



Agro-techniques of selected medicinal plants

Volume 1



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National Medicinal Plants Board

Department of AYUSH, Ministry of Health and Family Welfare

Government of India, Chandralok Building, 36, Janpath

New Delhi – 110001

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The agro-techniques covered in this publication are based on the reports of various institutions and may not meet the exact agronomic requirement of a particular crop in another agro-climatic region. The National Medicinal Plants Board, therefore, does not take any responsibility for any variation in the agronomic practice, crop yields, and economic returns indicated in the agro-techniques in this publication.

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Foreword

We in India have a rich heritage of plant-based health care systems like Ayurveda, Unani, and Siddha, which have a very high degree of societal acceptance as they provide quality health care to a large segment of our population. Forests, however, continue to be the main source of the raw material used for the manufacture of medicines of Ayurveda, Siddha, and Unani. The unsustainable collection from the wild not only puts the species at the risk of extinction but also affects the quality of the medicines manufactured due to absence of standardization in the quality parameters of the raw material.

A recent study by the NMPB (National Medicinal Plants Board) has highlighted the fact that although about 6000 plants are used in the folk and documented systems of medicine in India, less than 50 species of medicinal plants are cultivated to any sizeable extent. The main factor behind the slow pace of domestication of medicinal plants sourced from the wild is the absence of knowledge on cultivation practices for such medicinal plants.

The NMPB has the primary mandate of supporting programmes relating to conservation and development of medicinal plants. While conservation of medicinal plant resources *in situ* is the major component of the schemes of the Board, promoting cultivation of medicinal plants is also of equal, if not greater, importance, considering the potential that medicinal plants offer for crop diversification and income generation, if supported with proper extension and marketing linkages. Cultivation can also ensure production of raw material of standardized content and quality, thereby enhancing the quality of the products manufactured.

The agro-techniques developed by the NMPB through the various university and R&D institutes will go a long way in disseminating scientific information to the growers who are keen to take up cultivation of medicinal plants but have not been able to do so due to the absence of authentic scientific information.

I am confident that the book will fill this critical void in the programme for promoting cultivation of medicinal plants.

Anita Das
Anita Das

Acknowledgements

Cultivation of medicinal plants offers opportunities for crop diversification and income generation to the farmers. However, development of sound agro-techniques for the plants that have traditionally been collected from forests has been a major challenge in promoting cultivation. It is in this background that a need was felt to develop agro-techniques for some of the important medicinal plants by involving the key R&D institutions and universities in the country. Accordingly, the Department of AYUSH decided to support studies for development of agro-techniques under the 'Central scheme for development of agro-techniques and cultivation of medicinal plants', specifically for those plants that are used in AYUSH systems of medicine.

Projects were, therefore, allocated to 33 specialized scientific organizations consisting of agriculture/horticulture universities and the R&D institutions of CSIR (Council of Scientific and Industrial Research), ICAR (Indian Council of Agricultural Research), and ICFRE (Indian Council of Forestry Research and Education), which required infrastructure and expertise to study about 115 plants. Under the scheme, the organizations were required to undertake the experimental cultivation of allocated plants specifically for the development of agro-techniques through projects that were normally executed for three to four years. The performance and progress of the projects were monitored by the PEC (Project Evaluation Committee) set up by the Department. Of the 115 plants, 50 medicinal plants and their agro-techniques have been short-listed for publication in the first volume on the basis of reports received. It is proposed to finalize further reports for publication under subsequent volumes.

Development of agro-techniques for different medicinal plants is an endeavour of the NMPB (National Medicinal Plants Board) towards promoting cultivation of medicinal plants, through standardized agro-techniques so as to make available to the industry raw material of quality and standardized chemical ingredients.

The present publication is the first step in the series for finalization of the agro-techniques that have been developed by the various R&D institutions and universities. This would not have been possible without the efforts put in by the PIs (principal investigators) and project staff in the respective organizations that were assigned the projects for development of agro-techniques. The contribution of all the PIs, Co-PIs, and the organizations is deeply acknowledged. The agro-techniques included in the publication are based on the reports furnished by the project organizations. All other information relating to basic features of a particular medicinal plant is based on the published literature and formularies/pharmacopoeias. The agro-technique developed by an institution located in a particular geographical area is the outcome of its best efforts. The findings given are only indicative and may not meet the exact agronomic requirement of a particular crop in another agro-climatic region, as no agro-technique can suit all the diverse climatic regions. Therefore, anyone seeking to enter into cultivation as a commercial activity will be well advised to revalidate the agro-techniques from an R&D institution/university located in the region where cultivation is sought to be done. The NMPB has set up 23 facilitation centres for medicinal plants in different states, which may also be approached to confirm the applicability of the agro-techniques for a particular region.

The project work was evaluated and guided by the PEC consisting of Dr Rajendra Gupta (Retired Agricultural Scientist of NBPGR [National Bureau of Plant Genetic Resources]), Dr Mayaram Uniyal (Dravyaguna and Ayurveda expert), Dr S Natesh (Adviser, Department of Biotechnology), and Dr Sudeep Kumar (Principal Scientist, CSIR). Efforts of the members of the PEC, especially those of Dr Rajendra Gupta who chaired most of the meetings of the Committee, are gratefully acknowledged.

On behalf of the NMPB, Department of AYUSH, I feel it is my duty to place on record my sincere thanks and appreciation for all institutions/organizations that have worked for the development of agro-techniques. Editing of the text and preparation of final document for publication in a uniform pattern was a herculean task. Dr K K Bhutani, Dean, Department of Natural Products and Shri A S Sandhu, Garden Superintendent

of the NIPER (National Institute of Pharmaceutical Education and Research), Mohali have been responsible for the initial editing of the text, and I acknowledge with gratitude their contribution in the exercise. The final technical editing and designing have been accomplished by TERI (The Energy and Resources Institute) and the contribution of Dr P P Bhojvaid, Senior Fellow (TERI), Mrs Neelu Gera, and others in TERI is highly appreciated.

Development of agro-techniques of the medicinal plants has a great significance for overall development of this sector. Formulation, implementation and monitoring of the programme, and the outcome of the programme in the form of present publication is the result of untiring efforts of officers/staff of NMPB, Department of AYUSH. In particular, contributions by Dr S K Sharma, Adviser (Ay.), Sh R B S Rawat, former Chief Executive Officer (NMPB), Dr D C Katoch, Dy. Adviser (Ay.), Sh T U Haqqi, Assistant Adviser (Botany), Dr N Padma Kumar, Research Officer (Botany), Dr O P Mishra, Research Officer (Botany), Dr V K Singh, Asstt. Director (Botany), CCRUM (Centre Council for Research in Unani Medicine), New Delhi and all other officers/staff of NMPB and Department of AYUSH are gratefully acknowledged. The Board expresses its gratitude to everyone who has been directly or indirectly involved in bringing out this publication.

B S SAJWAN
Chief Executive Officer

Abbreviations

@	at the rate of
BA	butyric acid
°C	degree celsius
cm	centimetre
DAP	di-ammonium phosphate
FYM	farmyard manure
GA ₃	gibberellic acid
gm	gram
H ₂ SO ₄	sulphuric acid
ha	hectare = 10 000 m ²
IAA	indole acetic acid
IBA	indole butyric acid
K ₂ O	potash
kg	kilogram
m	metre
mg	milligram
ml	millilitre
mm	millimetre
msl.	mean sea level
MT	metric tonnes
NAA	naphthalene acetic acid
NER	North East Region of India
NPK	nitrogen + phosphorous + potassium
P ₂ O ₅	phosphate

PBZ	paclobutrazol
pH	acid/alkali value of soil (below 7 pH – acidic; above 7 pH – alkali)
PPM	parts per million
TRF	triademophon
WDP	wettable dispersible powder
ZnSO ₄	zinc sulphate

Introduction

More than 90% of the formulations under the Indian Systems of Medicine that is, Ayurveda, Siddha, Unani, and Homoeopathy (AYUSH), predominantly contain plant-based raw materials. The efficacy of these systems thus mainly depends upon the use of genuine raw material of quality and standardized ingredients in the manufacture of medicines of these systems. In all, about 2000 medicinal plants are used in the preparation of AYUSH medicines, and 500 of these are more commonly used. For centuries, the forests have been the source of herbs and medicinal plants. In the last few decades, while the availability of medicinal plants collected from forests is becoming uncertain, demand for herbs and plants has been increasing due to resurgence in interest in AYUSH systems. Therefore, the forest resources are under double pressure and are not able to meet the demand of providing medicinal plants and herbs. 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.

Considering the above situation, measures are required to promote the cultivation of medicinal plants and create awareness amongst the people, particularly amongst the farmers, about the medicinal and economic value of these plants so that these plants may be wisely used and at the same time conserved.

With the above objective in mind, the Ministry of Health and Family Welfare had organized five regional seminars on medicinal plants during the year 1986. These seminars were held at Junagarh, Guwahati, Coimbatore, Manali, and Nainital. These seminars brought together a

wide range of experts and were followed by a few workshops organized in various states. In this series, a national workshop was also convened in August 1990 in New Delhi. On the basis of recommendations of regional seminars and workshops, 45 medicinal plants were considered important for development of agro-techniques on priority, keeping in view their demand and availability status.

For these reasons a central sector scheme, that is, 'Central Scheme for Development and Cultivation of Medicinal Plants', was implemented in 1990/91 to encourage cultivation of medicinal plants through government-supported organizations that were engaged in, and had expertise in this field. Central assistance was provided for creation of basic infrastructure facilities comprising works relating to fencing/development of land, creation of irrigation facility, making available equipment, and construction of sheds and other miscellaneous expenditures. The intention behind this activity was to engage these organizations in cultivation of these plants and also develop agro-techniques for their cultivation. However, after a few years of implementation of this scheme, it was observed that the medicinal plant gardens set up under the scheme served the demonstration purpose only. The concerned organizations had not been able to properly take up the work of development of agro-techniques.

No systematic effort had been made in the past for developing the practices for cultivation of medicinal plants for providing raw material of standardized ingredients. The package of practices under the agro-technique should essentially consist of the following:

- Best method for raising the plants
- Best soil for the plants
- Seasonal practices including time of sowing the seeds and determination of growth behaviour
- Number of plants appropriate for plantation per unit area and for cropping/intercropping system
- Nutrient requirement
- Water management and weed control
- Maturity and best harvesting period
- Best harvest techniques and storage/packing methods
- Best period of harvesting, keeping in view the active chemical ingredients
- Commercial viability keeping in view the per acre input/output

Need for good cultivation and harvesting practices

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. The wild varieties also differ with respect to the presence of the active constituents from area to area. All such conditions may have adverse consequences. 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. This is the basic reason for their exploitation from wild sources. Non-availability of proper techniques, soil, and authentic plantation material are also some of the main constraints.

The safety and quality of raw medicinal plant materials and finished products depend on various factors like genetic makeup, environmental conditions, collection and cultivation practices, harvest and post-harvest processing, transport and storage practices, and so on. Inadvertent contamination by microbial or chemical agents during any of the production stages can also lead to deterioration in quality.

WHO guidelines on GACPs

The WHO (World Health Organization) has published guidelines for GACPs (good agricultural and collection practices) for medicinal plants. The national governments are required to develop country-specific guidelines for sustainable production of raw material of quality and standardized ingredients. The development of WHO guidelines on GACPs for medicinal plants is an important step to ensure quality of herbal medicines and ecologically sound cultivation practices.

The GACPs cover a wide spectrum of cultivation and collection activities, including site selection, climate and soil considerations, identification of seed, main post-harvest operations, and legal aspects. It is necessary to concentrate on standardizing the cultivation practices, collection practices, and post-harvest technologies for these plants adhering to GACPs.

Certain basic guidelines are to be followed under GACPs for cultivation and harvesting of the crop, some of which are described below:

- Select proper site for cultivation of a particular medicinal plant.
- Select correct time for cultivation.

- Select proper variety.
- Adopt organic farming.
- Prune and collect only desired mature part(s), without harming the mother plant.
- Do not collect the whole population; leave at least 30%–40% for regeneration.
- Do not cut twigs/branches for collection of plant parts.
- Use proper equipment for cutting, shearing, peeling, and so on.
- Start drying process immediately after collection; ensure complete drying before packing and storage.
- Dry aromatic herbs and delicate fruits in shade, and do not dry two or more herbs in close vicinity.
- Sift the herbs with appropriate sifter to remove dust and other undesirable matter.
- Pack the herbs in suitable packaging material to avoid losses due to external factors.
- Store the herbs in proper storage conditions to minimize loss on storage.

For collection of underground part(s), bark, and whole plant, following guidelines should be adhered to:

- Collect after the seeds are shed to facilitate regeneration.
- Do least digging for collection of underground parts and leave some underground part to facilitate regeneration.
- Collect underground parts when the mother plant is fully matured.
- Dry fleshy parts before packing and storing; cut large parts into smaller pieces.
- Do not harvest bark from immature plant; instead, collect from the branches of main trunk.
- Strip the bark longitudinally and not from all over the circumference of trunk/branches.
- Cut into small pieces to facilitate complete drying.
- Harvest only mature branches for stem.
- Dry the herbs properly before packing or storing.

For collection of leaves, flowers, fruits, seeds, floral parts, and so on, follow the following recommendation:

- Harvest only mature parts from healthy plants.
- Do not collect all material of the plant at a time.

- Do not cut branches for collecting leaves, fruits, flowers, and so on.
- Leave some floral parts on the plants to facilitate natural regeneration.
- Fleshy flowers may be dried in the sun, but should preferably be dried in shade.
- Parts like stigma, anthers, buds, and so on should be collected at appropriate time.
- Harvest the seeds once the fruits are completely mature.

For collection of gums, oils, resins, galls, and so on:

- Make incisions only vertically on some portions of the tree and not horizontally.
- Treat the incisions after collection of the desired material.
- Do not collect the gum or resin from a tree continuously and collect them in precisely right season.
- Do not leave gum/resin exposed in the field. Pack them in appropriate containers or drums with polyethylene lining.
- Collect the galls only from prescribed species (for example, Karkatshringi from *Pistacia integerrima*).
- No live insect should be present inside the galls.

Abroma augusta Linn.f.

Sterculiaceae

Ayurvedic name	Pisachkarpas
Unani name	Ulatkambal
Hindi name	Ulatkambal
Trade name	Ulatkambal, Devil's cotton
Parts used	Root, root bark, stem, and leaves



Abroma augusta

Therapeutic uses

Root bark of ulatkambal is a valuable emmenagogue and uterine tonic, chiefly used in intra-uterine diseases and other gynaecological disorders mostly related to menstrual disorders such as dysmenorrhoea, amenorrhoea, and gonorrhoea. Powdered root is an abortifacient and anti-fertility agent. The leaves and stem are demulcent. Infusion of fresh leaves and stems is effective in treatment of gonorrhoea.

Morphological characteristics

Abroma is a shrub or a small tree, attaining a height of 3–5 m, with horizontal and velvety branches. Leaves are about 10–30 cm long and 6–18 cm broad, ovate or lanceolate, more or less cordate, finely acuminate, membranous, entire, and three to five lobed with 1–12-cm-long petiole. The dorsal surface of the leaves is glabrous and ventral surface is pubescent.

Floral characteristics

Flowers are purple in colour, about 5 cm in diameter, occurring on few flowered cymes. Sepals are about 2.5 cm long, lanceolate, and persistent. Petals are imbricate and fall off soon. Stamens are present on short staminal tube; five staminodes are present. Ovary is five lobed, pyramidal with many ovules in each cell. Capsules are 3–5 cm long, obpyramidal, membranous, finely pubescent, and truncate at the apex. Each carpel has a triangular wing behind it. Flowering and fruiting occur in the months of December and January.



Field view of
Abroma augusta

Distribution

The species is of Indo-Malayan origin and occurs throughout tropical forests of India, particularly in North-East and East Coast. The species is often planted for its showy, deep scarlet flowers.

Climate and soil

Hot and humid climate is suitable for the growth of the crop. The plant grows well in a variety of soils, like sandy loam to loam type. It grows in open areas in nature.

Propagation material

Seeds are the best propagation material. Mature seeds, which are black in colour at maturity, can be collected during December to January.

Agro-technique¹**Nursery technique**

- *Raising propagules* The pretreated seeds are sown in well-prepared nursery beds during February to mid-March. Germination is completed in about 12–15 days. Germinated seedlings are transplanted in polybags filled with loamy soil, sand, and FYM (farmyard manure) in equal ratio. Seeds may also be directly sown in polybags after pre-treatment. Seedlings are ready for transplanting in field during May–June when they attain a height of about 20–25 cm.

¹ Agro-technique study carried out by Regional Research Laboratory, Itanagar Branch, P O Naharlagun – 791 110, Arunachal Pradesh

- *Propagule rate and pretreatment* About 150–200 g seeds are sufficient to produce 12 000–14 000 seedlings for 1 hectare plantation. To hasten germination, the seeds are dipped in dilute sulphuric acid for six minutes and then rinsed thoroughly in running water to remove any traces of acid. Soil in nursery beds and polybags should be treated with Bavistin 50 WP @ 0.20% to check damping off and 0.25%–0.30% Rogor 30EC to check insect attack.

Planting in the field

- *Land preparation and fertilizer application* Pits of 30 cm × 30 cm × 30 cm size are dug at a spacing of 1 m × 1 m, after light ploughing of the soil. A basal dose of FYM @ 10 tonnes/hectare is mixed with dried soil and filled in the pits for better and faster growth. The basal dose of NPK (nitrogen, phosphorus, potassium) @ 30:40:20 kg/hectare, along with FYM, may also be applied to the pit soil.
- *Transplanting and optimum spacing* May–June is the best time for transplantation of seedlings in the pits, as by that time, the seedlings attain a height of about 20–25 cm. This may be continued till August in North-East region where rainfall is well distributed throughout the year. At the time of transplantation, there should be sufficient moisture in the soil for establishment of the seedlings. Optimum spacing recommended in the field is 1 m × 1 m, that is, an optimum crop stand of 10 000 plants/hectare.
- *Intercropping system* Since good root growth is essential for optimum yield, the plant may be grown as a sole high-density crop. Intercropping may interfere with root growth and, therefore, should be avoided.
- *Interculture and maintenance practices* After basal dose of manure and NPK, top dressing of N @ 30 kg/hectare is given 120 days after transplanting. The follow-up fertilizer is provided in the second year with doses of NPK @ 30:40:20 kg/hectare after 12 months at the time of soil working, followed by applying N @ 30 kg/hectare after 18 months. First intercultural manual weeding operation is done 45 days after plantation and second after four months of plantation.



Abroma augusta –
root

In the second year, intercultural weeding operations are done at the end of 12 and 18 months.

- *Irrigation practices* The crop is grown under rain-fed conditions in North-East India. Elsewhere, the crop should be regularly irrigated to maintain humidity. Water logging should be avoided.
- *Disease and pest control* Damping off is a serious disease in this crop due to high moisture conditions. Control measures include spraying of Bavistin 50 WP @ 0.20% to check damping off and 0.25%–0.30% Rogor 30EC to check insect attack. No other infection has been observed on this crop.

Harvest management

- *Crop maturity and harvesting* Best time for seed collection is November–January. The crop takes 24 months to mature. Harvesting of medicinally useful parts should be done at post-flowering stage. For harvesting, the roots are dug out and cleaned with water. The soil should be sufficiently moist before digging out the roots.
- *Post-harvest management* Root bark should be shade-dried, packed in gunny bags, and kept in a cool and dry place.
- *Chemical constituents* Roots contain alkaloids abomine, abomasterol, and digitonide. The acceptable range of active constituents is 5.5%–5.7% of total constituents.
- *Yield and cost of cultivation* About 1.95 quintals of dry root bark is obtained per hectare after two years. Estimated cost of cultivation per hectare is Rs 54 000.

Aconitum balfourii (Benth.) Muk.

Syn. *Aconitum atrox*

Ranunculaceae

Ayurvedic name	Vatsanabh
Unani name	Bachnak
Hindi name	Meetha vish
Trade name	Meetha vish, Indian aconite
Parts used	Tuberous roots



Aconitum balfourii

Therapeutic uses

The roots of bachnak are diaphoretic, diuretic, analgesic, febrifuge, anti-inflammatory, anti-rheumatic, anti-pyretic, and vermifuge. It is used in all types of pains and inflammations. In large doses, it acts as powerful sedative, narcotic and poison.

Morphological characteristics

The roots of meetha vish are tuberous with broad and depressed initial bud that is conical or hemispherical in shape. The scales are broad with a clasping base. They usually decay after sprouting. The stem is erect, robust, and more than a metre in height, generally with one to eight branches. The leaves are scattered, orbicular or ovate-cordate.

Floral characteristics

The inflorescence is a many flowered compound raceme. Flowers are bluish-violet with five carpels. The fruit is an achene containing 16–25 seeds, and is obpyramidal in shape. Flowering and fruiting occur during September to November.



Aconitum balfourii
– nursery

Distribution

The plant is found in the temperate alpine ravines in the Himalayas and also with the *Rhododendron* community at altitudes between 2800 m and 4200 m.

Climate and soil

Areas above 2200 m altitude are suitable for the cultivation of Indian aconite. Sandy loam and slightly acidic soils (pH 5.1–5.5), rich in humus, are suitable for cultivation of this crop. Partially shaded areas, thick soil, and moist conditions provide a healthy environment for the plants.

Varieties

No variety of this plant has been identified. However, strains collected from timberline populations show better survival and good response to vegetative propagation, growth and yield, when cultivated at comparatively lower altitudes, that is, about 2200 m.

Propagation material

Propagation is done through seeds and tuber segments. The fruits (capsules) that turn light brown (before splitting) are collected in late October to mid-November for better germination of seeds. Stem cuttings have also been found to be successful in multiplication at higher altitudes.

Agro-technique¹

Nursery technique

■ Raising propagules

- Seeds are sown in a nursery at a soil depth of 0.5–0.7 cm in mist chambers or shade houses. Seeds may also be sown in open beds followed by mulching. Seed sowing may be done during October–November or March–April in temperature controlled chambers at middle altitudes (1800–2200 m). At lower elevations, sowing is done in February–March in glass houses (for example, at 1550 m altitude at Srinagar, Garhwal) and during May–June at alpine sites in open beds or hot house.
- Tuber cuttings are planted during the same period as mentioned for seedlings. The tubers sprout in about 6–45 days in laboratory conditions and 12–65 days in polyhouses under suitable soil and optimal temperature (15–20 °C). In case of availability of tubers in late season (October–November), instead of dividing into segments, whole tubers should be used at all altitudes.



