropical regions of India, Indo-Malaysia, and China.

### Climate and Soil

Evergreen and shola forest provides favourable conditions for the species. It is an altitude-specific species and found at medium high elevation.

### Propagation Material

Seed and vegetative (stem cuttings and ring air layering among juvenile seedlings below 5 years old) propagation techniques are used for multiplication. At the time of maturity, fruits turn purple-black from green color.

### Agro-Technique

### Nursery Techniques<sup>23</sup>

<sup>23</sup> Agro-technique study carried out by  
Tree Physiology Department, Kerala Forest Research Institute, Peechi



### Raising Propagules

Seeds are sown in a sand bed and germinated within 6 months. Seeds illustrate dormancy. Chilling temperature conditions were sensitive to the seeds. However, seeds could be dried without losing viability and hence categorized under the intermediate type. The raised seedlings were transplanted after attaining 5 pairs of leaves as the seedlings showed slow growth. The planting medium consists of soil: sand: cow dung in ratio of 3:1:1. As a part of the hardening process, the poly bagged seedlings were maintained in the mist house conditions ( $28\pm 2^{\circ}\text{C}$ ; 80-90% RH) for 1 month and subsequently moved to the shade and open conditions.

Both control sets and auxin such as IAA, IBA, and NAA at different concentrations were used for the vegetative propagation of the species. Stem cuttings of 10- 15 cm long with 2-3 nodes were prepared and are planted in sand beds of the low poly-tunnel. The rooting was noted after 45 days of planting. The ring air layering was carried out in the primary stem by using the medium, coir pith: sand: cow dung in a ratio of 2:1:1. The rooting was observed after 4 months of girdling. The layered plants were kept in the mist house conditions maintained at  $28\pm 2^{\circ}\text{C}$ ; 80-90% RH for monitoring purposes. As part of hardening, both ramets and layers transferred in polybags were kept in the mist house for two weeks.

**Propagule rate and pre-treatment:** The seeds resulted in 20% germination at an initial moisture content of 35%. However, the seeds with a reduced moisture content of 13%, demonstrated enhanced germination of 50-60%. In stem cuttings, 80% rooting was recorded with the aid of auxins. In all the sets, auxins at 1000 ppm were optimum for rooting. The control sets resulted in 40% success. In air layering, 75% rooting was achieved with IAA 1000 ppm whereas, no response was in control.

### Planting in the field

- **Land Preparation and Fertilizer Application:** The weed growths are removed from the planted site. Pits of 30 cm × 30 cm × 30 cm size are suitable for planting. Pits are half filled with organic manure viz. cow dung and leaf litter compost before the planting.
- **Transplanting and Optimum Spacing:** The plants with an average height of 50- 60 cm are better for planting. Plants transferred in the field during the onset of South West monsoon (June) for better establishment. The optimum space recommended is 3m x 3m between the plants.
- **Intercropping System:** It is good as a shade tree and is maintained in Tea estates for providing optimum shade to the Crop. The tree could be planted as intercrop in the high-altitude crop plantation areas. Being a good colonizer, the species are well suited for eco-restoration of degraded sholas of the Western Ghats.
- **Intercultural and Maintenance Practices:** Weeding at regular intervals to be carried out in the planted sites to avoid suppression of seedlings by the weed growth. Mulching of seedlings during the December- January months with leaf litter will be aided to maintain the soil moisture. Casualty planting could be done during the rainy season.
- **Irrigation Practices:** A drip system through drip cables is ideal for watering the growing saplings during summer. Irrigation twice a week is optimum for the seedlings.
- **Weeding:** As and when required.

- **Disease and Pest Control:** Follicolous fungal infestations were visible on leaves. Synthetic fungicides are used as primary means of control of plant diseases.

### Harvest Management

- **Crop Maturity and Harvesting:** The bark is harvested from the mature trees, attained above 12-15 years old. The summer season is ideal for bark extraction. Deep incisions on the bark are to be avoided as it touches the cambium layer which causes degeneration of the stand.
- **Chemical Constituents:** Arjunolic and Asiatic acids glucosides are terpenes obtained from stem bark. L- arabinose, and D-galactose are also found in leaves. It contains phenolic hydroxyoleosides and symplocochinside.
- **Yield and Cost of Cultivation:** The yield of the bark is depended on the girth size of the tree. The cultivation cost is comparatively less than other tree crops as the species is easily established in high-altitude degraded forest and outside forest areas, preferably above 750 m asl.