Aconitum balfourii
– plant

- *Propagule rate and pretreatment* Nearly 2 kg seeds are required for raising seedlings for 1 hectare of land, that is, for planting 50 000 seedlings at a spacing of 45 cm × 45 cm. Pretreatment of seeds with GA₃ (gibberellic acid) (100 and 200 PPM [parts per million]) favours germination. In open beds, sun drying of seeds before sowing, followed by mulching, is recommended for better germination.

¹ Agro-technique study carried out by High Altitude Plant Physiology Research Centre, Hemwati Nandan Bahuguna Garhwal University, Srinagar (Garhwal) – 246 174, Uttarakhand.

Planting in the field

- ***Land preparation and fertilizer application*** The field is ploughed well during winter till a fine tilth is obtained. Weeds should be removed along with addition of manure about 10–15 days before transplantation. Humus/compost/FYM (farmyard manure) may be added as per the requirements, for example, soils with 1%–2% organic carbon will need FYM/compost at the rate of 25–30 quintals/hectare/year as basal dose at the time of land preparation. Application of forest litter at the rate of 100–150 quintals/hectare/year for the entire crop period (5–7 years) has also been reported to give good yield results. However, no studies are available for application of inorganic fertilizers.



Aconitum balfourii
– flowering plants

- ***Transplanting and optimum spacing*** Seedlings are transplanted after three months of the first true leaf initiation during March–April at lower and middle altitudes and during May–August at alpine sites. Tuber segments can be directly planted in the well-prepared field. For better growth and development of tubers, the recommended optimum spacing is 45 cm × 45 cm. Alternatively, seedlings can be transplanted at a distance of 20–25 cm initially and then thinned after two years of growth. For 45 cm × 45 cm spacing, about 50 000 seedlings and for 20 cm × 25 cm spacing, about 200 000 seedlings are required. The seedlings may suffer a mortality rate of 25%–40% during transplanting due to desiccation or mechanical injury.
- ***Intercropping system*** This plant is preferred as a sole crop. Intercropping with *Aconitum heterophyllum* has been tried but mortality rate for *A. heterophyllum* was as high as 80% when cultivated with *Aconitum balfourii*.
- ***Interculture and maintenance practices*** To achieve high production, soil treated with high doses of humus has been found suitable for cultivation. However, in the absence of adequate amount of leaf litter, FYM prepared from sheep or buffalo dung may be used. But, at lower elevations, no seed and tuber formation has been observed even in the nursery beds treated with higher doses of organic manure. It is,

therefore, recommended that leaf litter or humus should preferably be used. In the winter season, mulching is recommended as also the manuring before the initiation of new plantlets

- *Irrigation practices* Watering is not required during the monsoon period in cultivated fields. Irrigation depends on the location of sites and texture of soil. At lower altitudes (1800–2200 m), frequent watering at short intervals (two to seven days) is required till the seedlings are six months old. Soil humidity should be maintained constantly.
- *Weed control* After the establishment of seedlings or sprouting of tuber cuttings in early growth period, mulching through the layer of broad leaf litter (up to 5-cm thick) is done. Manual weeding operations are not required at this stage. However, regular weeding at an interval of 20–30 days is required in early development stages of the growth, and during winter season.
- *Disease and pest control* No serious disease affecting the plant has been observed, although insects may harm the flowers. No chemical pesticides or insecticides are applied to the crop.

Harvest management

- *Crop maturity and harvesting* In nature, plants require five to seven years to complete the reproductive phase. In comparison, at lower altitudes, plants mature within three to five years when cultivated through seedlings. However, plants of ten produce flowers within one to two years when raised through tubers. After completion of the reproductive phase, plants become mature for harvest and achieve good percentage of active contents. Time of completion of reproductive phase differs with altitude. Generally, the plants from alpine areas complete their reproductive phase by the last week of October or first week of November, while the plants at lower altitudes complete their reproductive phase during the first half of October. Plants raised from tuber segments complete their reproductive phase by the end of third year. Highest quantity of active ingredients is found during November–December. However, percentage of pseudoaconitine and aconitine is found to be maximum during May–June when the plant becomes six years old. Thus, plants can be harvested during that period to achieve the high quantity of active contents. However, to get maximum yield as well as quality germplasm (seeds) for multiplication, plants should be harvested during September at lower altitudes and in October–November at higher altitudes.

- *Post-harvest management* Harvesting can be done simply by digging the fields. Usually, whole tuber is harvested. However, rhizomatic segments of tubers (that is, tubers with roots) can be used for further multiplication as they have better survival rate and growth percentage. The tubers without rhizome are cut into 4–6 cm long slices. They should be dried in shade at room temperature. After complete drying, when moisture content is not more than 10% in slices, tubers can be stored in damp-proof containers in dark, dry, and preferably cool places for not more than six months, after which the quality starts deteriorating.
- *Chemical constituents* Tubers of *A. balfourii* contain a crystalline toxic alkaloid called pseudo-aconitine (0.4%–0.5%) and small quantities of aconitine, picroaconine, aconine, benzyl aconine, and hemonapelline.
- *Yield and cost of cultivation* Based on the dry weight of tubers and total plants cultivated in 1 hectare of land, the estimated production of root is nearly 450 kg dry weight, which is greater than the production determined for natural sites. However, considering the survival rate to be between 25% and 40% of transplanted seedlings/tubers, the actual productivity has been estimated between 275 kg/hectare for seedling-raised crop and 345 kg/hectare for tuber-raised crop after the maturity of plants during third year of cultivation through vegetative propagation. Plants grown from seedlings have yielded a maximum production of 302 kg/hectare after third year of cultivation. Estimated cost of cultivation per hectare is approximately Rs 120 000/hectare, including the cost of land preparation, irrigation facilities, labour charges, manure costs for three years, besides harvesting and drying costs, but, excluding the cost of planting material.

Market trend – 2006/07

Market price: Rs 172 per kg

Aconitum heterophyllum Linn.

Ranunculaceae

Ayurvedic name Ativisha
Unani name Atees
Hindi name Atees
Trade name Atis
Parts used Dried tuberous roots



Aconitum heterophyllum –
plant in flower

Therapeutic uses

Tubers of *Aconitum heterophyllum* are cooling in potency and bitter in taste. They are used as expectorant, febrifuge, anthelmintic, anti-diarrhoeal, anti-emetic, and anti-inflammatory. They are also used against poisoning due to scorpion or snake bite and to cure fever and contagious diseases. The aqueous extract of the root induces hypertension through action on the sympathetic nervous system and in higher doses, it becomes lethal.

Morphological characteristics

The shoot of atees is annual, while the root is biennial. The stem is clasp- ing and erect. The branches are absent or rarely one or two in number. Leaves are glabrous, sessile, and variable in shape and size. The tubers are

up to 3 cm long, conical at ends. The mother and daughter tubers occur in pairs. The initial first bud of the daughter tuber is conic in shape.

Floral characteristics

Flowers are large, hooded, white–violet in colour and occur in slender racemes or lax leafy panicles. Corolla is hairy. Carpels are five in number, containing 10–18 follicles. Flowering and fruiting occur from August to October in the third year of growth.



Aconitum heterophyllum –
seedlings in root-trainers

Distribution

The species is found in grassy slopes of alpine Himalayan region, between 3000 m and 4200 m altitude, sometimes descending up to 2200 m.

Climate and soil

Although atees generally prefers sub-alpine and alpine climate, cultivation up to 2000 m altitude has been recommended in sandy (10 cm deep) soils with rich organic matter. In Garhwal Himalayas, altitudes above 2000 m above mean sea level have been found to be suitable for the cultivation of atees. Sandy loam and slightly acidic soil, with pH about 6, has been found to be the best for seed germination, survival, better growth, and yield. Addition of humus or leaf litter to the soil increases survival rate and growth of seedlings at all

altitudes. Forest leaf litter also helps in retaining moisture content in the soil. The plant prefers open, sunny sites, and abundant air and soil moisture during summer months.

Varieties

Although no variety has been developed for this plant, yet based on the colour of the tubers, *Aconitum heterophyllum* is classified into white, yellow, red, and black varieties. The white (daughter tuber) variety, with rapid growth and high yield, is considered to be the best. Seeds and tubers collected from alpine meadows (about 3000–4000 m altitude) have better growth, survival, and yield than those collected from alpine pastures between 2500 and 3000 m altitudes.

Propagation material

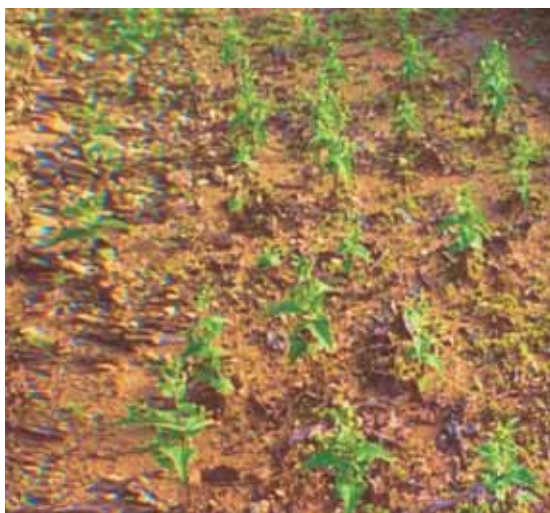
Seeds, tuber segments or young leafy stems can be used as propagules. The fruits (capsules) that turn light brown (before splitting) are collected during late October to mid-November for better germination of seeds. The seeds should preferably be collected during morning hours.

Agro-technique¹

Nursery technique

■ Raising propagules

- Seeds have no dormancy period and are sown immediately after collection. They are sown in sand and FYM (farmyard manure)/compost mixture (1:2) at a depth of 0.5 cm in styrofoam trays in a mist house. Nursery beds of 2 m × 2 m or even smaller size are better for raising seedlings inside the polyhouses. At a depth of 0.5 cm, germination is delayed to some extent, but first true leaf initiation occurs earlier as compared to sowing at other depths. Seeds are sown during October–November or March–April in polyhouses at middle altitudes (1800–2200 m), during February–March in glass houses at lower altitudes (600–1000 m), and during May–June at alpine sites in open beds or in hot houses. Plants raised from seeds have very slow growth and the cotyledonary phase (pseudomonocotyle) persists for at least one growth season (three to four months). Under polyhouse conditions and sandy textured soil, germination takes about two months to complete. However, diurnal temperature variations (25–25 °C) and mulching of soil promote germination within 15–25 days.
- When tuber segments are used as planting material, they are treated with GA₃ (gibberellic acid) (200 PPM [parts per million]) for



Aconitum heterophyllum –
young plants

¹ Agro-technique study carried out by High Altitude Plant Physiology Research Centre, Hemwati Nandan Bahuguna Garhwal University, Srinagar (Garhwal), Uttarakhand.

maximum rooting percentage and survival. Tuber segments are also planted during the same period as mentioned for seedlings. Propagation using young leafy stems, when inserted in moist soils under scrub canopy or in soil trenches covered with thin layer of moss, induces rooting at every node. Even the top nodal segment roots within 30–35 days under above conditions during July–August. About two to four plantlets can be produced from one leafy stem.



Aconitum heterophyllum

- *Propagule rate and pretreatment* Approximately 1.5 kg seeds are required for obtaining seedlings for 1 hectare. However, about 111 000 tuber segment are needed for plantation on 1 hectare. Pretreatment of seeds with GA₃ (200 PPM) results in early germination (9–20 days) and up to 55% germination.

Planting in the field

- *Land preparation and fertilizer application* During winter, the fields are thoroughly ploughed till fine tilth is obtained. Removal of weeds and addition of manure 10–15 days before transplantation improve the soil quality. A high leaf litter dose (150 quintals/hectare) is added to the soil before transplanting for good seedling growth and survival (up to 56%). In subsequent years, a dose of 60–70 quintals/hectare/year can be added for maximum yield.
- *Transplanting and optimum spacing* Propagules/seedlings are transplanted after three months of the first true leaf initiation during March–April at middle altitudes and during May–August at alpine sites. A spacing of 30 cm × 30 cm in field is considered optimum for better vegetative growth and resultant high tuber yield.
- *Intercropping system* The plant is grown as a mono crop.
- *Interculture operations and maintenance practices* Forest leaf litter/FYM from different sources/leaf compost can be used to provide nutrition to the growing plants. Leaves may turn slightly yellowish and the plants may wither due to waterlogging in beds. To overcome this problem, the crop should be planted in well-drained beds. During the rainy season, weeding is required every week. In other seasons,

weeding may be done as and when required. When the crop is cultivated at middle and lower altitudes, that is, as to 2200 m, weeding may be required at an interval of 15–20 days during the entire winter season.

- *Irrigation practices* Planted beds need irrigation during early summer. The retention of soil moisture is necessary to decrease seedling mortality. Irrigation requirement depends on the texture and porosity of the soil. In dry season, irrigation at least once in a week is necessary to retain soil moisture. However, waterlogging results in withering of plants at lower altitudes. Hence, well-drained beds are recommended for cultivation of the crop.
- *Disease and pest control* No serious pests or diseases are noticed in this crop.

Harvest management

- *Crop maturity and harvesting* Vegetative growth phase lasts for three to four years and finally leads to the reproductive phase. Flowering at alpine (natural) sites has been recorded in September and fruits mature during late October or November. Harvesting of tubers is recommended after the completion of reproductive phase and ripening of seeds during October–November, when maximum quantitative tuber yield is recorded. However, active content (atisine) and other alkaloid contents have been found to be maximum when tubers/plants are harvested in July–August at the budding stage. Further, percentage of active contents decreases slightly with the maturity of the plant. Plants raised from tuber cuttings complete their vegetative and reproductive phase within three years. *A. heterophyllum* tubers harvested in May–June contain lower quantity of atisine (0.35%) as compared to those harvested in November and December (0.43%), which also contain traces of aconitine. The tubers harvested in May, however, show higher quantity of aconitine and hypoaconitine as compared to those harvested in other seasons.
- To get maximum yield of tubers as well as seeds for multiplication, plants must be harvested during October at lower altitudes and in first week of November at higher altitudes. At lower altitudes, flowering and fruiting season comes nearly 1–1.5 months earlier. Stigma receptacles of many alpine plants are sensitive to low temperatures and remain active for 10–25 days. At lower altitudes, where temperature is

comparatively higher, these stigmas become inactive and thus proper pollination does not take place. Often, no seed and tuber formation is observed even in the beds treated with higher doses of organic manure.

- *Post-harvest management* Tubers are harvested simply by digging the field. Usually, whole tuber is harvested. However, topmost segments of tubers can be used for further multiplication, as they have better survival and growth rates. After harvesting, the whole tubers or the tubers without the top segment should be dried in partial shade or at room temperature. After complete drying, slices of tubers can be stored in wooden boxes or airtight polythene bags.
- *Chemical constituents* In tubers, atisine content varies from 0.19% to 0.27%. However, 0.79% of total alkaloids of the plant are found in tubers. Other alkaloids found in *A. heterophyllum* are heteratisine (0.3%), histisine, heterophyllisine, heterophylline, heterophyllidine, atidine, and hitidine. Also present are aconitic acid, tannic acid, a mixture of oleic, palmitic, and stearic acids, glycerides, and vegetable mucilage in addition to starch and sugars.
- *Yield and cost of cultivation* Actual production of 518 kg/hectare and 579 kg/hectare, respectively, from seedlings and tuber cuttings has been recorded after third year of cultivation under experimental conditions. Cost of cultivation is nearly Rs 84 000 for three years for 1 hectare of land. This includes cost of land preparation, irrigation facilities, low-cost polyhouse for the seedling establishment, manure, labour charges, and harvesting cost. Cost of developed seedlings or seeds is not included. After including this cost, the cost of cultivation rises to approximately Rs 110 000/hectare.

Market trend – 2006/07

- Market price: Rs 2800–3600 per kg
- Market demand: Approximately 40 tonnes per annum

Alpinia galanga Willd.

Syn. *Amomum galanga* Lour

Zingiberaceae

Ayurvedic name	Kulanjana
Unani name	Khulanjan
Hindi name	Kulanjan, sugandha bach
Trade name	Kulanjan
Part used	Rhizome and seeds



Alpinia galanga

Therapeutic uses

The rhizome of kulanjan is carminative, aphrodisiac, febrifuge, and bronchodilator. It expels the phlegm (mucus), improves voice, and is very useful in sore throat and respiratory congestion. It is also used in rheumatism. The seeds have the same uses as the rhizome.

Morphological characteristics

The plant is a rhizomatous, perennial herb, and attains a height of about 1.5–2.5 m. The rhizome is very prominent and aromatic. Externally, it is reddish brown-white and internally reddish-white. Leaves are leathery, about 30–60 cm long and 10–15 cm, glossy on both surfaces, lanceolate and smooth, with white margins.

Floral characteristics

Flowers are greenish-white, about 3 cm long, and occur in dense panicles. Corolla has distinctly clawed lips. Flowering occurs in May and June, while fruiting occurs in August and September. Fruits are orange-red in colour.

Distribution

The species occurs naturally in shady and marshy lands in tropical areas, particularly in South India, and North-East India; elsewhere, it is cultivated.



Alpinia galanga –
rhizomes

Climate and soil

The plant is successfully cultivated only on sandy loam soils and in humid tropical climate. It can be grown in open sunny areas with sufficient rainfall. With adequate irrigation provisions, it can be grown upto an altitude of 1000 m.

Varieties

No variety has been released so far. However, as per experi-

ments, the accession no. IC-319683, available at NBPGR (National Bureau of Plant and Genetic Resources), Umiam (Meghalaya), has been found to give better yield.

Propagation material

Rhizome splits are used as planting material for commercial cultivation. Seed propagation is not feasible due to low germination rate.

Agro-technique¹**Nursery technique**

- *Raising propagules* Rhizome slices are directly planted in the field and no nursery stock is generally raised.

¹ Agro-technique study carried out by NBPGR (National Bureau of Plant Genetic Resources), Regional Station, Umiam, Shillong – 793 103, Meghalaya.

- *Propagule rate and pretreatment* Planting rhizome slices @ 5.5 tonnes per hectare with a spacing of 30 cm × 30 cm for one-year crop and 3.5 tonnes per hectare with a spacing of 45 cm × 30 cm for two-year duration crop is recommended. No pretreatment is required before planting.

Planting in the field

- *Land preparation and fertilizer application* The land is prepared by ploughing to achieve a fine tilth. FYM (farmyard manure) @ 5 tonnes is applied in the field at the time of land preparation. Besides, 150 kg of urea, 100 kg of muriate of potash, and 600 kg of single super phosphate are added as basal dose before planting. If required, lime @ 2 tonnes may also be applied in the field one month before planting to counter the acidic nature of soil. Well-decomposed humus or vermicompost may also be used as manure instead of FYM.
- *Transplanting and optimum spacing* February to mid-April is the best time for raising the crop in north-eastern hilly tracts. Elsewhere, it could be planted in monsoon season. Whole or parts of rhizomes of approximately 50 g weight with 8–10 internodes are directly planted on hills in rows in the field. The rhizomes sprout in 15–20 days in the field. Optimum crop stand per hectare is 111 000 hills for one-year crop at a spacing of 30 cm × 30 cm and 74 000 hills for two-year crop at a spacing of 45 cm × 45 cm.
- *Interculture and maintenance practices* The total nitrogen requirement of the crop is about 300 kg, half of which is applied through urea at the time of planting. The rest of nitrogen (urea) should be applied in two equal split doses, that is, 75 kg; one at the time of first earthing-up and the rest at the time of second earthing-up. Each urea application should always be followed by watering. Hoeing should be done twice, one at 45 days and another at 60 days after planting. Manual weeding should be done thrice at 60, 90, and 120 days after planting.



Alpinia galanga –
a crop view

- *Irrigation practices* The crop can be raised under rain-fed conditions on terraces in Meghalaya and other north-eastern states and elsewhere in India. Watering is done only during long dry spells.
- *Disease and pest control* No significant pests and diseases have been observed on this crop except *Colletotrichum* spots, which can be controlled by spraying 1% Bordeaux mixture at monthly intervals after the appearance of leaf spots.

Harvest management

- *Crop maturity and harvesting* Keeping in view the active chemical ingredients, the best time for harvesting of rhizome is last week of February when the crop becomes 12-month old. At this stage, the leaves turn pale or start drying. The rhizomes, thus harvested, contain 0.32% to 0.35% oil on dry weight basis. Generally, the crop can be harvested after either one or two years. But for preserving the germplasm, it can be kept as a perennial. In that case, frequent weeding, pegging, fertilizer application and related practices are to be carried out at regular intervals.
- *Post-harvest management* After harvesting, the rhizomes should be cleaned, cut into slices, dried in the shade, and finally, stored in suitable containers in dry and cool places.
- *Chemical constituents* The green rhizomes are reported to contain 0.04% essential (galangal) oil, which consists of methyl-cinnamate (48%), cineol (20%–30%), some camphor, and *d*-pinene. The dry rhizome has 0.12% (approximately) of oil, which is low in asarone.
- *Yield and cost of cultivation* For a 12-month-old crop, yield of fresh rhizome is 23.93 tonnes per hectare, which on drying reduces to 5.65 tonnes per hectare. For 24-month-old crop, yield of fresh rhizomes is 82.91 tonnes per hectare, which gives 22.65 tonnes per hectare of dry rhizome. The cost of cultivation for one-year-old crop is approximately Rs 75 811 per hectare and that for a two-year-old crop is about Rs 64 272 per hectare.

Market trend – 2006/07

- Market price: Rs 50 per kg
- Market demand: Above 100 MT/year

Alstonia scholaris R. Br.

Apocyanaceae

Ayurvedic name	Saptaparna
Unani name	Kashim
Hindi names	Saptaparna, Chhatwan
Trade name	Saptaparni
Parts used	Stem bark, leaves, latex, and flowers



Alstonia scholaris –
sapling

Therapeutic uses

Alstonia is a bitter tonic, febrifuge, diuretic, anthelmintic, stimulant, carminative, stomachic, aphrodisiac, galactagogue, and haemostatic. It is used as a substitute for cinchona and quinine for the treatment of intermittent periodic fever. An infusion of bark is given in fever, dyspepsia, skin diseases, liver complaints, chronic diarrhoea, and dysentery.

Morphological characteristics

Saptaparna is a medium-sized evergreen tree, usually 12–18 m high, sometimes up to 27 m high, with close-set canopy. Bark is rough, greyish-white, yellowish inside, and exudes bitter latex when injured. Leaves are four to seven in a whorl, and are thick, oblong, with a blunt tip. They are dark green on the top, and pale and covered with brownish pubescence on the dorsal surface.

Floral characteristics

Flowers are fragrant, greenish-white or greyish-yellow in umbrella-shaped cymes. Follicles (fruits) are narrowly cylindrical, 30 cm × 3 cm, fascicled, with seeds possessing brown hair. Flowering and fruiting occur from March to July, extending to August in subtropical climate.

Distribution

The species is found in the sub-Himalayan tract from Yamuna eastwards, ascending up to 1000 m. It occurs in tropical, subtropical, and moist deciduous forests in India, and is widely cultivated as avenue tree throughout India.



Alstonia scholaris

Climate and soil

The species can be grown in a variety of climatic conditions in India, ranging from dry tropical to sub-temperate. However, it thrives well in areas where annual rainfall is about 100–150 cm, as it prefers a fairly moist habitat. The species grows well in the red alluvial soil having proper aeration. It can thrive in black cotton soils as well, but the growth is slow due to prevailing moist soil conditions during rainy season.

Propagation material

Seeds are the best planting material for raising the crop. No pretreatment is generally required. Fruits may be collected during summer before splitting of thin and wiry pods. Seeds are feathery but unable to disperse easily and automatically.

Agro-technique¹

Nursery technique

- *Raising propagules* The seeds are sown in polybags or in beds of size 10 m × 1 m by broadcasting/dibbling method in March to April. Beds are prepared by adding FYM (farmyard manure) and a little sand to

¹ Agro-technique study carried out by the NWFP Division, Tropical Forest Research Institute, PO RFRS, Mandla Road, Jabalpur – 482 021, Madhya Pradesh.

improve porosity and drainage. About 25 g of clean seeds are required/m² (square metre) of nursery beds. Seeds should be mixed with fine sand before sowing, either in polybags or in the nursery beds. Mixing with sand helps to avoid germination in clumps. Protection from strong winds is very important, especially in dry localities, as the dry winds are extremely harmful to the tender plants. The seeds start germinating in polythene bags or nursery beds after a fortnight. Seeds remain viable for more than a year, but the percentage of germination declines from 90% to about 40% after one year. When the seedlings in mother beds are about 5–10 cm high, they are picked and transferred to polybags, so that they attain a height of about 30–45 cm in about two months. These seedlings are ready for transplanting during rainy season in refilled pits.

- *Propagule rate and pretreatment* Approximately, 250 g seeds in a bed of 10 m × 1 m size are sufficient to raise seedlings for 1-hectare plantation. Germination of fresh seed varies from 80% to 90% and no seed treatment is required before sowing. About 400 saplings are accommodated in 1 hectare of land at a spacing of 5 m × 5 m.

Planting in the field

- *Land preparation and fertilizer application* The land is prepared by loosening the soil through ploughing and is made porous. Ploughing also removes weeds. Pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 5 m × 5 m or 5 m × 6 m. Weathering of dug-out soil for about one to two months is essential. The pits are then refilled with equal amounts of FYM, sand, and soil, and watered so that the soil settles. Hoeing is done about a fortnight before the transplantation.
- *Transplanting and optimum spacing* The polybag seedlings are transplanted in prepared pits at a spacing of 5 m × 5 m or 5 m × 6 m in the rainy season in June–July.
- *Intercropping system* No reports on intercropping with this crop are available. However, annual herbs of medicinal value can be grown as intercrops in the early stages as well as after canopy development, depending upon the requirements of herb crops. Beneath its shade



Alstonia scholaris –
a 15-year old
mature tree

Curcuma longa (turmeric), *Curcuma angustifolia* (tikhur), and *Alpinia galanga* (kulinjan) can be successfully grown as intercrops.

- **Interculture and maintenance practices** No fertilizer is applied after the initial use of FYM at the time of planting. Plants raised in the field require two timely weeding around the pits, especially in rainy season. Plantations in the black cotton soils require four weeding at monthly intervals. The weeds between the rows are removed by scythe or sickle. If the tractor is available, cultivator ploughing is beneficial to remove the weeds as well as loosen the soil, especially in the black cotton soil belt. This operation not only conditions the soil but also avoids cracking associated with the black cotton soil during the summer months. It is advisable to run the cultivator before the commencement of summer months to avoid cracking of soil, which leads to loss of soil moisture and breaking of root tips.
- **Irrigation practices** Pit irrigation is required in summer season at weekly intervals when planted without intercrop. In case of intercropping, flood method of irrigation is beneficial. Light irrigation at an interval of 15–20 days in winter season is sufficient. About 15–20 litres of water per pit per week is required for proper growth of the plant.
- **Disease and pest control** Many insects are known to attack the tree. *Ceroplastes actiniformis* feeds on sap, while *Pauropsylla tuberculata* makes hard barrel-shaped semi-woody galls on the leaves. The larvae of some other insects of the family Pyralidae (*Caprinia conchylalis* and *Glyphodes bicolor*) are known to defoliate the tree. The insects can be controlled by using 0.03% herbal pesticide nuvacron in the early stages of plantation, that is, till the plant is two to three years old. Diseases caused by *Collectotrichum goeosporioides*, *Sardaria humana*, and other fungi have also been reported. However, no control measures are generally required.

Harvest management

- **Crop maturity and harvesting** It takes about 8–10 years for the tree to reach maturity, and thereafter bark or other parts may be harvested. Peeling of bark from the trees is normally done for trees that have attained a girth of 50–62 cm, in the intermittent and strip manner. It is suggested that partial debarking should be done from each tree by removing bark in strips of 15 cm × 15 cm, 30 cm apart. October–January is the best season for collecting of stem bark.

- *Post-harvest management* The medicinally important part of this tree is the stem bark. Properly shade-dried bark with less than 10% moisture content should be stored in containers in a well-ventilated store room. If the bark is not properly dried, it may get infected with many storage fungi and attain black colour, thereby becoming useless for medicinal use.
- *Chemical constituents* Mature bark contains 0.16%–0.27% total alkaloids containing mainly echitamine, ditamine, and ditaine.
- *Yield and cost of cultivation* On the basis of yield assessment done on available mature trees, it has been estimated that for getting a sustainable yield without damaging the tree, a maximum of 2.5 kg of fresh bark can be extracted per tree from 10-year-old plantations, which on drying, weighs about 625 g. Thus, 1 hectare of plantation may yield approximately 250 kg dry stem bark every year. An approximate cost of Rs 55 000 is incurred for raising and maintaining 1 hectare of plantation upto harvesting.

Asparagus racemosus Willd.

Liliaceae

Ayurvedic name	Satavari,
Unani name	Shatawar, Shaququl
Hindi name	Shatavar
Trade name	Shatavar
Parts used	Tubers and leaves



Asparagus racemosus

Therapeutic uses

The plant, *Asparagus*, is reputed to be a tonic and a geriatric. The tubers are anti-diarrhoeic, diuretic, nutritive, tonic, aphrodisiac, appetizer, and alterative. They are also reported to increase lactation. In addition, the plant is considered slightly sweet, and is useful in the diseases of blood, kidney, liver, scalding urine, rheumatism, gleet, and gonorrhoea.

Morphological characteristics

Shatavar is a scandent, much-branched, spinous under-shrub with tuberous roots. The roots are fascicled, fleshy, spindle-shaped, light ash-coloured externally and white internally, more or less smooth when fresh, but on drying, develop longitudinal wrinkles and lack any well-marked odour. Branches are modified into cladodes with long basal decurved spines.

Floral characteristics

Flowers are white, fragrant, and minute, about 3 mm long and occur in solitary or fascicled, 2.5–5 cm long, racemes. Fruit is a three-lobed, red coloured berry, up to 6 mm in diameter, with mottled seeds and oily endosperm. Flowering and fruiting occur in December–January.

Distribution

Shatavar is common throughout the tropical and subtropical regions, particularly central India. It is also found up to an altitude of 1500 m in subtropical Himalayas. By nature, the plant is xerophytic and prefers the semi-arid to subtropical, cool environment.



Asparagus racemosus –
mature and
viable seeds

Climate and soil

The plant prefers annual average rainfall of 600–1000 mm or less, of which 85% is received during July to September. A well-drained fertile sandy-loam to clay-loam soil, with a pH of 6–8 is best suited for its cultivation with staking support. Shatavar can be grown in open land as well as under shade, but very high moisture levels result in rotting of root.

Propagation material

Both seeds and crown rhizomes can be used for propagation. However, seeds are preferable on account of high production that makes up for low germination percentage in cultivation. Seeds may be

collected from March to May when their colour changes from red to black.

Agro-technique¹

Nursery technique

- *Raising propagules* Seeds are sown during the first week of June in well-prepared and raised nursery beds containing good amount of

¹ Agro-technique study carried out by

- NBPGR (National Bureau of Plant Genetic Resources), Pusa Campus, New Delhi – 110 012.
- NIPER (National Institute of Pharmaceutical Education and Research), SAS Nagar, Mohali – 160 062, Punjab.

FYM (farmyard manure). The beds should ideally be 10 m × 1 m in size. Seeds are sown in lines 5 cm apart and covered with a thin layer of fine sand. The beds are lightly watered at regular intervals using a rose water cane.

- *Propagule rate and pretreatment* About 7 kg of seeds are required for raising seedlings for 1 hectare of crop. The seeds of satavar have a hard seed coat. To obtain early and higher germination percentage, pre-soaking in water is required for softening the seed coat. Higher germination is also achieved by soaking the seeds in cow urine for 24 hours. The germination commences after 20 days of sowing and is completed in 30 days.

Planting in the field

- *Land preparation and fertilizer application* The land should be given a deep disc ploughing, followed by harrowing and levelling. The field is normally divided into plots, keeping one irrigation channel in between two rows of plots. Ridges and furrows are made about 45 cm apart in the plots. About 10 tonnes of well-decomposed FYM is thoroughly mixed in the soil one month before transplanting. Shatavar further requires a fertilizer dose of 60 kg nitrogen, 40 kg phosphate, and 40 kg potash per hectare for optimum growth and higher tuberous root yield. One-third of nitrogen and entire dose of phosphate and potash should be placed 10–12 cm deep in the rows before transplanting.
- *Transplanting and optimum spacing* The seedlings are ready for transplanting after 45 days of sowing. These are transplanted in field at the onset of monsoon in July. Ridges and furrows are made 45 cm apart and seedlings are transplanted on ridges, keeping the plant-to-plant distance at 15 cm. The ridge method of transplanting is superior in comparison to flat method. Optimum number of seedlings required per hectare using the recommended spacing is about 150 000.



Asparagus racemosus –
crop view

- *Intercropping system* Shatavar is normally grown as a monocrop, but it can be grown in inter spaces available in orchards having low light interception. Plants need staking material, thus poles or shrubs serve for support.
- *Interculture and maintenance practices* The balance two-third N is applied in two equal split doses at ridges during September and in late February. The fertilizer is broadcast in between the rows and mixed in soil followed by irrigation, if the soil is dry. Shatavar initially grows slowly for 60 days, which keeps inter-row space virtually vacant, allowing easy weed growth. It is necessary to carry out three weeding and hoeing operations to keep the field free from weeds for initial two-

month period. After two months, Shatavar grows enough to cover the inter-row spaces and prevents weed growth.

- *Irrigation practices* Water requirement of Shatavar crop is not much. It can be grown without irrigation in areas that receive 800–1200 mm of well-distributed rainfall. Irrigating the field once immediately after transplanting is a must for establishment of seedlings in field. The second irrigation is done after seven days of seedling establishment. If there is no rainfall and dry

spell prevails for more than 15 days, one more irrigation should be given. During winters, irrigation at 30-day intervals is enough for good growth. Irrigation should be done during seed formation stage and before harvesting of the tuberous roots for obtaining higher seed yield and easy digging of tuberous roots. Deficient soil moisture during March–June brings down root yield significantly. Hence, three to four irrigations during this period are essential.

- *Disease and pest control* No serious insects, pests, and disease have been reported in this crop.

Harvest management

- *Crop maturity and harvesting* The crop matures in 12 months after planting; however, for seed harvesting, it is recommended to be harvested only after 20 months. Rabi season, that is, November–December, is the best



Asparagus racemosus –
harvested roots

time for harvesting tuberous roots when the above-ground parts start turning pale yellow. The crop, when harvested in 12 months, yields about 4–5 tonnes/hectare, while harvesting after 20 months yields about 6 tonnes/hectare of tubers along with 35 kg/hectare of seeds, which are not obtained in the 12-month-old crop.

- *Post-harvest management* After harvesting, the tubers are washed well in running water thereafter, these are dried in open sun for one to two days. The tuberous roots are then kept in luke warm water for one hour to soften the outer covering of the tubers. It facilitates removal of outer skin. The harvested roots are peeled manually by pulling their outer thin covering. These peeled tubers are then kept in shade for four to five hours, followed by further drying at 40 °C in hot air oven for 20 minutes or more, depending upon their moisture content. The roots should be completely dry for storage. If the tuber breaks with a cracking sound, it means that it has completely dried. Dried tuberous roots are packed in cardboard boxes and stored. Boiled tubers turn yellowish and fetch much higher market rate. Dry root in pieces of 5–15 cm × 1–2 cm are marketed as 'A' grade variety.
- *Chemical constituents* Sapogenins are the active principles found in the tuberous roots. Chemical evaluation studies suggest that the sapogenin content varies in the range of 0.7%–0.9% in the tubers.
- *Yield and cost of cultivation* The tuberous root yields 10%–12% of dry matter after removal of outer wall. An average shade-dried tuberous root yield of 3 tonnes per hectare is obtained from 20-month-old plants under experimental conditions. A two-and-a-half-year-old crop gives a dry yield of 4–5 tonnes per hectare. It gives a seed yield of 30–35 kg/hectare. The estimated cost of cultivation is about Rs 100 000 per hectare, including land preparation, nursery raising, cost of planting material, FYM, cost of transplanting, harvesting, peeling and processing for market, and so on. The calculated yield of 20-month-old crop of Shatavar is 3 tonnes/hectare, which can fetch net returns of approximately Rs 62 500/hectare. Dry root in 5–15 cm × 1–2 cm pieces are marketed as 'A' grade variety.

Market trend – 2006/07

- Market price: yellow variety – Rs 180–340 per kg; white variety – Rs 35–40 per kg
- Market demand: 900 tonnes or more

***Bacopa monnieri* (L.) Pannell**

Syn. *Herpestris monnieri* (L.) H.B. & K.

Scrophulariaceae

Ayurvedic name	Brahmi
Unani name	Brahmi
Hindi name	Neer brahmi
Trade name	Brahmi
Parts used	Whole plant



A single plant of *Bacopa monnieri*

Therapeutic uses

Brahmi is a reputed intellect promoter, hypotensive, and neuro-pathic sedative drug. It is a potent tonic used to improve mental alertness, learning performance, and memory as well as in the treatment of insomnia. It is the principal ingredient of classical Ayurvedic preparations like brahmighritam and brahmirasayanam.

Morphological characteristics

Bacopa is a succulent, glabrous, creeping herb, with rooting at nodes. The plant is easily recognized by its spreading habit, sessile and fleshy leaves, and light bluish, purple or white flowers. Leaves are ovate and opposite with dotted lower surface.

Floral characteristics

Flowering occurs chiefly in September–October, sporadically throughout the year. Fruiting occurs simultaneously with flowering. Flowers are solitary, axillary, white or purple-tinged, with short pedicels and two bracteoles. Sepals are five in number, 0.4–0.9 cm long. Corolla tube is cylindrical with spreading lips, twice as long as sepals. Capsule is ovoid in shape, acute, two-grooved and two-valved with numerous seeds that are very minute, pale, and irregular.

Distribution

The plant is a short duration annual herb, frequent in moist habitat and water edges throughout tropical and subtropical India. It grows best near flowing water and wetlands in plains and foothills, and is particularly abundant in monsoon.



Bacopa monnieri –
crop grown in hills

Climate and soil

The plant occurs in a variety of soil types if the habitat provides wet and semi-shade conditions. It is found at altitudes up to 1300 m. Near-neutral, clayey loam to clayey soils are best suited for the growth of *Bacopa monnieri*. In North India, it can grow in a wide range of temperatures (15–40 °C) and soil pH (5–7.5). However, it can even grow well in soils with pH 7.5 or even more. It becomes dormant during the winter months except when grown near running water.

Varieties

Saplings from the catchment areas of the River Ravi have proved to be the better germplasm than those from the Indo-Gangetic plains in terms of yield and bacoside content. CIMAP (Central Institute of Medicinal and Aromatic Plants), Lucknow, has also developed three varieties of this crop, namely, subodhak, pragyashakti, and CIM-jagriti, which can be grown as perennials with at least two harvests per year. Subodhak is a selection from wild collections providing a dry herb yield of 47 quintals/hectare/harvest (with 1.6% bacoside A). Pragyashakti is a selection from

Orissa with dry herb yield of 65 quintals/hectare/harvest (with 1.8% bacoside A). CIM-jagriti has a potential of producing 85 kg/hectare of bacoside A from a dry herb yield of 40 quintals/hectare. The RRL (Regional Research Laboratory), Jammu, has also developed a cultivar with 1.8%–2.2% bacoside A content.

Propagation material

Freshly collected shoot cuttings of 5–10 cm length with internodes and rootlets are the best planting material for cultivation. The plant shows luxurious growth during rainy season when the propagules multiply fast. Seeds are very minute and produced during October/November. Germination studies with seeds have not shown encouraging results.

Agro-technique¹

Nursery technique

- *Raising propagules* Best time for planting a nursery is from May to July. The nursery soil is mixed with well-decomposed FYM (farmyard manure) at the rate of 3 kg/m². About 200 m² of nursery, that is, 210 beds of 10 m × 1 m, is sufficient for raising 1 hectare of plantation. The freshly collected propagules (shoot cuttings) of 5–10 cm length bearing internodes and rootlets should be manually embedded in the soil at a distance of 5 cm × 10 cm in the well-prepared nursery beds followed by light irrigation. The propagules develop roots within a week of planting and are ready for transplanting in field in about 35–40 days.
- *Propagule rate and pretreatment* About 70 kg of fresh weight or about 40 000 propagules are required for planting the nursery for 1 hectare plantation.



Bacopa monnieri –
flowering

¹ Agro-technique study carried out by

- National Institute of Pharmaceutical Education and Research, Sector 67, S A S Nagar, Mohali – 160 062, Punjab.
- Herbal Garden, Herbarium and Research Institute ISM, Joginder Nagar, Dist Mandi, Himachal Pradesh.

Planting in the field

- ***Land preparation and fertilizer application*** The land should be appropriately tilled to make it weed free and planked to a uniform level. For optimum yields, 10 tonnes/hectare of well-decomposed FYM, 30 kg/hectare of nitrogen, 50 kg/hectare of phosphorus, and 40 kg/hectare of potash are required to be mixed with soil before planting. A basal dose of 20 kg/hectare of zinc (ZnSO_4) is often required in areas showing deficiency, such as plains of Punjab and Uttar Pradesh. Nitrogen is also required to be applied later in two split doses, after four to five weeks and six to eight weeks of transplanting.



Bacopa monnieri –
harvested crop

- ***Transplanting and optimum spacing*** Propagules, that is, stem cuttings with rootlets, are transplanted in field at a spacing of 20 cm × 20 cm. Propagules can be planted directly in the well-prepared field if sufficient planting material is available. Best time for direct planting or transplanting in the field is beginning of rainy season commencing in last week of June to first week of August. Transplanted field is immediately flooded. Propagules take about one week for establishment and fresh root development.

- ***Intercropping system*** *Bacopa* may fit well in the kharif season's rice-based cropping systems in the plains of North India. All paddy-based rotations, namely, *Bacopa* and rice–wheat; *Bacopa* and rice–pea–wheat; *Bacopa* and rice–berseem–maize; *Bacopa* and rice–winter vegetables–maize, are suitable, depending on the choice of crops grown in a region. *B. monnieri* and rice have matching growth periods and similar soil and nutritional requirements. Medium duration dwarf rice varieties (140–148 days) are ideal for intercropping with *B. monnieri*. This pattern requires low additional inputs at minimum risk.
- ***Interculture and maintenance practices*** Three to four manual weedings are required from the time the crop is 15–20 days old, at about 20-day intervals, so that the weeds remain under control in the monsoon season (July–September). If grown as a round-the-year crop, *Bacopa* field

should be kept weed-free during winter months and irrigated regularly.

- *Irrigation practices* The crop is preferably kept inundated with water, at 4–5 cm depth, throughout the growth period. Irrigation could be done either weekly or at intervals, depending on the type of soil and availability of water to maintain constant humidity in soil.
- *Weed control* Butachlor 50 EC at the rate of 3 kg mixed with 60 kg sand should be applied uniformly in 1 hectare of land in 4–5 cm deep standing water before transplanting *Bacopa*. About three to four manual weeding, at approximately 20-day intervals, are required to check the seasonal weeds in monsoon season (July to September).
- *Disease and pest control* No pests, insects or pathogens have been reported to affect the crop seriously.