### Therapeutic Uses

- The bark is used in the treatment of uterine complaints, vaginal diseases, and menstrual disorders. Bark also acts as a promising remedy in treating diarrhoea, dysentery, eye diseases, fever, cough, ulcers, swellings, arthritis, and leprosy along with anticancer, anti-inflammatory, and antidote properties. The bark is strongly astringent and febrifuge. The dried bark powder is used with honey to treat internal bleeding. The leaves juice along with cucumber juice used to cure diabetes in traditional medicine. Leaves also possess hyperlipidemic properties. In traditional medicine, the extract prepared from the leaves have a significant effect in reducing the blood sugar level in type-2 diabetes. The bark extract found to have anti-diabetes properties.

### Market trend (2019/2020)

- **Market price:** The twigs along with leaves and stem bark are collected by the tribals and local people. The price varying from Rs. 100-150 /kg.
- **Market demand:** The plants parts have high demand in the market. It is the major income source for the tribal and local people.



## Woodfordia fruticosa (Linn.) Kurz

Family -Lythraceae

Ayurvedic Name	Dhataki, Dhatupushpi
Hindi Name	Dhataki, Shiranjitea.
English Name	Fire Flame Bush
Unani Name:	Tamrapushpi, Kunjara
Trade Name:	Dhawai, Dhataki
Parts used	Leaves, Flower, Fruits, Bark, Roots and Gum



*Woodfordia fruticosa* (Linn.) Kurz

### Morphological Characteristics

It is a traditional medicinal shrub growing gregariously reaches up to 5-12 m and normally found in higher altitude of about 1500 m. Bark is thin, smooth and reddish brown in color and leaves are 5-9 cm long, ovate and lanceolate in shape. Flowers are bright red in color, observed in the month of January to April. Fruits are capsule about 1 cm long, observed in the month of April to June. Seeds are very fine, powdery in nature and 1 mg contains more than 3000 seeds.

### Floral Characteristics

This gregarious shrub species flowers profusely during the summer months and seeds are produced abundantly. Flowers are numerous, brilliant red in dense axillary panicle-cymose clusters and seeds are brown, minute, smooth and obovate.

### Distribution

It is a traditional medicinal shrub widely present in India and South East Asia.

### Climate and Soil

Adapted to subtropical and tropical climate grows well in open, sunny places, often on disturbed soils and on old agricultural land. Prefers well-drained soil and can grow in nutritionally poor soil. It cannot grow in the shade and prefers moist soil. The plant can tolerate strong winds but not maritime exposure.

### Propagation Material

Freshly harvested seeds are best for the cultivation. Mature seeds can be collected in April to June. In the absence of sufficient seeds, apical shoots (2-3 node), explants and stem cuttings may be used as propagating materials.

### Agro-Technique<sup>24</sup>

#### Nursery Technique

Trees are distributed in the tropical and subtropical regions of India, Indo-Malaysia, and China.

**Raising Propagules:** The species can be propagated through seeds and vegetative means as well. Survival of seedlings is very low under normal conditions. Seeds sown in soilrite medium germinated in

<sup>24</sup> Agro-technique study carried out by

Department of Forestry, Uttar Banga Krishi Viswavidyalaya, Pundibari- 736 165, West Bengal, India.

7-15 days. Successful germination was also achieved when seeds were sown in sandy soil or sterilized coir pith compost medium.

**Propagule rate and pre treatment:** Different categories of primers with different concentration and duration were compared with control for germination followed by seedling establishment. Refrigerating the Dhawai seeds for 24 hours is recommended for easy, effective and uniform germination, seedling growth and establishment. Soilrite growing media was suitable for enhancing seed germination and seedling establishment. In macro-proliferation cup technique maximum survival per cent and growth performance were recorded in three nodes shoot cutting treated with root hormone. In vitro propagation technique was also performed to produce elite seedlings.