Harvest management

- *Crop maturity and harvesting* The crop can be harvested 75–90 days after planting. September–October is the best time for harvesting. The crop should be harvested when plants attain a length of 20–30 cm. The whole plant should be pulled out, uprooted or scraped off manually. In severe cold conditions of North India, ratoon crop is not possible since the aerial parts of the plant die almost completely even after the application of irrigation and fertilizers, and the field is invaded by winter weeds.
- *Post-harvest management* The produce should be dried by spreading it on clean area or sheets in the sun for four to five days, followed by shade drying for next 7–10 days. The dried material should be stored in clean containers. Bacoside content starts reducing after six months of storage. Therefore, long storage should be avoided.
- *Chemical constituents* The results of chemical analysis indicate that the percentage of total bacosides is about 5.6% (based on bacoside A₃ estimation) for the dried material that is initially sun-dried for four days.
- *Yield and cost of cultivation* As a pure crop, fresh yield is 22.5 tonnes/hectare, reduced to approximately 5.5 tonnes/hectare on drying. As an



Bacopa monnieri

intercrop with paddy, dry matter production of *Bacopa* is estimated to be about 3.75 tonnes/hectare. The cost of cultivation is Rs 40 000/hectare in the first year. Second year onwards, it is reduced to Rs 10 000/hectare due to the use of bulk planting material from harvest. An additional income of Rs 20 000/hectare can be generated annually, if *Bacopa* is grown with paddy as an intercrop.

Market trend – 2006/07

- Market price: Rs 25–75 per kg
- Market demand: 1000 tonnes

***Baliospermum montanum* Muell. Arg.**

Syn. *B. axillare*

Euphorbiaceae

Ayurvedic name	Danti, Dravanti
Unani name	Danti
Hindi name	Danti
Trade name	Danti, Jangli jamalgota
Parts used	Roots, leaves, and seeds



Single plant of
Danti

Therapeutic uses

The roots and leaves of *Baliospermum* are cathartic, pungent, thermogenic, purgative, anthelmintic, and diuretic. The roots are used in dropsy, anascara, and jaundice. Decoction of leaves is used for treating asthma. Seeds are purgative, used externally as stimulant, and are rubifacient. The oil from the seeds is hydrogogue, cathartic, and used for external application in rheumatism.

Morphological characteristics

The plant is a stout, monoecious undershrub up to 3.5 m high, with toothed leaves and stiff branches arising from the root. The upper branches bear small, lanceolate leaves, while the lower branches have large, and often broad, ovate, three- to five-lobed leaves with rounded base. Petioles are 5–15 cm long.

Floral characteristics

The flowers of the plant are unisexual. In male flowers, the calyx is globose, 2.5 mm long, four to five partite, glabrous or slightly pubescent, membranous, finely mottled with a disc of six glands. Stamens are about 20 in number. Female flowers have ovate-lanceolate and pubescent sepals, and a disc about 2.5 mm in diameter. Fruit is a three-lobed capsule, about 8–13 mm long and usually hairy. Seeds are mottled, smooth, and

have oily endosperm. Flowers appear during January–February, while fruits mature a month later.



Baliospermum montanum – seeds

Distribution

The species is distributed throughout tropical and subtropical areas receiving rainfall above 1000 mm, that is, in Himalayan foothills, Kashmir to Khasi hills, and particularly in Vindhyas southward. It is very common in North and East Bengal, Chhota Nagpur, and peninsular India.

Climate and soil

Danti prefers humid climate for better growth. Well-drained sandy-

loam soils with pH normally ranging from 6.5 to 7.5 are good for its cultivation. But it can also grow in soils with pH up to 8.2. This is a shade-loving plant but can be grown in open sun when cultivated. Low rainfall areas are not conducive for its growth.

Propagation material

Danti can be easily propagated by seeds and terminal cuttings. The best season for seed collection is from February to April. The seeds are collected when the outer tri-lobed covering around fruits starts turning brown and dry.

Agro-technique¹

Nursery technique

- **Raising propagules** Kharif season (onset of monsoon) is the best time for raising the crop. The crop should be raised in the last week of June or beginning of monsoon rains. After raising nursery, the seedlings can be transplanted in the main field or seeds can be sown in the rows directly in field. In the nursery, seeds can be sown during June in well prepared nursery beds, with sand, soil, and FYM (farmyard manure) in 2:1:1 ratio. Seeds are sown at a depth of 3 cm in shade. A minimum distance of 8–10 cm should be maintained between two rows and 3 cm between the seeds. Two seeds per hill may be sown to compensate for any failure in seed germination or mortality later. Regular watering should be done to keep the nursery beds in moist condition. To raise the planting stock, terminal cuttings can also be planted in nursery beds or polybags after treating them with commercially available rooting hormones. The cuttings should be kept in shade houses or mist chambers for better rooting. The stock raised through cuttings takes longer time than seedlings to attain transplantable size.
- **Propagule rate and pretreatment** About 7–8 kg of seeds are required for raising seedling stock on 1 hectare of land. Seeds require mechanical scarification pretreatment before sowing to obtain higher seed germination. Soaking of seeds in water for two to three hours and then drying in shade before sowing also promotes germination. It takes about 25 days for complete germination to take place.



Baliospermum montanum –
crop

Planting in the field

- **Land preparation and fertilizer application** The land should be given a deep disc ploughing followed by harrowing and levelling. The field is

¹ Agro-technique study carried out by National Bureau of Plant Genetic Resources, Issapur Farm, New Delhi.



Baliospermum montanum

divided into appropriate beds, usually 4–5 m × 10 m in size. One irrigation channel is kept between the two rows of beds. A basal dose of 10 tonnes/hectare of FYM is applied at the time of field preparation. In addition, NPK (nitrogen, phosphorus, and potassium) @ 75:50:25 kg/hectare may also be applied as basal dose at the time of transplantation.

- *Transplanting and optimum spacing* Seedlings are ready for transplanting after 40 days of sowing. Terminal cuttings, when used for raising the nursery, take longer time. The optimum spacing recommended is 1.5 m × 1.2 m. In monocropping system, approximately, 5500 plants are required as planting material for 1 hectare of land.
- *Intercropping system* *Baliospermum* is generally grown as a monocrop due to its dense growth, but, it may also be raised as a catch crop beneath trees and in fruit orchards.
- *Interculture and maintenance practices* Fertilizer is applied at the time of field preparation and at the time of transplanting. In general, half of the N and full dose of P and K are applied at the time of planting, and the remaining half of the N dose, that is, 75 kg/hectare, is added after 60 days of planting. Intercultural operation is necessary at 30 days after transplanting. Later, weeding cum hoeing is done at an interval of 30–45 days.
- *Irrigation practices* Initial irrigation should be done for the establishment of plants immediately after transplanting, followed by irrigation at an interval of seven days in summer season and at an interval of 20 days during winter season.
- *Weed control* Initial weeding should be done manually after 30–35 days of transplanting. Regular weeding at an interval of 30 days up to four months keeps the field free from weeds. After five months, there is enough vegetative growth, which does not allow the weeds to come up in the field.

- *Disease and pest control* No serious insect pests or diseases have been reported. However, ants are observed when the crop is about six months old. The water sap that oozes near the inflorescence attracts the ants. No chemical pesticides should be used on the crop.

Harvest management

- *Crop maturity and harvesting* The plant flowers in January–February, while fruits appear a month later. Fruit is initially green and turns brownish black at maturity. Danti is a 10-month-duration crop. Individual plants are dug out; roots and seeds are dried under shade.
- *Post-harvest management* The produce is dried under shade and stored in dry cool areas in gunny bags.
- *Chemical constituents* Axillarenic acid is present in the seeds, while 12-deoxy-5 β -hydroxyphorbol-13-myristate, 13-palmitate, 12 deoxyphorbol-13-palmitate, baliospermin, and montanin are reported to be present in the roots.
- *Yield and cost of cultivation* A dry root yield of 2 tonnes/hectare is obtained in a 10-month-duration crop. Estimated cost of cultivation is Rs 72 000 per hectare.

Market trend – 2006/07

- Market demand: Above 100 MT/year

Caesalpinia sappan Linn.

Caesalpinaceae

Ayurvedic name Patangah
Unani name Pattang
Hindi name Patang
Trade name Patang, Brazil wood
Parts used Wood, leaves, pods, and seeds



Caesalpinia sappan plant

Therapeutic uses

Chiefly *Caesalpinia* is emmenagogue, haemostatic, and anti-inflammatory. It is one of the ingredients of indigenous drug 'lucol', which is administered for the treatment of non-specific leucorrhoea. The heartwood is used in traditional medicine as a treatment for contusion and thrombosis. The paste of the wood is used in curing rheumatism, haemorrhages, and wounds. The heartwood yields a red dye, which is used for cosmetic purposes, as it is resistant to sun rays, light, heat, and water. The plant has anti-cancerous and anti-diarrhoeal properties. The oil obtained from the leaves shows anti-bacterial and anti-fungal action.

Morphological characteristics

Patang is a small to medium sized, thorny tree, growing up to 10 metres, with conspicuous spines on the stem and leaf rachis. Branchlets are dull,

lenticellate, usually armed with paired, recurved stipular prickles. Leaves are large, hairy or glabrate with 9–14 pairs of pinnae.

Floral characteristics

Flowers are golden yellow, arranged in supra-axillary and terminal racemes forming a large panicle. Pods are ellipsoid and brown to black in colour. Flowering and fruiting occur from July to September, extending rarely to November.

Distribution

The species is frequent in Indian peninsular areas. It is also grown as plantation in all southern states, and extends northwards to Orissa and Bengal. It is native to Indo-Malayan region.



Flowering in
Caesalpinia sappan

Climate and soil

The plant is xerophytic in nature and grows best in subtropical and tropical regions with dry and hot climatic conditions. It can be grown in a wide range of soils. The red loamy soils rich in humus nutrients are the best suited for its growth.

Propagation materials

Usually the stock raised from seeds is used for planting. Fruits are formed 5–15 days after flowering and attain maturity in three months time, that is, during October–December. Seeds for raising the nursery are collected in November–December.

Agro-technique¹

Nursery technique

- *Raising propagules* April and May are suitable for raising the seedlings. A nursery is raised in the polybags. The H₂SO₄ (sulphuric acid)-treated seeds are sown in polythene bags containing sand, FYM (farmyard

¹ Agro-technique study carried out by the Division of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra Campus, Bangalore – 560 065.

manure), and red laterite soil in 1:1:1 ratio. The seedlings are ready for planting in the main field during June–July.

- **Seed rate and pretreatment** About 600–800 g seeds may be needed for raising seedlings for planting on 1 hectare of land. The seeds should be treated with diluted H_2SO_4 for six minutes. Concentrated H_2SO_4 and soaking for a longer time in acid may damage the radical and the plumule. This should be followed by washing well in running water. The seeds should be shade-dried for 24 hours and again soaked in 300 PPM (parts per million) GA_3 (gibberellic acid) for six hours to promote rapid germination.

Planting in the field

- **Land preparation and fertilizer application** The soil should be ploughed and brought to a fine tilth. Then pits of size 45 cm × 45 cm × 45 cm should be dug at a spacing of 4 m × 4 m and filled with topsoil and organic mixture. An application of 6–8 kg FYM along with 100:50:75 g NPK (nitrogen, phosphorous, potassium) per plant is ideal as basal dose before planting.
- **Intercropping system** The species cannot be grown under the shade of other crops. Hence, the plant is favoured as a single crop. However, some annuals may be grown between the rows of *Caesalpinia* in the initial years.
- **Transplanting and optimum spacing** The 30–45 days old seedlings are transplanted in the pits in the field immediately after the onset of monsoon rains, after they attain a height of 30–40 cm. If there is no rain, the field should be irrigated immediately after transplanting. For 1 hectare of land, 625 seedlings shall be required at a spacing of 4 m × 4 m.
- **Interculture and maintenance practices** Application of 150:60:160 g NPK per plant in second year and 200:100:150 g NPK per plant from third year onwards is recommended. Manuring and watering are done twice by opening rings around the stem base at a distance of 30 cm, first during May–June and then in September–October. Gap filling for seedlings may be done 30 days after planting along with staking of



Caesalpinia sappan
– twig

seedlings. Weeding in the entire field should be done during the second week of September, followed by application of fertilizers. Manual weeding around basin is recommended once in four months.

- *Irrigation practices* Light irrigation is done once daily up to 15 days after transplanting, and thereafter, may be done at weekly or fortnightly intervals, depending upon the season and water requirement. Furrow is the best method of irrigation, though drip irrigation may also be adopted.
- *Disease and pest control* Pod borer insect bores the pod and eats seeds. It can be controlled by spraying 0.2% nuvacron during fruiting stage at weekly intervals. Termites attack the roots and trunk, which leads to drying of the plant. The affected plants should be drenched with chlorpyrifos (2 ml/litre dilution in water).



Caesalpinia sappan

Harvest management

- *Crop maturity and harvesting* Flowering takes place after the plant attains two to three years of age, and the pods and seeds can be plucked during October–November. The wood can be harvested 10–15 years after planting during October–November.
- *Chemical constituents* The pod shell contains 4% and bark of the plant contains 1.8% tannins along with aromatic compounds such as brazilin, sappanchalcone, ceasalpin-J, caesalpin-P, and protosappanin A and B.
- *Estimated yield* A yield of 2000–2500 kg pods, producing 200–250 kg dry seeds per hectare per year, may be obtained. Estimates for wood production are not available. The cost of cultivating the crop on 1 hectare of land is Rs 75 000 approximately.

Market trend – 2006/07

- Market demand: Above 100 MT/year

Clerodendrum indicum (Linn.) Moon

Syn. *C. siphonanthus* C.B. Clark

Verbenaceae

Ayurvedic name	Bharangi
Unani name	Arni
Hindi name	Chhoti arani, Chingari
Trade name	Chhoti arani, Chingari
Parts used	Roots and leaves



Clerodendrum indicum

Therapeutic uses

The root of chingari is stomachic, expectorant, anti-inflammatory, anti-bronchitis, febrifuge, hence useful for asthma, cough, and scrofulous affections. The root increases appetite and lowers fever (Unani medicine). The leaves and roots are used externally to treat tumours and certain skin diseases.

Morphological characteristics

Clerodendrum species is an erect, less branched shrub, 1.5–3.0 m tall. The roots are light brown in colour and more than 2.5 cm in diameter. Stem is herbaceous, ridged, fluted, and hollow. Leaves are axillary, fascicled or terminal, and hang from the upright branches.

Floral characteristics

Flowers of the species occur in axillary or terminal racemes. Calyx is about 7.5 mm long with a cleft halfway down; lobes are oblong or ovate and acute. Corolla tube is 7.5–10 cm long, curved, and very slender, with upto 1.5-cm-long and ovate-oblong lobes. Fruit is upto 1.5 cm across, dark bluish green when ripe and seated on the enlarged red fleshy calyx. Flowering and fruiting occur from January to May.

Distribution

The species occurs throughout the peninsular India, from Vindhya onward to foothills of Uttarakhand, Sikkim, and north-eastern states. It is often cultivated elsewhere. Chingari is supposed to have originated in East India and has been dispersed and extended to southern and eastern India; sometimes it is planted as an ornamental species.

Climate and soil

Chingari requires moist tropical and subtropical climate, which should be free from frost during winters and dry heat in summers. It is also possible to grow the species in the dry regions under partial shade. The plant is affected by frost in northern India, which causes burning of leaves, defoliation, and drying up of young shoots, and the plants ultimately die. The plant is not very selective in its soil requirements and can be grown successfully in soils ranging from clay-loam to sandy-loam. However, the soil should be deep, fertile, and well drained, having a pH range of 6.0–8.0. It can be grown in semi-humid climate.



Clerodendrum indicum –
plantlet

Propagation material

Chingari is commercially propagated by stem cuttings as well as root cuttings. The stem cuttings should be taken from semi-matured branches and root cuttings from about 2-cm-thick roots in July–August. Semi-hard woody stem cuttings give higher success rate than soft wooded and hard wooded cuttings. Rooting success rate in cuttings may go up to 90% under favourable conditions.

Agro-technique¹

Nursery technique

- *Raising propagules* A nursery is raised for producing planting stock from stem and root cuttings during March–April, and the propagules so developed are transplanted in the field during July–August (monsoon season). For this purpose, 10–15-cm-long cuttings having three to five buds are obtained from partially matured shoots, known as semi-hard wood cuttings. While planting, care should be taken that the basal two nodes of the cuttings are inserted in the soil. In case of root cuttings, about 2-cm-thick roots should be selected. These roots are cut into 5–6-cm-long pieces and planted horizontally in the sand bed for sprouting. All cuttings are planted with a spacing of 7–8 cm within the row and 15 cm between the rows. The rooted cuttings are transplanted in the field along with the ball of earth.
- *Propagule rate and pretreatment* The cuttings are soaked in 500 PPM (parts per million) of IBA (indole butyric acid) for one minute before planting to promote easy and early rooting of the propagules.

Planting in the field

- *Land preparation and fertilizer application* The field is ploughed well, at least twice, to have a fine tilth. The quantity of manure and fertilizers depends upon the season, climatic conditions, and soil fertility. However, in general, the crop responds well to the basal application of 100 quintals of well-decomposed FYM (farmyard manure) along with 40 kg nitrogen and 75 kg phosphorus per hectare
- *Transplanting and optimum spacing* It is always advisable to take up transplanting in the field in the afternoon or in the cloudy weather for higher survival rate and early establishment. Planting is done in the centre of the small pit by burying completely the ball of earth containing the rooted cutting. The soil around the plant is pressed properly without breaking the earth ball. Irrigation should be done as soon as the planting is over. Later, irrigation should be done regularly. The transplanting of chingari in the field at a spacing of 45 cm × 30 cm gives good



Clerodendrum indicum –
floral bud

¹ Agro-technique study carried out by the Department of Horticulture, SKN College of Agriculture, Jobner, Rajasthan.

returns. Planting at a spacing of 45 cm × 30 cm can accommodate about 74 000 plants per hectare.

- *Intercropping system* *Clerodendrum* is grown as a pure crop.
- *Interculture and maintenance practices* Besides basal application of FYM, and 37.5 kg of nitrogen/hectare, an additional 37.5 kg of nitrogen should be applied in two equal split doses as top dressing: first at one month after transplanting and the second after six months (February–March) of transplanting.



Clerodendrum indicum –
inflorescence

- *Irrigation practices* *Clerodendrum* needs watering regularly. However, excess irrigation leads to waterlogging and should be avoided. The first irrigation should be done soon after transplanting. In rainy season, frequency of irrigation depends on the rainfall. In winter, irrigation should be done at an interval of 15–20 days. In summer months, irrigation should be done at an interval of 7–10 days, depending on the severity of the summer.
- *Weed control* Weeds create a serious problem in the cultivation of the crop, as it is planted during monsoon. Being a long duration and non-spreading type of crop, frequent manual weeding and hoeing at monthly interval keeps the field free from weeds and facilitates good aeration and plant growth.

■ *Disease and pest control* Chingari is affected by termites, which feed on the roots. The attacked plants turn yellow and finally die. Drenching of the field twice with chloropyrriphos 20% EC @ 4.0 litres per hectare, at an interval of 10 days, effectively controls the termite. No other disease has been observed.

Harvest management

- *Crop maturity and harvesting* Chingari bears flowers during January–February, that is, 100–120 days after planting. Seed setting does not take place in extreme hot and dry weather conditions. The crop is ready to be harvested in 10–12 months after planting. May–June is the best time for harvesting the crop. Irrigation of field four to six days before harvesting facilitates digging of roots. Mechanical injury

to the roots during digging should be avoided because it affects the quality of the produce.

- *Post-harvest management* The roots are dug out manually with the help of spade. Detach the shoot from the roots and then allow the roots to dry in the sun and then in shade. These roots are wrapped in gunny bags and stored in well-ventilated cool godowns for a long period without any deterioration quality. The roots may be graded for marketing.
- *Chemical constituents* The root contains sapogenins, saponins, triterpenes, and D-mannitol as active constituents.
- *Yield and cost of cultivation* An average crop of Chingari produces about 10–12 quintals per hectare of dry roots. Input cost is estimated to be Rs 75 000 per hectare.



Clerodendrum indicum –
root

Colchicum luteum Baker

Liliaceae

Ayurvedic name	Suranjan, Hiranatutia
Unani name	Suranjan talkh
Hindi name	Suranjan, Hirantutiya
Trade name	Suranjan, Suranjankadva
Parts used	Corms and seed



Colchicum luteum in the nursery

Therapeutic uses

Colchicum luteum is used as a carminative, laxative, and an aphrodisiac. Colchicines are effective in the treatment of gout, rheumatism, and diseases of liver and spleen. Externally, the corms are applied as paste to lessen inflammation and pain.

Morphological characteristics

Suranjan is an annual alpine herb. It can be recognized by an almost conical corm with a longitudinally grooved flat side, rapier-like leaves, short scape, and golden yellow flowers. Corms are almost conical, brownish in colour, with one side flat and other rounded, and can be either translucent or opaque. Leaves are 15–30 cm long and 0.8–1.5 cm broad and few in number. They appear with flowers and are narrow but broader towards the tip. They increase in size as the plant approaches fruiting stage.

Floral characteristics

The scape is very short and sessile. Flowers occur in large, erect terminal cymes with one to three flowers. Perianth is funnel-shaped and golden yellow in colour. Stamens are six in number. Ovary is sessile, three-celled with three long styles. Capsules are septicidal with recurved beaks. The plant flowers soon after the snow melts at higher altitudes in March, followed by fruiting in May.

Climate and soil

Natural habitat of suranjan is characterized by physiologically temperate conditions like severe winter, snow, and low humidity. The plant grows well in sandy-loam soil. Drainage is very important to avoid waterlogging.



Colchicum luteum
in the field

Distribution

The plant is usually found on the edges of forests or in open grassy places and temperate western Himalayas from Kashmir to Chamba, at altitudes ranging from 700 m to 2800 m in India.

Propagation material

The plant can be successfully propagated through corms, which can be extracted from natural habitats when snow melts in April–May. The corms should be free from any injury or infection.

Agro-technique¹

Nursery technique

- *Raising propagules* No nursery is generally raised for the crop and the corms are directly planted in the field.
- *Propagule rate and pretreatment* Corms do not require any pre-planting treatment. About 0.5 million corms are required for planting in 1 hectare of land.

¹ Agro-technique study carried out by the Department of Agroforestry and Environment, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh – 176 062.