#### Planting in the field

- **Land Preparation and Fertilizer Application:** Land is repeatedly ploughed to a fine tilth and remove the weeds and pebbles
- **Transplanting and Optimum Spacing:** The seedlings are transplanted at a spacing of 3 m x 3 m. For a hectare of land, 15 tonnes of FYM to be applied at the time of planting. Two-three months old seedlings are transplanted to outfield with root ball. The optimum spacing for *Woodfordia* is 3m x 3m and this can be varied based on practitioners perspective.
- **Intercropping System:** Intercropping was done with Poplar in terai region of India. *Woodfordia* is an economically important shade adapted medicinal plants which is naturally growing under the canopy of plantation crops and home steads of many states including Kerala.
- **Irrigation Practices:** Irrigation is not essential in the rainy season, during summer provide irrigation once in a month.
- **Weeding:** The crop is given 2-3 periodic weeding and hoeing at an interval of one month.
- **Disease and Pest Control:** Not reported

#### Harvest Management

- **Crop Maturity and Harvesting:** Flowering appears earlier in vegetative means of propagated plants than seed-origin plants. Maximum growth and flower yield parameters were observed in vegetative means of propagated plants over seed origin.
- **Post-harvest Management:** The harvested flowers, cleaned, and dried in shade. The dried produce is packed in gunny bags and stored under humidity-free conditions.
- **Chemical Constituents:** Woodfordins A, B, C, D, E, F, G, H, I and were identified from the flowers.
- **Yield and Cost of Cultivation:** Two years old vegetatively propagated each plant can produce 50 g of dry flowers.

#### Therapeutic Uses:

Ancient Verse regarding *W. fruticosa* states that Dhataki, Dhatupushpi, Tamrapushpi, Kunjara, Subhiksha, Bahupushpi and Vahnijwala all are synonyms of *Woodfordia*. It is pungent and astringent in taste with cold potency causes delirium in higher dose and this herb is very light in nature. It is used in treating thirst, diarrhea and dysentery, bleeding, poisoning, worm infestation and herpes. Compounds like tannins, flavonoid, glycosides, and sterols and, polyphenols have been isolated from this species particularly the flower and leaves possess pharmacological importance. Both leaves and flowers used as astringent, antibacterial, acrid, refrigerant, stimulant, styptic, uterine sedative, constipating, anthelmintic, emetic and stimulant.



## Glossary of Botanical Terms

	
Abscisic acid	: Plant hormone that inhibits growth
Achene	: Single seeded, unicellular, dry, indehiscent fruit also called caryopsis
Acicular	: Needle like
Acuminate	: Long, pointed, gradually tapering towards apex
Adaxial	: Located on the side towards the axis. The adaxial surface of a leaf is the upper side
Aerial root	: An aerial root is a plant's root that is produced above the ground
Agriculture	: It is the science of farming, including growing plants and raising animals
Airspace	: These are the inter-cellular gaps within the Spongy mesophyll of leaves
Amplexicaule	: Encircling of the node by leaf bases
Annual	: An annual is a plant that goes through its entire life cycle within a year
Apex	: Tip, uppermost part
Apices (apex)	: Top
Arable	: Arable land is suitable for growing crop plants
Arcuate	: Leaves with arcuate venation have veins that are curve towards the apex (Tip)
Areole	: Areoles are circular clusters of spines on a cactus
Aristate	: Ending in bristle or awn
Articulate	: Jointed
Auxin	: Growth hormone found in plants
Awn	: Bristle-like extension of a plant near its tip
Axillary bud	: The axillary bud is a bud that develops in the axil (The angle between the stem and the leaf) of plant
Bark	: Outer covering of trunk, branches and roots of trees
Berry	: Small juicy, fleshy, stoneless fruit that contains one or many seeds
Biennial	: Plant takes two years to complete the full life cycle
Bilateral	: Two sides
Birch	: These are broad-leaved, deciduous trees and shrubs with paper like bark
Bladder	: Small air-filled sac
Blade	: Narrow flat leaf
Bract	: Reduced leaf-like structure associated with a flower
Bracteole	: A small bract or leaf structures below perianth in a flower
Bud	: A small developing part of a plant that will grow into a flower, a new leaf or a stem
Bud scale	: Modified leaf that covers and protects the bud
Bulb	: An underground stem usually globular that has fleshy leaves emerging from the top and roots emerging from the bottoms
Bulbils	: Vegetative propagative spherical structure arising at the leaf base ( <i>as in Dioscorea bulbifera</i> )
Bulblet	: A small bulb that grows from another bulb (for vegetative propagation)
Caducous	: Falling soon
Campanulate	: Bell-shaped

## Agro-Techniques of Selected Medicinal Plants : Volume-IV

Canopy	: It consist upper part of the trees of a rain forest
Capitulum	: Head-shaped inflorescence, as in Asteraceae
Capsule	: It is a seed pod that opens when it is dry and the seeds are mature
Carpel	: Female reproductive organ of a flower
Caudex	: An enlarged, woody base of the stem on some plants
Cauline	: Arising from stem
Clade	: A Clade is the group of all the organisms that share a particular common ancestors
Cladodes	: Modification of dwarf branches into leaf-like structure
Clasping	: Wrapping
Cleft	: A cleft leaf is one in which the margins between the irregular teeth go more than half way to the mid rib
Comose	: With long, white bunch of hair
Coppice shoots	: It is a shoot that arise from an adventitious or dormant bud on a branch or stem of a plant
Cordate	: Heart-shaped
Coriaceous	: Thick, stiff
Cork	: It is the soft, light weight bark of the cork oak tree.
Corm	: A stem modification, underground spherical in shape with reserve food material
Corona	: Bundle of hair between corolla and stamens arising from base of the corolla
Crenate	: A crenate leaf has margins (edges) shaped like rounded teeth
Crisped	: Tightly curled margin
Crystals	: Solid, whose atoms form a regular pattern
Culm	: Elongated straw or hollow stem of grasses
Cuneate	: Wedge-shaped, tapering towards base
Cuspidate	: Tapering to long point at tip
Cyme	: Arrangement of flowers with older flower on top and younger flower towards base
Deciduous	: Plants lose their leaves seasonally, usually for the dry season
Dehiscent Fruit	: A fruit splits open when it is mature, causing the dispersal of its seeds
Diadelphous	: Stamen divided into two groups 9+1 as in Fabaceae
Dichovenation	: It is a pattern of a leaf veins in which the veins branch in two over and over again
Didymous	: Two-sized (filament of stamens)
Dimorphism	: Two forms
Dioceous	: Male and female flowers on different plants
Dirt	: Another name of soil
Discoid	: Disc-shaped
Dispersal	: It is a process in which an organism spreads out geographically
Dominant	: It is the most abundant species an area
Dormancy	: It is a period in which a plant has no active growth in response to harsh environmental conditions
Elatr	: A cell or a part of a cell which assists in dispersing spores
Ellipsoid	: Eclipse-shaped
Emarginate	: Deeply and irregularly notched at apex
Embryo	: An embryo is a developing plant still inside the seed
Entemophylous	: Pollinated by insects



## Agro-Techniques of Selected Medicinal Plants : Volume-IV



Endemic	: Endemic plants are native to an area and are only found in that area
Entire	: Even margin, complete margin, no cut or lobation on margin (of leaves)
Epigynous	: Ovary seated above perianth
Epiphytes	: A plant which grows upon another plants
Exstipulate	: Without stipule, a leafy structure at the base of leaf
Extrose	: Facing outward
Fascicled	: Clustered at one point
Fibrous root	: A fibrous root is a type of root of a plant that has a lot of side branching
Fluted	: Hollow
Foliage	: Type of leaf
Follicle	: Dry dehiscent fruit opening only by ventral suture
Fragrant	: Emitting sweet smell
Gamo petalous	: Petals united with each other
Gamo sepalous	: Sepals united with each other
Gamo tepallus	: Perianth united with each other
Glabrous	: Without any hairy structure
Gynoecium	: Female part of flower having ovary, style and stigma
Habit	: The general growth pattern of a plant
Habitat	: A space suitable for the survival and reproduction of an organism
Haustorial root	: Root absorbs water and nutrients from another plant (not from soil)
Heart wood	: Central hardest part of wood/trunk
Humus	: Humus is the rich organic portion of the soil
Hypogynous	: Ovary inferior, sepals, petals and stamen above the ovary
Imbricate	: Arrangement of corolla with two outer, one inner, and two with one side outer other side inner
Imparipinnate	: Leaflet in odd number on top
Indehiscent	: A fruit that remains closed at maturity is indehiscent
Indigenous	: An organism is one that leaves naturally in a particular reason and were not introduced there by man
Inferior ovary	: An ovary located below the flower parts
Inflorescence	: A cluster of flowers
Lanceolate	: Shape of convex lens
Lateral	: Near or from the side of an organism
Latex	: Oozing milky sap
Leaflet	: In a compound leaf the individual blades are known as leaflets
Lemma	: A bract in a grass speculate that is located below the stamens and pistil of the flower
Lenticellate	: Slit-like raised cortical structure on the branches
Liana	: It is a woody climbing vine that grows on tree trunks in order to reach sun light in the rain forest
Linear	: Very narrow, like a line
Loam	: It is a type of rich crumbly soil that contains an almost equal amount of sand and silt, plus a small amount of clay
Lomentum	: Single seeded cell of pod, septate, and constricted between two seeds
Mesophyte	: A plant that has moderate water requirements