Planting in the field

- *Land preparation and fertilizer application* The fields should be ploughed two to three times to make the soil porous to facilitate planting and sprouting of the corms. The corms may rot in water-logged conditions. Therefore, the fields should be well drained and have some slope. The plant prefers sandy loam soil, and if required, sand may be mixed with soil to make it suitable for growth. FYM (farmyard manure) @ 6 tonnes/hectare should be broadcast and properly mixed with soil while ploughing the fields at pre-planting stage.
- *Transplanting and optimum spacing* The corms are directly planted in rows in small beds laid out in the field. The crop is sown in rabi season, generally in October, in temperate zones. The corms should be placed at an optimum spacing of 10 cm × 20 cm. Corms germinate and develop roots within one month.
- *Intercropping system* The crop is preferably grown as a sole crop. No intercropping is recommended.
- *Interculture and maintenance practices* Only organic manure @ 6 tonnes/hectare is recommended as a basal dose. No further application of manure is necessary. No inorganic fertilizers are used.
- *Irrigation practices* This crop is very sensitive to waterlogging, so field should be free from excess water. This could be done by digging channels around the field well in advance to save the crop. The field should be irrigated as and when required, especially during the hot weather. Irrigation may be done every alternate day during summers.
- *Weed control* The initial growth of the crop may be hampered because of increased infestation of weeds during the sprouting period. So, the field should be kept free from weeds in the initial stages, and thereafter, weeding and hoeing should be done at an interval of one month.
- *Disease and pest control* The crop, in general, is not attacked by any insect/pest. There is no disease infestation as well.



Colchicum luteum

Harvest management

- *Crop maturity and harvesting* The crop matures in about 16–18 months. The seeds should be harvested immediately after ripening of fruits in April. Corms are taken out after a gap of one month in May, giving sufficient time for the hardening of the protective layers of the corm.
- *Post-harvest management* The collection/harvesting of seeds is difficult due to their very small size. Therefore, while collecting the seeds, a piece of cloth should be placed below the plant. For medicinal purposes, corms must be harvested before the development of offshoots. Corms are harvested by manual digging, sun dried, and packed in damp-proof containers. The corms are stored in sand at a cool place and are used to raise new crops.
- *Chemical constituents* Seeds contain 0.41%–0.43% poisonous alkaloids colchicine and cornigerine. The dried corms contain alkaloid colchicine in a range of 0.21%–0.25%. Colchicine occurs in the form of yellow flakes, crystals or as a whitish-yellow amorphous powder, which darkens on exposure to light.
- *Yield and cost of cultivation* By following the standard package and practices, corm yield of 500–750 kg dry weight is obtained from plantation on 1 hectare land under experimental conditions. The estimated cost of cultivation for raising crop on 1 hectare of land is about Rs 90 000 including the cost of planting material, other material, and labour cost.

Market trend – 2006/07

- Market rate: Rs 450 per kg
- Market demand: 2 tonnes per annum

Coleus barbatus Briq.

Lamiaceae

Ayurvedic name	Gandhmoolika
Hindi name	Patharchur
Trade name	Coleus, Patharchur
Part used	Root



Coleus in a plantation

Therapeutic uses

The root of *Coleus* species is considered analgesic, ophthalmic, and febrifuge. It is very useful in epilepsy. Fresh aromatic root is offered in temples for its characteristic odour and is also used as a flavouring agent.

Morphological characteristics

Patharchur is a large, succulent, densely hairy, herb with aromatic roots. It grows up to a height of 70 cm. The roots are perennial, while the shoots are annual. Stems are much branched, scandant, hairy, fragile, and knotted at nodes. Leaves are thick, fleshy, ovate, hairy, with serrate margins.

Floral characteristics

Pink-white flowers appear in winter season, that is, from October to February. This is also the best growth period for shoots.

Distribution

Patharchur is found wild in tropical moist forests of Tamil Nadu and Karnataka. It is quite rare in nature but very commonly cultivated in moist tropical regions and southern states.

Climatic and soil

The plant is sun loving and grows well in tropical regions. The suitable soil for commercial cultivation is sandy loam or sand-rich loam. It is also cultivated on sandy beds and river banks and ridges in Tamil Nadu. Loose sandy soil permits roots to penetrate deep into the sand bed and maximum root yield is obtained this way. The crop is preferably cultivated in open sunshine.



Coleus barbatus – stem cuttings for planting

Propagation material

The species is mainly propagated through stem cuttings of length 15 to 20 cm, containing four to five nodes. The cuttings remain viable up to four days, thereafter, the survival and rooting percentage declines. The crop can be raised round the year under ambient conditions. However, rainy season promotes early and copious rooting of stem cuttings with almost 100% survival.

Agro-technique¹

Nursery technique

- *Raising propagules* A pencil-thick stem cutting bearing leaves is cut and all cauline leaves are removed except apical bud. The base of the branch is given a sharp inclined cut so that the plant does not get bruised while planting. These stem cuttings are inserted into the soil till a depth of 5–6 cm with at least three nodes inside the soil and remaining one to two nodes above the soil. The stem cuttings need to be placed in shade, preferably in net house or polyhouse, using sprinkler or misting system to maintain a minimum humidity of 85% for at

¹ Agro-technique study carried out by Indian Institute of Horticultural Research, PO Hessaraghatta Lake, Bangalore – 560 089.

least a fortnight. The initiation of roots can be seen within 10 days but the cuttings need about five weeks for better establishment. Thereafter, the cuttings can be kept out of polyhouse for conditioning and hardening of plantlets. After two weeks of conditioning, the propagules are ready for transplantation in the field. Transplantation is done after four to five weeks of completion of rooting process. This period also includes hardening of the cuttings outside the polyhouse after which these cuttings can be planted in the field.

- *Propagule rate and pretreatment* About 28 000 rooted cuttings are required for planting crops on 1 hectare of land, at a spacing of 50 cm × 60 cm or 60 cm × 60 cm. No specific treatment is required before planting of cuttings.

Planting in the field

- *Land preparation and fertilizer application*
The land is tilled twice to make it porous and weed-free. It is then planked to get a level field. FYM (farmyard manure) or vermicompost at the rate of 15 tonnes per hectare should be incorporated as a basal dose 15 days before planting. The crop responds well to fertilizer application @ 30 kg per hectare each of nitrogen, phosphorus, and potash, after about 10 days of transplanting. This may be followed by at least two irrigations, if sufficient soil moisture is not available.
- *Transplanting and optimum spacing* Ridges are made in the field at a distance of 60 cm and the rooted propagules are planted in the soil up to a depth of 15 cm, generally by using the crowbar method.
- *Intercropping system* This crop can be intercropped beneath perennial species as it performs well under partial shade.
- *Interculture and maintenance practices* Phosphate and potash fertilizers are given as basal application as mentioned earlier. Nitrogenous fertilizers may be used in two equal split doses, the first being the basal dose. Frequent earthing-up once in 15–20 days is essential for good root growth. The soil from the furrow is heaped on to the base, resulting in proliferation and good growth of the roots. Weeding of crop is done after 30 days of transplanting followed by weeding after 60 days of transplantation. There is no need of weeding when the plants grow



Coleus roots – economically important plant part

and spread well over the ground. However, two to three weedings are usually necessary depending on the weed intensity.

- *Irrigation practices* The crop needs intermittent irrigation due to its succulent leaves. The crop gives good fibrous root yield only when irrigated adequately.
- *Disease and pest control* No serious pests or diseases have been recorded on this crop. However, white scale insects often attack the leaves, usually between the leaf veins and midrib, and suck the sap. The pest can be controlled by spraying 1.5 ml Nuvacron per litre of water on the foliage. The crop is also susceptible to water stagnation, which leads to root rot. Proper drainage and porosity of the soil are very important for good growth and productivity.

Harvest management

- *Crop maturity and harvesting* The crop can be maintained for three to four years under good phytosanitary conditions. The roots are, however, harvested between fifth and sixth months after planting. Studies indicate that plants harvested when they are five-month-old are better than those harvested when they are three or seven-month old. Maximum oil content in roots (1.4%) is obtained if the roots are harvested at the end of five months of plantation.
- *Post-harvest management* Harvested roots are first cleaned under running water, soaked well, and dried in shade. These are graded into main and lateral roots. Only lateral roots are used to extract oil. Main roots are left out since they hardly contain any oil and may be replanted in the field for fresh sprout.
- *Chemical constituents* The roots contain 0.5% to 1.4% oil, on air dry weight basis.
- *Yield and cost of cultivation* Yield of roots is about 250 kg per hectare. The cost of cultivation is estimated to be approximately Rs 75 000 per hectare.

Market trend – 2006/07

- Market price: Rs 50 per kg (roots)
- Market demand: 100 tonnes per annum

Commiphora wightii (Arn.) Bhandari

Syn. *C. mukul* Wt. and Arn.

Burseraceae

Ayurvedic name	Guggulu
Unani name	Muqil
Hindi name	Guggal
Trade name	Guggal
Part used	Oleo-gum resin



Commiphora wightii –
mature leafless tree

Therapeutic uses

The gum of guggal is anti-inflammatory and efficacious in the treatment of arthritis, rheumatism, hyperlipidemia, thrombosis, and hypercholesterolemia. It has alterative, carminative, astringent, and antispasmodic properties.

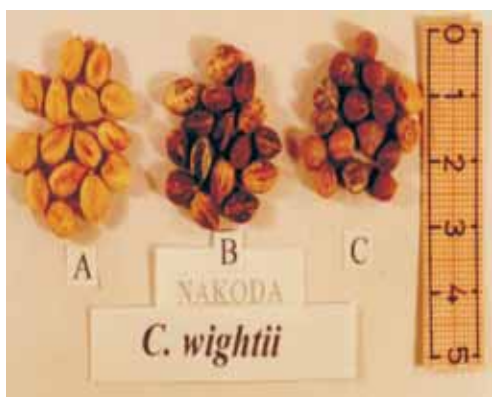
Morphological characteristics

Commiphora is a slow growing, highly branched, spiny shrub or a small tree with crooked and knotty branches ending in sharp spines. The stem is covered with silvery white, papery bark that peels off as flakes from the older parts of the stem, whereas, the younger branches are pubescent and glandular. Leaves are trifoliate; leaflets rhomboid, ovate, and entire at the base and serrate at the apex. The plant remains leafless during winter season, that is, from October to March. New leaves sprout during April, are

short-lived and do not fall until September. A short spell of rainfall initiates leaf formation. Guggal, an oleo-gum resin of pale brown or dull green colour, exudes from bark during winter season (November–February).

Floral characteristics

Flowers are sessile and appear singly or in groups of two to three. Fruits are ovoid, reddish brown to purple in colour. Two types of seeds, that is, black and yellowish-white, are produced. The flowering and fruiting take place throughout the year. However, maximum fruiting is observed from January to April.



Commiphora wightii – seeds

Distribution

Guggal is a xerophyte and grows naturally in arid and rocky zones of India, that is, Gujarat, Karnataka, Madhya Pradesh, and Rajasthan, and also in Pakistan.

Climate and soil

The plant grows well in arid, sandy, and rocky tracts of tropical India. Sandy or sandy loam soils are best for its cultivation.

Varieties

CIMAP (Central Institute of Medicinal and Aromatic Plants), Lucknow, has developed a good oleo-gum-resin-yielding cultivar called 'marusudha'. Some studies by CIMAP also indicate the presence of high guggul sterones in the cuttings obtained from Mangaliaswas area of Ajmer in Rajasthan and Kot Lakhat area of Bhuj in Gujarat. The germplasm from Nakoda in Rajasthan also gives a good yield.

Propagation material

Black coloured seeds may be used as planting material, although germination averages around 40% only. Seeds can be collected during February–March. Yellowish-white seeds are non-viable. One to four seedlings emerge from a single seed due to polyembryony. The plant can be easily propagated through leafless stem cuttings, prepared in May, or through air layering of 5–8-year-old mother plants in July–August.

Agro-technique¹

Nursery technique

- *Raising propagules* The planting stock for raising the crop can be prepared in a nursery through seeds, stem cuttings or air layering of 5–8-year-old mother plants. Only the black-coloured seeds are viable and sown during March to June, preferably in polybags. One seed may produce more than one seedling due to its polyembryonic nature. However, due to poor germination, two seeds are sown in each polybags. Seeds germinate within 7–10 days after sowing in the rainy season. Leafless stem cuttings are planted in the nursery in May. Similarly, air layering can be done during rainy season in July–August; roots develop in 15–20 days after setting.
- *Propagule rate and pretreatment* Approximately, 100 g of black seeds are required for raising plantation in 1 hectare of land at a spacing of 2 m × 2 m. No treatment of seed is required. Stem cuttings planted without any treatment show approximately 90% rooting. However, cuttings can be pretreated with guggulu solution (100 mg/litre) or IBA (indole-3-butyric acid @ 10 mg/litre) to hasten rooting and to achieve better survival rate.



Commiphora wightii –
field view

Planting in the field

- *Land preparation and fertilizer application* Pits of size 45 cm × 45 cm × 45 cm are dug at requisite spacing of 2 m × 2 m and refilled after mixing the sand, soil, and FYM in the ratio of 1:1:1.
- *Transplanting and optimum spacing* The plantlets obtained from seeds and rooted twigs from cuttings or air layerings are transplanted from polybags in the rainy season (July/August) to the pits containing a

¹ Agro-technique study carried out by

- Department of Botany, Jai Narain Vyas University, Jodhpur – 342 001, Rajasthan.
- Planting material source provided by Guggulu Garden Mangaliavas, Department of Forests, Ajmer, Rajasthan.

mixture of sand:soil:FYM (1:1:1). A crop stand of 2500 plants per hectare is obtained with a spacing of 2 m × 2 m.

- *Intercropping system* Guggal can be intercropped with crops like pearl millet and cluster bean. Experiments indicate a synergistic relationship between the intercropped species and guggal, resulting in better yield of pearl millet and cluster bean, while the quality and yield of guggal plantation remain unaffected. In Rajasthan, it is planted on the borders of the cultivated fields because of its very slow growing nature. Presence of spinous branches makes the field impenetrable.
- *Interculture and maintenance practices* Besides the basal dose of FYM provided in the pits, the plants may be provided with growth regula-



Commiphora wightii –
guggal

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

- *Irrigation practices* Irrigation with 8 litres of water per plant at an interval of 15 days results in best growth of plant.
- *Disease and pest control* No serious disease is observed in *Commiphora wightii* except for collar rot during rainy season, which is caused by *Sclerotium rolfsii*. The plant is infected at collar region when the water remains stagnant near the base at early growing stage. The condition may be controlled by avoiding stagnation of water around the base of the plant and spraying Diathane M-45 fungicide @ 2 g/litre of water on the crop. In desert areas, the early growth of the plant is often checked by termite attack, and in some cases, whole plant is damaged by the termite colony. Termite can be controlled successfully by drenching the soil with chloropyrophos @ 4 ml/litre of water.

Harvest management

- *Crop maturity and harvesting* The plant should be allowed to grow for at least five to six years before commencing incision of thick branches for extracting oleo-gum resin. The oleo-gum resin is tapped during winter, from November–February, by making a 7–10-cm long incision in the main stem near the base. The cut part is completely covered with resin in about a month's time. The exuded gum secreted is collected every week up to one month after which further exudation of gum stops.
- *Post-harvest management* After collection, the oleo-gum resin is stored in airtight plastic containers.
- *Chemical constituents* The gum resin contains 3.2% gum and 19.5% mineral matter chiefly consisting of silicon dioxide, magnesium, calcium, iron, and aluminium. It also contains about 1.5% essential oil, which contains 6.5% myrcene and 11% dinerycene. A number of steroids have also been isolated from guggul like Z-guggul sterone and E-guggulosterol I, II, and III.
- *Yield and cost of cultivation* A yield of 120–130 kg oleo-gum resin is obtained per hectare after about eight years. The per hectare cost of cultivation is approximately Rs 110 000 plus maintenance cost of Rs 5000 every year; thus, total input for eight years will be approximately Rs 160 000/hectare.

Market trend – 2006/07

- Market price: Rs 160–260 per kg
- Market demand: 900 tonnes per year (90% imported from Pakistan)

Curculigo orchioides Gaertn.

Hypoxidaceae

Ayurvedic name	Talamulika
Unani name	Musli Siyah
Hindi name	Kalimusali
Trade name	Kalimusali
Parts used	Tuberous roots and rhizomes



Curculigo orchioides –
plant in bloom

Therapeutic uses

C*urculigo* is used as a rejuvenating tonic, aphrodisiac drug, and diuretic. It is useful in general debility, cough, jaundice, asthma, and piles.

Morphological characteristics

Roots of kalimusali are straight, cylindrical, tuberous, 5–22 cm long, and 0.5–0.8 cm thick. The external surface is brownish, marked with loosely spaced, prominent, transverse wrinkles. Lateral roots are 5 cm or more in length, stout, fibrous, dull white in colour, and spongy externally. The freshly cut surface of tuberous rootstock has a starch-white colour within and is mucilaginous. Leaves are simple, sessile, crowded on the short stem with sheathing leaf bases, tapering into a short petiole, almost radical. They are 15–45 cm long and 1.2–2.5 cm broad, linear or linear-lanceolate,

membranous, glabrous or sparsely soft haired. The leaf tip, when in contact with the soil, develops roots and produces adventitious buds.

Floral biology

Flowers are epigynous, bright yellow, bisexual or unisexual, with a lanceolate and membranous bract. Perianth is located at the top of a slender sterile long extension of the ovary by means of which it is exposed above the ground. Perianth is gamotepallus with six equal lobes of size 1.5 cm × 0.2 cm; outer lobes are hairy on the back, while the inner ones are sparsely hairy along nerves. Ovary is tricarpeal, syncarpous, and trilobular with a fairly long slender beak (stipe). Flowering and fruiting occur mostly from October to January, rarely throughout the year.



Curculigo orchoides –
field view

Distribution

The species occurs in shady areas of sub-tropical Himalayas, Western Ghats from Konkan southwards, plains of West Bengal, Central India, Chhota Nagpur, and other tropical zones. Basically, it is a tropical plant and is found in almost all districts of India, from near-sea level up to 400 m altitude, especially in rock crevices and laterite soil. It is a shade-loving plant and thrives well in areas that receive high rainfall. It is considered to be a threatened species.

Propagation material

Tuber segments of 1.5–2 cm size, containing the apical bud, are collected during February–March and used for propagation.

Agro-technique¹

Nursery technique

- *Raising propagules* No stock is raised in the nursery. Tuber segments of size 1.5 cm × 2 cm, obtained from mother plants, are planted directly

¹ Agro-technique study carried out by Aromatic and Medicinal Plants Research Station, Kerala Agricultural University, Odakkali, PO Asamanoor Post, Ernakulam district, Kerala – 683 549.

in the main field at the onset of south-west monsoon, which breaks over South India in May–June. The tuber segments are planted at an optimum spacing of 10 cm × 10 cm. About 70%–80% sprouting is obtained after two months of planting in humid tropical regions like Kerala.

- *Propagule rate and pretreatment* The propagule rate is 600–750 kg of root segments per hectare. The tuber segments require no pretreatment before sowing.

Planting in the field

- *Land preparation and fertilizer application*

Talamuli grows well in moist and humus-rich soils. The land is ploughed well with the onset of monsoon. Organic manure is mixed before planting and raised beds are prepared to prevent waterlogging. FYM (farmyard manure) at the rate of 20 tonnes/hectare is applied at the time of land preparation. Alternatively, FYM at the rate of 15 tonnes/hectare may be applied at the time of land preparation and NPK (nitrogen, phosphorus, potassium) at the rate of 25:15:10 kg/hectare can be applied as top dressing during October–November. If available, well-decomposed poultry manure at the rate of 2.7 tonnes/hectare, instead of FYM, mixed well with the soil at the time of land preparation gives better yield.

- *Planting and optimum spacing* The tuber segments are directly planted in the field in rows. About 70%–80% germination/sprouting of tubers takes place after two months, when planted in humid tropical areas like Kerala. An optimum crop stand of 0.6–0.65 million is desirable for a pure crop with an optimum spacing of 10 m × 10 cm or 10 cm × 15 cm, while intercropping with a coconut gives a crop stand of approximately 0.2 million with a spacing of 20 cm × 25 cm.
- *Intercropping system* The crop grows well in the shade of irrigated coconut orchards. If it is to be raised as a pure crop, artificial shade has to be provided using shade nets of 25% density.



Curculigo orchioides –
rootstock

- *Interculture and maintenance practices* No additional manure is required for crop management. Manual weeding is usually adopted. Weeding twice at two and four months after planting is necessary to keep the crop weed-free. No special maintenance practices are required except for regular weeding and watering during dry spells.
- *Irrigation practices* The crop is grown in rain-fed area during the monsoon period. After the monsoon ceases, it is to be irrigated with 5 cm flooding fortnightly.
- *Disease and pest control* Seedling rot is observed during the rainy season and can be controlled by spraying and drenching the soil with 1% bordeaux mixture. Black rot disease is also observed and can be controlled by spraying 0.05% tridemorph. Rhizomes are often eaten by rodents and hence standard control measures may be taken for their control.

Harvest management

- *Crop maturity and harvesting* The plant starts flowering one month after planting and maximum number of flowers are noted during second and third months of planting. Flowering takes place throughout the year. However, fruits and seeds are not used as drug. Roots mature in the field in seven to eight months and may be harvested by digging.
- *Post-harvest management* Remnants of the shoot and rootlets are removed from tubers. The tubers are cleaned of the soil particles, dried well in the shade, and stored in gunny bags.
- *Chemical constituents* *Curculigo* roots contain acetone extractives (1.5%–1.8%), ash (3.3%–3.9%), and curculigosides (0.2%).
- *Yield and cost of cultivation* A dried tuber yield of 1000–1700 kg/hectare is obtained. The estimated cost of cultivation is Rs 28 000/hectare, which does not include the cost of planting material.

Market trend – 2006/07

Market price: Rs 300 per kg

Curcuma caesia Roxb.

Zingiberaceae

Ayurvedic name	Narkachur
Unani name	Siyah haldi, Kali haldi
Hindi name	Kali haldi, Narkachur
Trade name	Black zedoary, Kali haldi
Part used	Rhizome



Curcuma caesia –
plant

Therapeutic uses

The rhizome of kali haldi has a bitter, sharp, hot taste, and a pleasant odour. It has anti-bacterial and anti-fungal properties, and is laxative. It is used as a tonic for the brain and the heart. Rhizomes are useful in treating leucoderma, piles, bronchitis, asthma, tumors, tuberculous glands of the neck, enlargement of the spleen, epileptic seizures, inflammations, and allergic eruptions.