## Agro-Techniques of Selected Medicinal Plants : Volume-IV

Mineral	: A mineral is a naturally occurring solid of definite chemical compositions whose atom usually form a regular pattern
Moniliform	: Beaded in a row like a garland
Monoculture	: It is a system of agriculture in which a single type of crop is grown in an area
Monoecious	: Unisexual, male and female flowers on the same plant
Mucronate	: Small projection at the apex (acume)
Mycorrhizae	: It is a fungus that grows in a symbiotic relationship with the roots of a plant
Nutrient	: It is a chemical that an organism need to ingest in order to survive
Oblong	: Longer than broad with narrowing margin towards base
Obpyramidal	: Inverted pyramid shaped
Obsolete	: Minute or wanting
Obtuse	: Blunt top (apex)
Orbicular	: Almost circular
Ovate	: Egg shaped
Palmate	: Hand like structure of a leaf
Peat	: A type of soil which is composed of in completely decomposed plant material that waterlogged and low in oxygen
Pedicel	: Stalk of flower
Pedicillate	: Stalked flowers
Peduncle	: Stalk of inflorescence
Perennial	: A plant which continues to grow after it has reproduced, usually meaning that it lives for several years
Perianth	: Vegetative covering of sexual organ in flower, sometime differentiated into calyx and corolla
Peripinnate	: Leaflet in even number
Pesticide	: An agent that kills unwanted plants and insects
Petiole	: A petiole is a leaf stalk on a compound leaf, the petiole extends from the stem to the first set of leaflets
Petiolate	: Petiolate means having a petiole
Phylloclade	: Modified stem
Phyllode	: Leaf has enlarged midrib without blades
Pinnate	: Compound leaf with leaflets arranged on same rachis at length
Polyhedral	: Many faced, many angled
Prickle	: Sharp outgrowth of a plant's epidermis
Procumbent	: Creeping on ground then rising up
Pubescent	: Carpeting of small soft hair
Rachis	: Midrib of a leaf
Radical	: Arising from stem base (leaves or branches)
Receptacle	: Terminal portion of the flower stock
Reniform	: Almost kidney-shaped
Repand	: Leaf has a wavy margin
Reticulate	: Weaved
Rhizome	: Subterranean part between stem and root bearing buds that may be used as a propagative part
Rhomboid	: Quadrihedral with only opposite angles equal



## Agro-Techniques of Selected Medicinal Plants : Volume-IV



Rosette	: A series of whorles of leaves or leaf-like structure produced at the base of the stem, just above the ground
Rugose	: Ridged, rough or wrinkled
Sapling	: A small young tree
Sapwood	: It is an outer layer of wood in a tree and contains living cells
Sarmentose	: Growing among bushes, with long flexuous runners
Scale	: Tiny green leaves
Scandent	: Weak plants that need support; climbing without any climbing organ, and so on
Serrate	: Margin of leaf cut into saw-shaped structure, pointing upwards
Sessile	: Without any stalk
Sinuate	: Wavy margins
Spathulate	: Service spoon shaped
Spike	: Sessile flowers arranged on peduncle
Spikelet	: It is a secondary spike found in grasses; It is cluster of two or more flowers in the inflorescence
Staminode	: Barren stamen (infertile anthers)
Stellate	: Star-shaped arrangement of short stiff hair (trichomes)
Stipitate	: Stalked
Stipule	: Paired, appendages found at the base of the leaves
Striate	: Marked with vertical lines
Succulent	: Thick, soft and juicy
Suffruticose	: A herb becoming perennial at base and herbaceous at apices
Syncarpous	: Fused carpels
Tap root	: Type of root
Terete	: Lined
Terminal bud	: A bud located at the apex of a stem
Terrestrial	: Growing in soil
Tester	: Seed coat
Thorn	: Modified stem
Tomentose	: Dense, soft, layer of hair or cotton easily scraped off
Truncate	: Flat topped
Tuber	: A swollen, subterranean root containing reserve food material
Turbinate	: Tube shaped
Variegated	: Spotted with various colour
Veinlet	: Small vein
Venation	: The arrangement and pattern of veins in a leaf
Villous	: Long soft shaggy hair
Vine	: A plant that needs support as it grows
Whorl	: Arising more than two from one node (leaf or branches)
Wood	: A secondary tissue found in seed plants which consists largely of Zylum tissues
Xeric	: Dry conditions
Zygomorphic	: Asymmetrical plain of flowers not divisible into equal halves