Morphological characteristics

Black zedoary is an erect, rhizomatous herb, about 1.0–1.5 m high. The rhizomes are ovoid in shape, acute at tip, but not so thick as in other species of *Curcuma*. Leaves are about 30–60 cm long and up to 15 cm broad, broadly lanceolate or oblong, glabrous, with a deep ferruginous purple cloud down the middle, which penetrates to the lower surface. Leaves arise from the underground rhizome.

Floral characteristics

Inflorescence is a spike, about 15 cm long or altogether about 30 cm high on basal peduncle. Flowers are pale yellow, reddish at the outer border and shorter than their bracts. Petiole and sheath are about as long as the blade. Spikes appear before the leaves. Flowers appear in June and July, while fruits mature in September and October.

Distribution

The species occurs in moist deciduous forests, mostly in Bengal, North-East, and Central India, within the altitudinal range of 200–1000 m. It grows as ground cover of forest area in subtropical to temperate region. It is a rare species and is mostly under cultivation.



Curcuma caesia –
Kali haldi plant

Climate and soil

Curcuma caesia grows well in sandy loam, acidic soils of pH 4.5–6.5. It is a partial shade-loving species; however, it grows well in open sun under cultivated conditions.

Varieties

There is no recommended variety. However, among the collected materials, accession no. IC-319760 (NBPGR) was found to give better rhizome yield.

Propagation material

Rhizome is the propagation material. Mature rhizomes are collected in December or just before plantation and longitudinally sliced with one apical bud in each slice.

Agro-technique¹

Nursery Technique

- *Raising propagules* Rhizome pieces are directly planted in the field and no nursery stock is generally raised.

¹ Agro-technique study carried out by

- NBPGR Regional Station, Umiam, Shillong – 793 103, Meghalaya.
- Department of Forest, Bilaspur, Achanakmar, Chhattisgarh.

- *Propagule rate and pretreatment* Approximately, 2.2 tonnes of rhizomes shall be required per hectare for planting at a spacing of 30 cm × 30 cm. No particular treatment is given to the propagules before planting.

Planting in the field

- *Land preparation and fertilizer application* The land is ploughed, harrowed, and planked, mixed with FYM (farmyard manure) @ 5 tonnes per hectare together with NPK (nitrogen, phosphorus, potassium) @ 33:80:60 kg per hectare as basal dose during land preparation. If required, lime @ 2 tonnes per hectare may be applied to reduce excessive acidity in soils, at least one month before planting.
- *Transplanting and optimum spacing* Middle of April is the best time for raising the crop in North-East India, while in other regions, it is the pre-monsoon period. The crop is propagated vegetatively through rhizomes. The whole or parts of rhizome, weighing approximately 20 g, should be planted in rows directly in the field during April. Planting at a spacing of 30 cm × 30 cm is found optimum, for which 0.11 million propagules (rhizome segments) are required per hectare. The rhizomes sprout in about 15–20 days.
- *Intercropping system* Kali haldi is grown as a single crop. But, it may be intercropped beneath widely interrupted canopy trees.
- *Interculture and maintenance practices* A complete dose of NPK is to be applied @ 100:80:60 kg per hectare as urea, single super phosphate, and potash, respectively. One-third of urea, that is, 33 kg, and full recommended quantity of single super phosphate and potash are applied at the time of final land preparation. The rest two-thirds of nitrogen as urea is top dressed in two split doses, first at the time of first earthing-up and the rest at the time of second earthing-up. Earthing-up is carried out at 45 days and 60 days after planting. To reduce the crop–weed competition during the early stages of growth, manual weeding at 60, 90, and 120 days after planting is recommended.
- *Irrigation practices* The crop is usually grown under rain-fed conditions in high rainfall tracts of Assam and Kerala states. Constant humidity is to be maintained in other areas through regular irrigation. Sprinkler irrigation is the most suitable method.
- *Disease and pest control* Leaf spot (*Tephрина* sp., *Coletotrichum* sp.) and leaf blotch (*Corticium* sp.) are sometimes observed on the crop. They can be controlled by spraying of 1% Bordeaux mixture at monthly intervals.

Harvest management

- *Crop maturity and harvesting* The crop takes about nine months to mature. Harvesting is done in mid-January. Before digging the rhizomes, soil is moistened through irrigation, so that the rhizomes are not injured. Injury to the rhizomes may cause decay of the harvest.
- *Post-harvest management* Peeled, half cut or sliced rhizomes should be kept in oven at 55 °C or under well-ventilated shade for drying. These dried rhizomes should be stored in suitable damp-proof containers.
- *Chemical constituents* Dried rhizomes of *Curcuma caesia* are reported to contain 1.6% essential oil containing 76.6% *d*-camphor; 8.2% camphene and bornylene; and 10.5% sesquiterpenes, curcumine, ionone, and turmerone.
- *Yield and cost of cultivation* Estimated yield of fresh rhizomes is 48 tonnes per hectare while dry rhizome yield is about 10 tonnes per hectare. Estimated cost of cultivation is Rs 95 000 per hectare.

Curcuma zedoaria (Christ.) Rosc.

Zingiberaceae

Ayurvedic name Karchur
Unani name Zarambad
Hindi name Narkachur, Ban Haldi
Trade name Zerumbat, Zedoary
Parts used Rhizomes and leaves



Curcuma zedoaria –
plant in flower

Therapeutic uses

Rhizomes of Karchur are aromatic, cardio-tonic, carminative, diuretic, and anti-spasmodic. They are used to cure jaundice, cough, hiccups, and respiratory disorders. Essential oil extracted from leaves is used in perfumery and aromatherapy.

Morphological characteristics

Zedoary is an annual or biennial, aromatic, rhizomatous, tall herb. It attains a height of 1.8 m. Rhizomes are large, pale yellow or whitish inside. Roots are aromatic and end in ellipsoid tubers. The edible root of zedoary has a white interior and a fragrance reminiscent of mango; however, its flavour is more similar to ginger, except for the fact that it leaves a very bitter aftertaste. There is no distinct aerial stem, but the shoot has a pseudo stem formed of long and closely overlapping four to six sheathing leaf bases. Leaves are large, reaching upto 1 m in length, oblong and deeply veined, often coloured purplish in the centre.

Floral characteristics

Inflorescence is a spathe arising from the rhizome. Flowers are whitish or pale-yellow with bright reddish-green bracts. Corolla tube is pinkish and funnel-shaped. Calyx is whitish and obtusely toothed. Flowering occurs in May–June, but fruiting occurs rarely. Fruit is an ovoid capsule.

Distribution

The species is semi-domesticated and is found in the forests of eastern Himalayas, Bengal, and Kerala. It is cultivated in Kerala, Karnataka, Tamil Nadu, and other places that provide congenial climatic conditions.



Curcuma zedoaria
– view of crop

Climate and soil

Karchur is a semi-domesticated crop of moist tropical, subtropical, and temperate regions. Loam and sandy loam soil and rainfall of about 1100 mm per annum are best for its cultivation. It can grow in open as well as shady conditions.

Propagation material

Rhizome is the best material for propagation, which can be collected

in winter season (November–December). Seeding generally does not occur in this crop.

Agro-technique¹

Nursery technique

- *Raising propagules* The nursery is not raised for the crop. Rhizome pieces are planted directly in the field.
- *Propagule rate and pretreatment* Rhizome propagules @10–12 quintals per hectare are required for planting at a spacing of 40 cm × 20 cm. No specific treatment is required before sowing.

¹ Agro-technique study carried out by NBPGR (National Bureau of Plant Genetic Resources), Research Station, Niglat, Bhowali – 263 132, Dist Nainital, Uttarakhand.

Planting in the field

- *Land preparation and fertilizer application* One ploughing of disc harrow and two to three ploughings of desi plough are needed for conditioning of soil. About 150 quintals/hectare of FYM (farmyard manure) and 100:80:60 kg/hectare of NPK (nitrogen, phosphorus, potassium) are mixed thoroughly in the soil before planting.
- *Planting and optimum spacing* The crop can be planted anytime from April to June, depending upon the availability of soil moisture. Rhizome pieces are planted directly in the field in rows at a spacing of 20 cm, row-to-row distance being 40 cm. Rhizomes sprout in 10–12 days in moist soil conditions; otherwise, they remain dormant in soil and sprout after the first shower. For planting, about 125 000 propagules per hectare at a spacing of 40 cm × 20 cm are needed. However, a little wider spacing may increase the output.
- *Intercropping system* Both solo and mixed cropping system can be opted for this crop under partial shade of trees with thin canopy.
- *Interculture and maintenance practices* The crop requires two to three weedings at intervals of 30, 60, and 90 days after planting. Thereafter, the plants have a suppressing effect on the weeds. No further application of any organic or inorganic fertilizer is required.
- *Irrigation practices* The crop requires three to four light irrigations per month during summer and two to three irrigations per month in winter. Irrigation frequency depends on soil and weather conditions.
- *Disease and pest control* No visible symptoms for any kind of disease, physiological disorder, and so on have been observed or reported on *Curcuma zedoaria* during the experimental trials.



Curcuma zedoaria –
narkachur
plantation

Harvest management

- *Crop maturity and harvesting* Overall crop maturity occurs in six to eight months. Harvesting of rhizomes is done during November–December. These rhizomes are washed well in water to remove soil particles, cut into slices, dried in sun to remove surface water, and then again dried in shade. The best time for harvesting the leaves is October–November.

- *Post-harvest management* Sliced and dried rhizomes are stored in a cool place for commercial purposes. To get planting material, rhizomes are buried in soil pits or sand heaps up to March.
- *Chemical constituents* The rhizomes contain an average of 0.18% of essential oil when collected during February, March, and November. The major ingredients of essential oil are cineole, δ -pinene, β -pinene, camphor, and so on.
- *Yield and cost of cultivation* Fresh rhizome yield varies from 285 quintals/hectare to 315 quintals/hectare, while the yield of leaves is in the range 70–80 quintals/hectare on fresh weight basis. The essential oil yield from leaves is 7–8 kg/hectare (on 0.09% of fresh weight basis), while the essential oil yield from rhizomes is 80–90 kg/ha (at 0.28% of fresh weight). The estimated cost of cultivation is Rs 92 900 per hectare.

Market trend – 2006/07

- Market price: Rs 15 per kg (rhizomes)
- Market demand: 2.5 tonnes

Desmodium gangeticum (L.) DC

Fabaceae

Ayurvedic name	Shalparni
Hindi name	Salparni
Trade name	Sarivan
Parts used	Roots and whole plant



Desmodium gangeticum plant

Therapeutic uses

The plant has febrifuge, aphrodisiac, analgesic, diuretic, anti-inflammatory, and haemorrhagic properties. It is used in postnatal complaints, diarrhoea, chronic fever, biliousness, cough, vomiting, and asthma. It is an important ingredient of *dasmoolarishta* and *chyavanprash*.

Morphological characteristics

Salparni is a sub-erect, diffusely branched undershrub, up to 120-cm tall. Stem is short and woody at base. Leaves are unifoliate, ovate to ovate-lanceolate, membranous, and mottled with grey patches.

Floral characteristics

Inflorescence is elongated, lax, terminal or axillary raceme. Flowers are purple, lilac to white in colour. Fruit is a pod, moniliform (beaded), six

to eight jointed. Joints of pods are sparsely pubescent with hooked hairs. Joints separate into indehiscent one-seeded segments at ripening. Seeds are compressed and kidney shaped. Flowering and fruiting occur twice a year, from May to June and from September to October.

Distribution

The species is common as an undershrub in forests and wastelands throughout tropical and sub-tropical regions of India, predominantly in the lower Himalayan regions and Gangetic plains. It is never found in open grassy lands, but quite often found as orchard weed.

Climate and soil

Tropical and subtropical dry climate is suitable for the cultivation of *Desmodium*. It grows well in partial shade in moist orchards on loam to clay loam soil, with pH 8.5–9.0 (alkaline). It can also thrive well in heavy soils with high clay content.

Propagation material

The crop can be raised easily through seeds, which germinate without any pretreatment. Seeds are collected during July–August and October–November. The collected seeds retain their viability for three years under normal storage conditions.

Agro-technique¹

Nursery technique

- *Raising propagules* The seedlings can be raised from seeds in the nursery in March–April. Seeds are sown in polybags with a potting mix containing equal amounts of soil, sand, and FYM (farmyard manure). The seeds germinate in about 7–10 days and the seedlings are ready for transplanting in the main field after 45–50 days. Seeds planted directly in the field produce uneven or dense crop stand.
- *Propagule rate and pretreatment* Approximately, 3–4.5 kg seeds are needed for raising about 50 000 seedlings for 1 hectare plantation.

¹ Agro-technique study carried out by

- National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001, Uttar Pradesh.
- Zandu Foundation of Health Care, Vapi, Dist Bulsah, Gujarat.

No particular pretreatment is required; however, seeds soaked overnight in water show quicker germination.

Planting in the field

- *Land preparation and fertilizer application* The field should be prepared well by giving one ploughing and two harrowings, followed by planking. Manure at the rate of 10 tonnes/hectare should be mixed thoroughly with the soil at the time of field preparation. Nitrogen and phosphorus should be applied at the time of planting at the rate of 20 kg/hectare and 40 kg/hectare, respectively. Nitrogen and phosphorus can also be applied in the form of DAP (di-ammonium phosphate) at the rate of 100 kg/hectare. Zinc should be applied in deficient soils at the rate of 20 kg/hectare at the time of planting.
- *Transplanting and optimum spacing* Transplantation in irrigated farms can be done after seedlings attain 45 days of age. If dry conditions prevail, transplantation may be delayed till early July under rain-fed conditions. An optimum spacing of 45 cm × 45 cm is recommended, which can accommodate approximately 50 000 saplings in 1 hectare of land. For intercropping with widely spaced main crops such as aonla, planting can be done in two adjacent rows at a spacing of 30 cm × 30 cm.
- *Intercropping system* The plant can be grown either as a pure crop or as an intercrop with trees like poplar (*Populus deltoidea*), as it can withstand partial shade. Aonla, mango, and guava orchards are also suitable for intercropping.
- *Interculture and maintenance practices* All manures and fertilizers are applied just before transplantation while preparing the land. Although manual weeding is the norm, herbicides, such as glyphosate, can be used as pre-planting application. Glyphosate is sprayed about three weeks before planting the crop. This results in reduced intensity of weeds in the early stages of crop growth. Weeding and hoeing are done manually at the initial stages of crop–weed competition. The crop requires manual removal of weeds twice at early stages (25 and 45 days after transplantation) and once at the end of September.
- *Irrigation practices* First irrigation is essential just after transplanting, followed by irrigation at an interval of 12–15 days in summers (May–June). During monsoon, irrigation can be done depending on the rains received. In rain-fed conditions, irrigation depends upon the amount and frequency of rainfall. Irrigation once a month during winter season is sufficient.

- *Disease and pest control* No serious disease or insect pests have been observed. The roots of plantations older than one year are often severely damaged by rats in some dry regions. The rodents may be controlled by standard control measures.

Harvest management

- *Crop maturity and harvesting* The plants mature in six to seven months by November–December, and may be harvested as whole plants. If root is required for medicinal purpose, the plant may be allowed to stand for one year and harvesting may be done in April. One-year old crop produces higher root yield.
- *Post-harvest management* Irrigation is withheld three weeks before harvesting. The whole plant is dug out with spade and roots are separated. The produce is washed, cleaned, and dried in shade. The dried produce is packed in gunny bags and stored under humidity-free conditions.
- *Yield and cost of cultivation* The total herb yield per hectare is estimated to be 50–55 quintals dry weight, while the dry weight yield of roots is estimated to be 11–15 quintals/hectare. The approximate cost of cultivating 1 hectare of land is Rs 45 000.

Market trend – 2006/07

- Market price: About Rs 16 per kg
- Market demand: Above 100 MT/year

Dioscorea bulbifera Linn.

Syn. *D. crispata*, *D. sativa*

Dioscoreaceae

Ayurvedic name	Varahikhand, Varahi
Unani name	Zaminkand, Ratalu
Hindi name	Ratalu, Genthī
Trade name	Rattalu
Parts used	Corms and tubers



Dioscorea bulbifera –
plant in flowering

Therapeutic uses

Corms of *Dioscorea bulbifera* are aphrodisiac, tonic, and used for treating sore throat, boils and swellings, dysentery, piles, and syphilis. They are also used against tumour.

Morphological characteristics

Ratalu is a clockwise twining herb with glabrous stem. Leaves are alternate, simple, three to five veined from base, glabrous, ovate-triangular with deep cordate base. Axillary bulbils are spherical, tubercled, and dark brown-green in colour.

Floral characteristics

Flowers are arranged in hanging, axillary, solitary or fascicled spikes. Capsules are oblong and winged, while seeds are winged at the base. Perianth is tubular and fruit is three-valved. Flowering and fruiting occur from September to November.

Distribution

The species is distributed throughout tropical and subtropical areas, up to 1000 m altitude. It is a shade-loving species but grows well in open areas too.

Climate and soil

A subtropical or sub-temperate and humid climate with distinct two to three months of cold winters is ideal for the growth of the plant. Sandy loam soil is most suitable for its cultivation and better yield of corm.



Dioscorea bulbifera

Propagation material

The species can be easily propagated by underground corms or aerial bulbils. Vegetatively propagated plants have relatively faster growth than the seedlings. Larger bulbils that are more than 4 cm in diameter sprout about two days earlier than the smaller ones. November and December are the ideal months for collection of bulbils for propagation. Bulbils are buried in soil for protection and used as propagules for next season.

Agro-technique¹

Nursery technique

- *Raising propagules* Direct planting of the corms or bulbils in the field is more effective than transplanting nursery-raised seedlings, hence it is the preferred method. The suitable time for planting corms or bulbils is April–May in mid-hills. For raising seedlings, seeds are separated from mature fruits collected in November and are sown in spring or early summer. Germination takes about 15–30 days and is less than 40% even under laboratory conditions.
- *Propagule rate and pretreatment* About 80–100 kg well-developed bulbils or corms are required for plantation on 1 hectare of land at a spacing of 50 cm × 50 cm. No pretreatment is required before sowing the bulbils.

¹ Agro-technique study carried out by the Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh.

Planting in the field

- *Land preparation and fertilizer application* The planting beds should be tilled properly and made weed-free, and the soil should be well pulverized. A basal dose of 15–20 tonnes/hectare of FYM (farmyard manure) should be applied to the soil at the time of pre-planting tillage.
- *Planting and optimum spacing* Plant-to-plant spacing of 50 cm × 50 cm is considered optimum for good growth and yield. This spacing gives an optimum crop stand of 40 000 plants per hectare. Plant spacing of 100 cm × 100 cm yields higher number of bulbils per plant; however, the average weight of bulbils as well as their number per unit area are much higher at the spacing of 50 cm × 50 cm.
- *Intercropping system* The plant is preferred as a solo crop, but needs staking support or host of shrubs and trees.
- *Interculture and maintenance practices* Applying organic manure @ 15–20 tonnes/hectare at the time of planting enhances average weight and yield of bulbils. Where sufficient FYM/organic manure is not available, suitable doses of inorganic fertilizers can be given to compensate for FYM for higher yield. The twiner needs staking support to expose maximum foliage area to the sunlight. The plants may be supported by a system of bamboo pillars and string or wooden stakes or trellis.
- *Irrigation practices* Only light irrigation to maintain humidity during dry season is recommended through sprinklers. Flood irrigation may result in waterlogging and should be avoided.
- *Weed control* Manual weeding at monthly intervals during the peak period of weed growth (July–September) controls weeds to a great extent.
- *Disease and pest control* No serious disease or infestation has been reported in this crop.



Dioscorea bulbifera
– bulbil

Harvest management

- *Crop maturity and harvesting* Bulbils become ready for harvest within 180–200 days from sprouting. The mother corm may be harvested after two to three years. The crop undergoes dormancy during winter.

Hence, October–November are the ideal months to harvest bulbils/ underground corms. In subtropical and tropical areas, mid-September to mid-October is the most suitable time. The bulbils should be plucked as and when they become fully grown, otherwise they are shed before the foliage develops.

- *Post-harvest management* The corms and bulbils can be stored in gunny or paper bags without causing any adverse effect on the rate of sprouting. There might be delay in sprouting of the bulbils by about two days.
- *Chemical constituents* Chief active ingredient of corm is diosgenin along with furanoid norditerpenes, sinodiosgenin, diosgenin β , smilagenone, and epismilagenins.
- *Yield and cost of cultivation* The crop yields an average of 12 tonnes of fresh corms per hectare in the second year. The estimated cost of input is Rs 62 500 per hectare.

Market trend – 2006/07

- Market price: Rs 16 per kg dry weight
- Market demand: 3 tonnes per annum

Gymnema sylvestre R. Br. ex Schult.

Asclepiadaceae

Ayurvedic name Meshashringi
Unani name Gurmar buti
Hindi name Gurmar
Trade name Gurmar
Part used Leaf



Gymnema sylvestre – plants

Therapeutic uses

Gurmar is hypoglycaemic, astringent, stomachic, antiperiodic, diuretic, tonic, and refrigerant. It is used as a destroyer of glycosuria, and is believed to neutralize the excess sugar present in the body. It is also used to treat other urinary disorders.

Morphological characteristics

Gymnema is a gregarious woody climber, much branched, running over the tops of tall trees. Young stems and branches are pubescent. Leaves are 3–5 cm long and upto 3 cm broad, ovate-elliptic, acute or shortly acuminate, pubescent on both sides; base rounded or heart shaped with 6–13 mm long pubescent petioles.

Floral characteristics

Flowers occur in umbellate cyme inflorescences. Calyx is pubescent, nearly divided to the base. Corolla is yellow, tube campanulate with

thick, ovate, and recurved lobes. Follicles are up to 7.5 cm long and 1 cm broad, rigid, lanceolate, and attenuated into a beak. Seeds are about 1.3 cm long, narrowly ovoid-oblong, flat, with a thin, broad, brown, and glabrous marginal wing. Flowering occurs in October–January, while fruits mature from March to May.

Distribution

The species occurs in all tropical zones of India and is a common climbing plant in central and southern India.

Climate and soil

The plant grows in tropical and subtropical humid climate. It is common in hills of evergreen forests. Sandy loam soil is best for its cultivation. It may be cultivated on a variety of soils including gravelled soil.

Propagation material

Terminal and axillary cuttings with three to four nodes from one-year-old plants are the best planting material. Seed germination is poor; hence, plants are preferably raised vegetatively through cuttings. Cuttings can be obtained throughout the year in moist humid conditions of South India. In North and Central India, cuttings are preferably planted in February–March.



Gymnema sylvestre
– cutting

Agro-technique¹

Nursery technique

- **Raising propagules** Styrofoam trays or polybags are filled with soil, sand, and FYM (farmyard manure) in 1:2:1 ratio, and terminal or axillary cuttings are planted in them. Vermicompost may be used in place of FYM. February to March is the best season for planting the cuttings in nursery, especially in North Indian conditions. The cuttings are placed under humid conditions in shade houses or mist chambers for development of roots. Rooting is initiated within a month of planting.

¹ Agro-technique study carried out by Centre for Advanced Studies in Botany, University of Madras, Guindy Campus, Chennai – 600 025, India.

Seed setting is poor in this species and the seeds show a maximum germination percentage of 50%–55% when sown in soil mixed with vermicompost.

- *Propagule rate and pretreatment* About 6700 rooted cuttings are required for plantation in 1 hectare of land. At 80% survival, about 8400 cuttings would be required. The stem cuttings are dipped in IBA (indole-3-butyric acid; 100 PPM [parts per million]) for six minutes before planting in the nursery to promote rooting.

Planting in the field

- *Land preparation and fertilizer application* The field is ploughed to turn the soil and make it weed-free. About 10 tonnes of FYM is mixed with the soil as a basal application at the time of land preparation.
- *Transplanting and optimum spacing* The period between June and August is best for transplanting the rooted plants in the field. An optimum spacing of 1 m × 1.5 m is recommended for a crop stand of about 6700 plants per hectare. The rooted cuttings/seedlings may be planted by crow bar method.
- *Intercropping system* When the plants are young, green gram can be grown as an intercrop. Alternatively, the crop can be raised beneath the tree species that serve as host or staking for this twiner.
- *Interculture and maintenance practices* About 10–12 tonnes/hectare of FYM or 250 kg of NPK (nitrogen, phosphorus, potassium in equal quantities) is applied as basal dose at the time of land preparation. An additional equal dose may be added every year for maximizing biomass production.
- *Irrigation practices* Irrigation is required at least once in a week during summer season. Frequency may also depend on the soil moisture in winter. It may be limited to one per month.
- *Disease and pest control* An aphid (*Aphis* sp.) is observed to attack the apical tender parts of the plant during rainy season. However, if the



Gymnema sylvestre
– crop

damage is not severe, no control measures are required. Use of chemical pesticides should be avoided since leaves are to be regularly plucked for harvest.

Harvest management

- *Crop maturity and harvesting* Leaves that are about 30–40 days old can be plucked for use, and harvesting can be done every three months. However, better yield is obtained after one year of growth.
- *Post-harvest management* Leaves are dried in shade and the dried leaves are packed in polythene bags. The moisture content of the dry leaves should be less than 8% to prevent deterioration.
- *Chemical constituents* The produce contains 7%–9.6% of gymnemic acid as active principle. Besides, alanine, aminobutyric acid, isoleucine, valine, adenine, choline, gymnamine (alkaloid), and many other ingredients are isolated from leaves.
- *Yield and cost of cultivation* About 1250 kg of dry-weight leaves can be obtained per hectare every three months. The approximate per hectare cost of cultivation is Rs 25 000/hectare.

Market trend – 2006/07

- Market price: Rs 50 per kg (dry leaves)
- Market demand: 1 tonne per annum

Hedychium spicatum Ham. ex Smith

Zingiberaceae

Ayurvedic name	Shati, Karchur
Unani name	Kapoor kachari
Hindi name	Kapoor kachri
Trade name	Kapoor kachri
Parts used	Rhizomes and essential oil from rhizomes



Hedychium spicatum –
Kapoor kachri

Therapeutic uses

Rhizome of *Hedychium* is aromatic, acidic, bitter, pungent, carminative, stomachic, stimulant, expectorant, anti-asthmatic, anti-septic, and anti-inflammatory. It is useful in asthma, bronchitis, vomiting, dyspepsia, and inflammations. It has insect repellent properties, and is also used as a dye and perfume for making 'abir' powder used in 'Holi'.

Morphological characteristics

Kapoor kachri is a rhizomatous, fragrant leafy herb with robust stem, and is up to 1.5 m tall. Rhizomes have strong aromatic odour and bitter camphoraceous taste. They are white, starchy, and fragrant within. Bark is rough, reddish-brown with few deep-seated fibrous rootlets. Leaves are up to 30 cm long, lanceolate, with green, obtuse bracts and leaf sheath clasping the stem.

Floral characteristics

Flowers are fragrant, white with orange-red base, present in a dense, terminal, 15–25 cm long spike. Floral bracts are prominent, green with solitary flower in axil. Calyx is papery and three-lobed. Petals are linear and spreading; tip is white with two elliptic lobes and orange base. Corolla tube is about 5–6.5 cm long. Fruit is a spheroid, three-valved capsule with orange-red lining. Seeds are black with a red aril. Flowering occurs in August and fruits ripen in October.

Distribution

The species occurs in subtropical and sub-temperate Himalayan region in oak (*Quercus* spp.) and deodar (*Cedrus deodara*) forests on slopes between 1500 m and 2500 m altitudes.

Climate and soil

Kapoor kachri is sciophytic in nature and prefers shady slopes. Waterlogging in the soil is fatal due to rotting of rhizomes. Moderate temperature and well-spread rainfall are suitable for better growth. Sub-temperate to temperate climate with annual precipitation of 1000–1500 mm, and well-drained, deep sandy loam, and humus-rich soil with good moisture retaining capacity are most suitable for its cultivation. Soil with 40%–50% of sand gives better yield.

Propagation material

Both seeds and rhizomes may be used as propagation material, but when crops are raised through seeds, rhizomes may require three to four years to mature. Propagation by rhizome is preferred due to less time involved (about two years) in crop maturity.

Agro-technique¹

Nursery technique

- *Raising propagules* It is not advisable to raise the crop through seeds; rhizome pieces with apical buds are buried in 10 cm × 20 cm polybags containing soil, sand, and FYM (farmyard manure) in equal amounts and irrigated intermittently. Rhizomes may also be planted in mother

¹ Agro-technique study carried out by National Bureau of Plant Genetic Resources, Regional Station Shimla, Himachal Pradesh.

beds in the nursery and uprooted for planting in the field. Nursery is raised in April when the weather is little warmer. Propagules sprout between 25 and 30 days. Rhizomes may also be planted directly in the field.

- *Propagule rate and pretreatment* About 25 quintals of healthy rhizomes, segregated into pieces with one bud in each and weighing about 40–50 g, are required for raising plantlets in 1 hectare of land. Though rhizome rot is not a serious problem, high rainfall and waterlogging may cause damage to propagules. Therefore, rhizomes should be dipped in 0.01% bavistin solution for 25–30 minutes, followed by shade-drying for six to eight hours before planting.

Planting in the field

- *Land preparation and fertilizer application* First ploughing with soil-turning plough is done in the first week of March in montane ranges and in last week of March on higher hills. This makes the soil free from weeds and buries the previous crop residues. The field is left fallow for 15–20 days for solar treatment, aeration, and to facilitate decay of crop residues. With second ploughing, well-decomposed FYM at the rate of 20 tonnes per hectare should be spread well and thoroughly mixed. Planking should be done after second and third ploughing to make the soil friable and turn it into a fine tilth.
- *Transplanting and optimum spacing* Propagules are transplanted in April in middle zones and in May in high ranges of hills. The rhizomes are planted in furrows at a depth of 10–12 cm, at an optimum spacing of 45 cm × 30 cm. At this spacing, about 64 000 propagules per hectare will be required. Saplings should be taken for transplantation when they attain a height of 12–15 cm. These saplings should immediately be planted after uprooting them from the nursery bed.
- *Intercropping system* *Hedychium* is preferred as an intercrop in fruit orchards. Experiments of intercropping in apple orchards have given better results perhaps due to the availability of congenial environment for better growth. The yield is about 60–65 quintals per hectare. In an apple orchard, only about 44 000 propagules/hectare may be required.
- *Interculture and maintenance practices* The quantity of FYM recommended is about 30–35 tonnes/hectare. It should be applied in three split doses: the first one at the time of land preparation (20 tonnes/hectare) and the other two doses (5–8 tonnes/hectare each) should be applied well before the onset of monsoon in the first and second year

of cropping. Interculture operations mainly comprise weeding, earthing-up (hoeing), and timely watering. First hoeing is done at the time of top dressing, that is, 45–50 days after transplanting, and the second hoeing can be done just after rainy season to loosen the soil. If required, inorganic fertilizer, such as NPK (nitrogen, phosphorus, potassium), may be applied at the rate of 100:120:60 kg/hectare in three split doses. The entire amount of phosphorus and potassium along with one-third of nitrogen should be applied in furrows at the time of land preparation. The remaining nitrogen should be applied in two equal split doses: first after two months of planting and the second in the next rainy season after new sprouting.

- *Irrigation practices* Since the crop is grown in areas with well spread-out rainfall, it requires no irrigation, except in the case of rainfall deficiency or during long spells of no rain. During winter, light irrigation at an interval of 15–20 days is sufficient. Sufficient moisture should always be available, but there should be no waterlogging.
- *Weed control* Manual weeding is recommended for the crop. Three weedings are sufficient. First weeding is done 15–20 days after completion of sprouting. Second and third weedings are done with the first and second hoeing operations.
- *Disease and pest control* In rhizome rot, leaves of the affected plant become pale and the affected rhizomes become soft and pulpy, and ultimately rotten. Rhizome rot can be controlled by dipping the rhizomes in 0.01% bavistin solution for 25–30 minutes followed by shade-drying before planting. In leaf spot disease, spots appear over leaf lamina; control measures involve spraying with 4:4:50 bordeaux mixture.

Harvest management

- *Crop maturity and harvesting* The crop is biennial when planted through rhizomes, and hence, matures in second season during October–November, depending upon the elevation. Dried leaves and stalks are removed after they turn yellow, while rhizomes are left in soil for about 20–25 days for ripening before being dug out.
- *Post-harvest management* Rhizomes should be properly cleaned in water to remove soil particles. Small roots and rootlets are also removed. The produce is then dried in shade and stored in containers in damp-proof stores. Healthy rhizomes should be selected before drying as future propagules and treated with 0.01% bavistin solution to prevent rotting and then buried with pits in sandy soil till next sowing period.

- *Chemical constituents* α -pinene, β -pinene, limonene, camphor, linalyl acetate, β -terpineol, β -caryophyllene, benzyl cinnamate, benzyl acetate, γ -terpinene, β -phellandrene, methyl paracumarin acetate, cinnamic ethyl acetate, ethyl cinnamate, sesquiterpene alcohols, and hydrocarbons.
- *Yield and cost of cultivation* Second year harvesting yields about 115–120 quintals/hectare dry weight of rhizomes. However, first year harvesting can also yield 45–50 quintals/hectare dry weight. Since there is a significant increase in produce, it is recommended to harvest the crop in the second year. Estimated cost of cultivation is approximately Rs 40 000/hectare for complete crop duration.

Market trend – 2006/07

- Market price: Rs 10–12 per kg of dry rhizomes
- Market demand: 15 tonnes per annum

Hemidesmus indicus R. Br.

Asclepiadaceae

Ayurvedic name	Sveta Sariva, Anantmool
Unani name	Ushba
Hindi names	Anantamul
Trade name	Anantmool, Sariva
Part used	Root



Hemidesmus indicus

Therapeutic uses

The root of the *Hemidesmus* plant is demulcent, alterative, astringent, diaphoretic, diuretic, tonic, anti-pyretic, and blood purifier. It is used in leprosy, skin diseases, fever, asthma, bronchitis, syphilis, pruritus and other urinary diseases, chronic rheumatism, and leucorrhoea.

Morphological characteristics

Anantmool is a perennial, slender, twining undershrub with woody and fragrant rootstock. Stems are numerous, slender, wiry, and laticiferous. Leaves are simple, opposite, variable, elliptic-oblong to linear-lanceolate, variegated, and white above and silvery-white pubescent beneath.

Floral characteristics

Flowers are greenish purple, crowded in axillary cymes in small compact clusters. Fruits (follicles) are paired, cylindrical, pointed, and slender. Seeds are oblong in shape. Flowering is usually sparse and occurs in October, while fruits mature in January.

Distribution

The species is distributed throughout the tropical and subtropical parts of India, especially in upper Gangetic plains, Bengal, Madhya Pradesh, and South India. It generally occurs on sub-ravine slopes, twining on shrubs and trees.

Climate and soil

The plant is found throughout the tropical and subtropical parts of India. Loam to silt-clay loam soils with appropriate humus are suitable for its cultivation. The soil should be slightly alkaline with a pH of 7.5–8.5.

Propagation material

The plant can best be propagated from stem and rootstock cuttings obtained from more than one-year-old plants. Rootstock cuttings have better sprouting and survival rates than stem cuttings.

Agro-technique¹

Nursery technique

- *Raising propagules* Planting stock is raised in nursery through stem and root cuttings. The cuttings are planted in polythene bags or styrofoam trays between July and September. The cuttings establish or initiate roots in 30–45 days. The cuttings may be treated with commercially available root-promoting hormones before being planted in the nursery. Nursery can also be raised in shade net house in early summer under humid conditions.
- *Propagule rate and pretreatment* About 28 000 rooted cuttings are required for planting in 1 hectare of land. No specific treatment other than dipping in rooting hormones is required.

¹ Agro-technique study carried out by National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001, Uttar Pradesh.

Planting in the field

- *Land preparation and fertilizer application* The field is ploughed and harrowed, and levelled properly. Pits of size 30 cm × 30 cm × 30 cm are dug at a spacing of 60 cm × 60 cm in the prepared field. A basal dose of about 1–2 kg of FYM (farmyard manure) is mixed with soil and sand in equal quantities for filling in the pits.
- *Transplanting and optimum spacing* Rooted plantlets can be transplanted in the field at three- to five-leaved stage in August and September under rain-fed conditions. The propagules are planted in 30 cm³ pits with a spacing of 60 cm × 60 cm for better harvest.
- *Intercropping system* Since Sveta Sariva is a twiner and needs support for growth, it can be intercropped with trees in orchards/plantations where it may get staking support.
- *Interculture and maintenance practices* Only organic manure @ 1–2 kg/plant is recommended to be mixed with the soil at the time of field preparation. As many as three to four weedings are recommended for the crop. The interval between subsequent weeding and hoeing may be 30–45 days. Common weedicides based on glyphosate may be used at the time of land preparation.
- *Irrigation practices* The crop may be irrigated at the time of transplanting. Two subsequent irrigations are required during establishment stage, 15 and 45 days after transplanting. The crop grows as a rain-fed crop under humid tropical conditions, thus not much irrigation is required.
- *Disease and pest control* No serious damage by diseases and insect pests has been observed in the crop.

Harvest management

- *Crop maturity and harvesting* A minimum period of two-and-a-half years is required for root maturity. Harvesting may be done in December and January.
- *Post-harvest management* The roots are dug with care and some part of the root is left within the soil for regeneration. The harvested roots are washed, dried in shade, and stored in moisture-free packing in cool and dry places.
- *Chemical constituents* The roots contain coumarin and two sterols – hemidosterol and hemidesmol – besides resins and tannins. Aerial parts of the plant contain carotenoid (22.4 mg/100 g), provitamin A, vitamin C (27.2 mg/100 g), tannins (1.7%), phenolics, anthocyanins,

reducing and non-reducing sugars (17.6%), and anti-nutritional factors.

- *Yield and cost of cultivation* A total dry root biomass of approximately 1.2 tonnes per hectare is obtained. The estimated cost of cultivation is about Rs 35 000 per hectare.

Market trend – 2006/07

- Market price: Rs 65 per kg dry root
- Market demand: 300 tonnes per annum

***Holostemma ada-kodien* Schult.**

Syn. *H. annulare* (Roth.) Schum

Asclepiadaceae

Ayurvedic name	Jivanti, Ark pushpi
Hindi name	Dudhi bel, Chirvel
Trade name	Dudhi bel
Part used	Root



Holostemma ada-kodien

Therapeutic uses

The roots of *Holostemma* are useful in treating ophthalmopathy, or chitis, cough, burning sensation, stomach pain, constipation, fever, and *tridoshas*. The root can also be used as a rejuvenative drug, imparting resistance to diseases.

Morphological characteristic

Chirvel is a large woody climber and glabrous. Its latex is milky white. The leaves are opposite and simple, with petioles decussate, ovate-oblong to broadly ovate, cordate, caudate or aristate at apex. Basal lobes are rounded, more or less pubescent beneath lateral nerves that are prominent and arched.

Floral characteristics

The flowers of the plant are arranged in umbellate axillary cymes; peduncles are terete and glabrous; bracts are linear acute, grooved on ventral

surface, glabrous. Pedicels are 1–4 cm long, glabrous; sepals are five in number, free up to the base, and broadly ovate, glandular within. Corolla rotate lobes five in number, united about halfway, ovate-oblong, obtuse, leathery with papery margin. Corona is staminal, uniseriate, with annular ring at the base staminal tube. Stamens are five in number; pollinia are five in number; pollen masses are solitary 11 cm × 3.5 cm, ovoid, thick, acute, and glabrous. Seeds are many, comose, small ovate, thick acute, brown, coma shaped, silky-white, and 2–4 cm long. Flowering occurs in September–October, while fruiting occurs in November–December.



Holostemma ada-kodien – young plant

Distribution

The species occurs in tropical peninsular India, Vindhyas, and southwards in humid areas, in open forests, and ravine edges.

Climate and soil

The plant prefers a tropical humid climate and partially sunny locations. Sandy-loam soil is best for its cultivation.

Propagation material

The plant can be propagated through seeds. Matured seeds are collected from the plant during December–January before they disperse. Seeds are cleaned, dried, and stored for sowing. However, fruit set is generally less than 10% in this crop, which is a major constraint for large-scale cultivation through seeds. The crop can also be propagated by vegetative means through root and stem cuttings.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop is raised in a nursery in February. The seeds are sown on sand beds. Adequate moisture in beds is maintained by light irrigation. Partial shade is provided to the germinating seedlings. The seeds sprout in about 10 days. About one-month-old seedlings are transplanted in polybags of size 14 cm × 10 cm, which are

¹ Agro-technique study carried out by Aromatic and Medicinal Plants Research Station, Kerala Agricultural University, Odakkali, Asamannoor Post, Ernakulam District, Kerala.

filled with soil, sand, and well-decomposed FYM (farmyard manure) in the ratio 1:1:1. Polybags should be kept in shade and irrigated regularly. Seedlings are ready for planting in the field in May–June.

- *Propagule rate and pretreatment* About 1.5 kg of seeds are required to raise a plantation in 1 hectare of land. About 28 000–30 000 seedlings per hectare would be required for planting at a spacing of 60 cm × 60 cm. When intercropped with another species, seedling requirement would reduce by half. The seeds are soaked in water for four to five hours before they are sown in raised beds in nursery.

Planting in the field

- *Land preparation and fertilizer application* The sowing is done at the start of rainy season in May–June in South India. Towards northern areas, it should be sown just after pre-monsoon showers. The land should be loosened properly by ploughing and harrowing. Pits of size 30 cm × 30 cm × 30 cm are dug at a spacing of 60 cm × 60 cm, and are filled with thoroughly mixed surface soil and sand in 1:1 ratio along with FYM @ 2 kg for each plant, and mounds are formed. Seedlings are carefully transferred to the centre of the mounds from the polybags. FYM @ 30 tonnes/hectare is applied at the time of land preparation in case of intercropping.
- *Transplanting and optimum spacing* The seedlings are transplanted in the main field in May–June just at the onset of monsoon, after about 30–45 days of transfer to polybags. An optimum spacing of 60 cm × 60 cm is maintained for the sole crop. This accommodates a crop stand of approximately 28 000 plants per hectare. When intercropped with another species, crop stand would be approximately 14 000.
- *Intercropping system* The plant can be grown as a sole crop as well as an intercrop. Since it is a twiner, it has to be provided with trellises or some live support of tree or shrub. The light requirements of the intercrop must then be taken into consideration before deciding the intercrop species.
- *Interculture and maintenance practices* No inorganic fertilizer may be used for the crop if sufficient FYM is applied as a basal dose



Holostemma ada-kodien –
crop view

(30 tonnes/hectare or 1 kg/plant). The plants need stakes as support in July–August. First weeding operation should also be carried out in July–August. Manual weeding twice at two and four months after planting is necessary to keep the crop weed-free.

- *Irrigation practices* Dudhi bel is grown as a rain-fed crop during the monsoon period. It is irrigated with 5 cm water on alternate days after the cessation of monsoon.
- *Disease and pest control* Spraying of 0.05% quinalphos effectively controls the attack by aphids, which is observed during the rainy season.



Holostemma ada-kodien –
plant with fruit

Harvest management

- *Crop maturity and harvesting* The root parts are used as drug and it takes one to two years for its good development. The crop yield is maximum (400–450 kg/hectare of fresh roots) after about one year of planting. However, the crop quality reaches the peak only after 18 months, although the yield of fresh roots may be reduced to about 250 kg/hectare. Thus, keeping in mind quality considerations, the crop should preferably be harvested when it attains 1.5–2 years of age. Harvesting is done by digging the soil to collect the roots. These roots are then cleaned well.
- *Post-harvest management* The roots are cut into pieces of 10 cm length, dried in shade, and stored in gunny bags before sale within six months, after which the active constituents start degrading.
- *Chemical constituents* The major constituents in the produce are 40%–50% starch, 10%–15% crude protein, 2%–3% crude fat, 15%–25% crude fibre, and 4%–6% ash.
- *Yield and cost of cultivation* The yield of dry roots varies in the range 10–15 tonnes per hectare. The cost of cultivation of crop on 1 hectare of land is approximately Rs 50 000.

Market trend – 2006/07

- Market price: Rs 65 per kg dry roots
- Market demand: 85 tonnes per annum in South India

Inula racemosa Hook. f.

Syn. *Inula helenium* L.

Asteraceae

Ayurvedic name	Puskara
Hindi name	Puskarmool
Trade name	Puskarmool
Parts used	Root and rhizome



Inula racemosa –
a plant

Therapeutic uses

Puskarmool is an aromatic tonic, febrifuge, and expectorant with anti-inflammatory, carminative, diuretic, and antiseptic properties. The plant is used in chronic bronchitis and rheumatism. Dried rhizomes and roots are used to cure loss of appetite and stomach troubles.

Morphological characteristics

The species is a perennial herb up to 1.5 m tall with fragrant prominent root and rootstock. Stems are many in number, ascending from the base of the rootstock. Leaves are leathery, rough above and densely hairy below, 25–50 cm long and 10–12 cm broad, and elliptic–lanceolate in shape.

Floral biology

Flower heads are yellow in colour, have bisexual florets, and occur in terminal racemes. Flowering occurs from January to July, while fruiting



Inula racemosa –
a field view

occurs in October–November. Fruits (achenes) are slender and about 0.5 cm long.

Distribution

The species occurs in temperate areas of Kashmir, Himachal Pradesh, and Uttarakhand in India. It extends up to Iran, Afghanistan, Baluchistan, and Europe, and is cultivated in temperate and sub-alpine regions of India. It is an oriental species in origin and distribution.

Climate and soil

The conditions of temperate and sub-alpine regions are most suited for the cultivation of *Inula* species. Well-drained, clay-loam soils are ideal for the crop. It prefers open and sunny locations.

Propagation material

Propagation can be done both by seeds and rootstocks. However, it is preferable to raise seedlings through seeds. The fruits (achenes) mature in winter and can be collected by the end of cold season (March–April) in high hills.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop can be raised through seeds in nursery in November or early March by broadcasting the seeds in well-prepared nursery beds. Germination is completed in about 50 days. Seedlings are transplanted in the field with a ball of earth after about two months of growth.
- *Propagule rate and pretreatment* About 1 kg seeds are required to raise about 40 000 seedlings required for 1 hectare of land. No specific seed treatment is required before sowing.

¹ Agro-technique study carried out by S K University of Agricultural Sciences and Technology, Division of Floriculture, Medicinal and Aromatic Plants, Shalimar, Srinagar – 191121, Jammu and Kashmir.

Planting in the field

- *Land preparation and fertilizer application* The land should be ploughed lightly in order to loosen the soil and mix organic manure or FYM (farmyard manure). Usually, FYM @ 15 tonnes/hectare is applied at the time of land preparation. If inorganic fertilizers are used, half of nitrogen (100 kg/hectare) and full dose of phosphorus and potassium at the rate of 100 kg/hectare and 50 kg/hectare, respectively, are applied at the time of land preparation.
- *Transplanting and optimum spacing* The germinated seedlings may be transplanted to the main field after about two months. Optimum spacing recommended in the main field is 50 cm × 50 cm. An optimum crop stand of approximately 40 000 plants per hectare is accommodated with the above-mentioned plant density.
- *Intercropping system* Puskarmool is preferred as a sole crop without intercropping.
- *Interculture and maintenance practices* NPK (nitrogen, phosphorus, potassium) @ 200 kg/hectare, 100 kg/hectare, and 50 kg/hectare, respectively, may be used per year to achieve high biomass yield. Nitrogen is usually applied in two split doses, one as a basal dose and the other (100 kg/hectare) as top dressing in six to eight weeks after transplantation. Only manual weeding is recommended twice during the establishment phase of the crop.
- *Irrigation practices* Light irrigation at an interval of three to four weeks is sufficient to maintain the crop.
- *Disease and pest control* No serious incidence of disease or pest has been observed in this crop.



Roots of *Inula racemosa*

Harvest management

- *Crop maturity and harvesting* The crop is harvested after about one-and-a-half years in October–November under temperate conditions of Kashmir. Roots are dug after wetting the soil. The roots are cleaned well and soil particles are removed.



Inula racemosa –
in full bloom

- *Post-harvest management* The harvested crop should be cut or sliced into small pieces, dried, and stored in airtight containers. The rootstock and roots should be separated from the aerial portion, chopped into small pieces, and allowed to dry in shade.
- *Chemical constituents* The rootstock and roots contain inulin, alantolactone, β -sitosterol, isoalantolactone, dihydroalantolactone, and its glucosides. Four sesquiterpene lactones have also been isolated from *Inula* sp.
- *Yield and cost of cultivation* The crop is harvested at one-and-a-half years of growth.

About 80 quintals of dried roots are obtained from 1 hectare cropped area. The estimated cost of cultivation is about Rs 37 800 per hectare.

Market trend – 2006/07

Market demand: 3 tonnes per annum

Leptadenia reticulata Retz.

Asclepiadaceae

Ayurvedic name	Jeevanti
Unani name	Jeevanti
Hindi name	Jeevani
Trade name	Jeevanti
Parts used	Leaves, stem, and roots



Leptadenia reticulata –
jeevanti

Therapeutic uses

Leaves and roots of *Leptadenia* species are useful in treating skin infections and wounds. Their major use is to prevent prolapse of uterus and vulva in controlling habitual abortion in women. The roots are used in cardiac disease and haemorrhage, as diuretic, and to cure fever and opthalmia. They are also used as a tonic for general debility to strengthen the body. Leaves are also used as galactagogue for nursing mothers.

Morphological characteristics

The species is a much branched laticiferous twining shrub with yellowish brown, deeply cracked bark. Leaves are ovate, cordate, coriaceous, glabrous above and more or less finely pubescent beneath.

Floral characteristics

Inflorescence is a many flowered cyme with greenish yellow flowers. Fruit (follicle) is horned shaped and slender. Seeds are lanceolate and comose.



Leptadenia reticulata –
single plant

Flowering occurs in May and June, while fruiting begins in October and continues up to November.

Distribution

Jeevanti is found in the sub-Himalayan tracts of Punjab, Himachal Pradesh, Uttar Pradesh, and Deccan Peninsula up to an altitude of 900 m.

Climate and soil

The plant grows well in warm tropical and subtropical regions with moderate rainfall. Sandy-loam and alluvial black soils are found to be good for commercial cultivation. However, the crop can also be grown satisfactorily on red laterite soils. It responds very well to mild weather conditions and requires open sunlight.

Varieties

At present, no certified varieties of jeevanti are available. However, in nature, two morphological variants are available, namely, narrow-leaved and broad-leaved variants. Generally, the broad-leaved types are preferred for cultivation.

Propagation material

Rooted semi-wooded stem cuttings from six-month-old to one-year-old plants having three to four nodes at pre-flowering stage are generally used for planting. Seeds may also be collected in November for raising the plants.

Agro-technique¹

Nursery technique

- *Raising propagules* The planting stock can be raised primarily in a nursery. The period February–March is suitable for planting the

¹ Agro-technique study carried out by

- Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra Campus, Bangalore – 560 065
- Dhanvanthari Vana, Department of Forestry, Government of Karnataka, Bangalore University, Bangalore
- State Department of Horticulture, Hulimavu, Biotechnology Centre, Banneraghatta Road, Bangalore

cuttings in the nursery. The cuttings should be collected before flowering occurs. Cuttings (12–15 cm long, with three to four nodes) are treated with 200 PPM (parts per million) TRF (triademophon) or 25 PPM PBZ (paclobutrazol) or 300 PPM IBA (indole-3-butyric acid) or NAA (naphtha-leneacetic acid) for obtaining good rooting and for better field establishment of the rooted cuttings. They can be planted directly in the polybags or in the seed pans/root trainers filled with the potting mixture of sand, FYM (farmyard manure), and red earth in the ratio 1:1:1. Rooted cuttings from the seed pans/root trainers are transferred into the polybags after 45 days. Three-month-old rooted cuttings are transplanted in the centre of the prepared pit in the main field, with the ball of soil of saplings intact. Fields or pits should be irrigated immediately after transplantation.

- *Propagule rate* At a spacing of 2 m × 1 m, about 5000 plantlets shall be required for planting in 1 hectare of land.

Planting in the field

- *Land preparation and fertilizer application* The land is prepared by ploughing three to four times with disc plough, and the soil is brought to a fine tilth. The land is divided into plots of convenient size. The main and sub-irrigation channels are laid out. Pits of 45 cm × 45 cm × 45 cm size are dug at a spacing of 2 m × 1 m and should be filled with topsoil and well decomposed FYM in the ratio 1:1. FYM at the rate of 20 tonnes/hectare and NPK (nitrogen, phosphorus, potassium) at the rate of 80:160:160 g/plant are used as a basal dose in first year. Full dose of FYM should be applied to the soil while preparing the land.
- *Intercropping system* It is a partial-shade-loving species, and being a profuge twiner, it needs a host or stalks. It should be preferably intercropped at the base of the trees and shrubs or along hedges, when planted on a smaller scale.
- *Transplanting and optimum spacing* Rooted cuttings are planted in the centre of the pits of size 45 cm³ at a spacing of 2 m × 1 m and filled with topsoil and well-decomposed FYM. A population of 5000 plants/hectare is recommended for maximum yield.



Field view of
Leptadenia reticulata

- *Interculture and maintenance practices* Staking is done 20 days after planting along with gap filling. Application of 2 tonnes FYM per hectare and NPK in the ratio 100:200:200 per plant in subsequent years is recommended. After two months of planting, full dose of phosphorus and potassium and 50% nitrogen should be applied in a band all around the plant by opening furrows. The remaining 50% nitrogen should be top dressed during June. Top dressing should immediately be followed by earthing up and irrigation.
- *Irrigation practices* The crop is given furrow irrigation twice a week for about two to three months after planting in the field. Later, the irrigation may be done at an interval of 8–15 days, depending on the climate and soil conditions. Drip irrigation can also be adopted.
- *Weed control* Manual weeding in basins at an interval of one to two months is the best method to control weeds.
- *Disease and pest control* Powdery mildew is a serious problem during the winter months. Control measures involve spraying wettable sulphur (sulfex) at the rate of 3%, at weekly interval for three to four times. During the rainy season, wilting is occasionally noticed and can be controlled by taking phytosanitary measures and drenching the affected vines with carbendiazim (0.15%). Aphid and mite infestations are noticed at various stages of crop growth and can be controlled by prophylactic sprays of monocrotophos (0.15%) and dicofal (0.2%), respectively.

Harvest management

- *Crop maturity and harvesting* The crop remains in the field for 10–15 years. Best time for harvesting is once in six months at 50% flowering, without taking out whole roots that serve as future planting material/ rootstock in the same field.
- *Post-harvest management* The roots and leaves are shade-dried, keeping the moisture content up to 10%, and later packed in gunny bags and stored in dry and cool place.
- *Chemical constituents* A fructosan of insulin type has been reported from the roots of the plant.
- *Estimated yield* A yield of 6–7 tonnes dry weight of roots per hectare per year may be obtained. Total cost of cultivation is Rs 62 500 per hectare.

Market trend – 2006/07

- Market price: Rs 65 per kg dry roots
- Market demand: 23 tonnes per annum

***Marsdenia tenacissima* (Roxb.) Moon**

Syn. *Asclepias tenacissima* Roxb.

Asclepiadaceae

Ayurvedic name	Murva
Hindi name	Murva, Chinhaur
Trade name	Murva
Part used	Roots



Marsdenia tenacissima

Therapeutic uses

Roots of murva are purgative, alterative, and given in colic and gonorrhoea.

Morphological characteristics

Marsdenia tenacissima is a perennial climber with grey bark. Leaves are 7–15 cm long and 7–10 cm wide, broadly ovate, acuminate, deeply cordate at the base with rounded lobes; both surfaces are densely velvety tomentose when young, but become almost glabrous above when old. Petioles are pubescent and about 5–10 cm long.

Floral characteristics

Flowers of murva are greenish yellow, arranged in much branched, corymbose cymes. Calyx is deeply divided; lobes 3–4 cm in diameter, hairy outside. Corolla lobes are acute. Fruit is a follicle, about 10–15 cm long, paired, ovoid, lanceolate, and longitudinally wrinkled. Seeds are about



Marsdenia tenacissima –
a plant

1–2 cm long, flattened, and ovate–oblong in shape. Flowering occurs in March and April, while fruits mature in May and June. The seeds are dispersed very frequently by splitting of fruits.

Distribution

The species is occasionally found in tropical hilly tracts of peninsular India and Vindhyan ranges as well as lower Himalayan tracts.

Climate and soil

Tropical and subtropical dry and moist deciduous forests having annual rainfall between 1000 mm and 1500 mm are the natural habitat of *Marsdenia*. It grows in moist places in nature

and is a shade-loving plant. Sandy-loam soil is suitable for its cultivation and it can grow in nutritionally poor soils.

Propagation material

Both seed and vegetative cuttings are suitable for raising commercial-scale planting material. However, vegetative propagation method is more cost-effective, as the rooted cuttings show better survival, growth, and yield. Vegetative propagation through leafy stem cuttings is, therefore, recommended.

Agro-technique¹

Nursery technique

- *Raising propagules* The best time for raising the crop is May–June. For propagation through vegetative means, fresh and healthy leafy cuttings, having two to three nodes with axillary buds, are treated with 1000 PPM (parts per million) solution of IBA (indole-3-butyric acid), by quick dip method (60 seconds). Treated cuttings are planted at 10 cm × 10 cm spacing in nursery or mist chambers to hasten rooting. Rooted cuttings are ready for planting in the field after 45–60 days, that is, in July–August. Freshly collected, air-dried seeds should be sown in polybags or a mist chamber after scarification for raising the

¹ Agro-technique study carried out by State Forest Research Institute, Polipathar, Jabalpur, Madhya Pradesh – 482 008.

seedlings. Scarified seeds take about seven days for germination. The potting mixture for sowing seeds or transplanting cuttings should contain sand, soil, and FYM (farmyard manure) in equal quantities.

- *Propagule rate and pretreatment* About 100 g of seeds are required for a nursery bed of size 10 m × 1 m, which is sufficient to raise seedlings for 1 hectare. Freshly collected seeds should always be used for sowing. About 30 000 plantlets would be required for 1 hectare if rooted cuttings are used.

Planting in the field

- *Land preparation and fertilizer application* Land preparation must be done before rains. Land should be free from weeds, well ploughed, well drained, and have a fine tilth. This species does not tolerate water stagnation, hence, proper drainage and porosity are very important factors for raising this species. FYM @ 5 tonnes/hectare should be added at the time of field preparation and thoroughly mixed in the soil.
- *Transplanting and optimum spacing* Seedling/rooted cuttings are transplanted at a spacing of 60 cm × 60 cm, with an optimum crop stand of approximately 28 000 plants per hectare.
- *Intercropping system* Murva requires host plant/stalk, hence, intercropping beneath trees with partial shade is most suitable. Intercropping with trees in orchards can be tried in this species. However, studies are not available regarding the effect of intercropping on yield of murva or the support crop.
- *Interculture and maintenance practices* FYM @ 5–7 tonnes hectare is applied as basal dose at the time of field preparation. No further application of FYM is required. The FYM should be properly mixed in soil before planting takes place. First weeding is done after 15 days of plantation. Regular weeding at monthly intervals is required.
- *Irrigation practices* The plant needs humid soil for better growth, hence, appropriate irrigation should be done as and when required to maintain soil humidity, but care should be taken that there is no waterlogging. After the rainy season is over, the crop could be irrigated twice a week in October and November. Thereafter, in the ensuing dry season, irrigation may be required three to five times a week.



Marsdenia tenacissima
– a plant in nursery



Marsdenia tenacissima –
rooting from leaf petiole

- *Disease and pest control* No serious pests and diseases are noticed in this crop.

Harvest management

- *Crop maturity and harvesting* The crop matures in six to eight months after plantation. March–April is the best period for harvesting the crop. The root may be dug out, washed thoroughly, and kept for air drying in shade. Completely air-dried roots are stored in airtight containers.
- *Chemical constituents* Roots and seeds are reported to be rich in pregnane glycosides of 2-deoxysugars, which on hydrolysis give genins, sugars, cinnamic, and acetic acid.
- *Yield and cost of cultivation* The estimated yield of dried roots is about 528 kg/hectare. The estimated cost of cultivation is approximately Rs 85 000/hectare.

Market trend – 2006/07

- Market demand: Above 6 tonnes/year

***Microstylis wallichii* Linn.**

Syn. *Malaxis acuminata*

Orchidaceae

Ayurvedic name	Jeevak, Rishbhak
Hindi name	Jeevak
Parts used	Pseudobulbs and tubers



Microstylis wallichii –
growing plant

Therapeutic uses

The *Microstylis* plant is rejuvenating tonic, styptic aphrodisiac, and antioxidant. It has a cooling action and cures bleeding diathesis, fever, phthisis, and burning sensation. It is an important ingredient of *Ashtawarga*, under *Jivaniya Varga* of *Charaka Samhita*, which literally means 'life-giver'.

Morphological characteristics

Jeevak is an erect, tuberous, small, terrestrial orchid, about 20–25 cm high. The stem tends to be pseudo-bulbous at the base. New plants arise from the rootstock and the mother plant decays as the daughter plants grow. Leaves are simple, three or five in number, and sheathing at the base.

Floral characteristics

Flowers are minute, pale yellowish-green in colour, tinged with purple,



Microstylis wallichii –
flowers

and borne in terminal racemes. Flowers bloom in mid-May and the plant remains in full bloom till October. Fruiting is completed in October–November, after which it enters into dormant stage.

Distribution

The species is found in temperate to sub-alpine ranges of the Himalayas, between 1800 m and 2300 m altitude. Its distribution is scarce and restricted. It is a shade-loving species and needs rich humus and soil moisture.

Climate and soil

Microstylis wallichii thrives well in moist, shady places covered with thick leaf litter deposits in dense oak–deodar forest zone. It preferably grows on the cool northern and

western hill slopes. Sometimes, this species is also found in depressions and gorges in hills such as shola forest type habitat. It grows in loose sandy loam soil, rich in humus, chiefly on upper stratum of organic layer, in the wet localities. The requirement of mean annual rainfall ranges between 1000 mm and 1500 mm, and the optimal mean annual temperature range is 10–15 °C.

Propagation material

Orchids are characterized by very small seeds that are not fit for propagation. Only vegetative parts, whether pseudobulbs, daughter plants, nodal segments of rhizomes or tubers, are feasible as propagation material. Studies conducted on this species suggest that seeds show poor germination and produce seedlings of low vigour. Also, the fruiting pods are very small and most of the seeds are dispersed before collection. Seed viability studies are also not available. Each pseudobulb has four to five nodal segments. These pseudobulbs are collected in the first half of November. Mature bulbs may be collected from the wild sources in the rainy season.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop is raised by planting whole, half or segmented pseudobulbs directly in main field in the first fortnight of May. The soil is treated with fungicide or solarized to check the fungal attack.
- *Propagule rate and pretreatment* About 250 000 nodal segments or 125 000 bulbs are required for planting as a sole crop in 1 hectare of land at a spacing of 20 cm × 20 cm. Nodal segments or pseudobulbs may be treated with fungicide to prevent decay. When it is intercropped with crops like colocasia, turmeric, ginger, and so on, about half the bulbs or nodal segments may be required as per the spacing because of alternating pattern of cropping.

Planting in the field

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



Microstylis wallichii
– pseudobulbs

¹ Agro-technique study carried out by Non-Wood Forest Products Division, Forest Research Institute (ICFRE), P O New forest, Dehra Dun, Uttarakhand.

- *Interculture and maintenance practices* Mycorrhizal association is necessary for increasing nutrient uptake efficiency in this orchid. Application of FYM and leaf mould @ 40–50 tonnes per hectare is optimum for the crop growth. The organic manure is applied in two doses. Frequent weeding is required in the rainy season. Mulching of the beds with leaf litter ensures control of weed growth, checks soil erosion, and helps to conserve moisture during the dry period.



Microstylis wallichii –
plant in nursery bed

- *Irrigation practices* This species is planted just before the onset of the rain, so irrigation is needed immediately. However, if rains do not commence within a week of planting, repeat irrigation becomes necessary to save the sprouting bulbs. Frequent watering is required in the early stages of the cropping. Thereafter, sprinkler irrigation may be done twice a week.
- *Disease and pest control* Attack of white grub or June beetle, a subterranean pest, is occasionally noticed on the bulbs. Application of phorate @ 10 g/litre as a basal treatment at the time of planting can check the white grub attack. Manual picking or solarization of soil also helps in countering the grub. No fungal attack has been reported in the field. Moist bulbs are susceptible to attack of rot fungus during storage. Beds under open conditions show leaves tinged yellow, which is not the case in beds in shade.

Harvest management

- *Crop maturity and harvesting* The crop matures in five months and the tubers are ready to be harvested when dormancy sets in during the last week of October or first week of November. Bulbs are dug carefully after watering. The injured bulbs cannot be stored and are prone to decay.
- *Post-harvest management* Storage of harvested tubers is done by burying them in sand/soil. Pseudobulbs can also be stored in pots or brick chambers filled with sand or inside the pits made on the sloping walls of terraces. Storage in sand and inside sloping pits gives 100% protection for future plantation, but there are chances of damage due to rodent attack and accumulation of water inside the pits. The produce is cleaned, dried in shade, and stored in cool dry place for marketing.
- *Chemical constituents* Biochemical studies of pseudobulbs have shown major constituents as carbohydrates (23%–28%), proteins (30–42 mg/g),

total sugars (29–32 mg/g), and phenols (1.2–2.1 mg/g). Collections from wild sources are generally more rich in these constituents than the cultivated produce. Phenolic content is marginally higher in the cultivated crop.

- *Yield and cost of cultivation* Average yield of dried tubers varies from 600 kg per hectare to 750 kg per hectare. An annual expenditure of nearly Rs 110 000 is incurred on cultivating the crop on 1 hectare of land.

Market trend – 2006/07

- Market price: Rs 160–180 per kg dried tubers

Nardostachys grandiflora DC

Syn. *Nardostachys jatamansi* DC

Valerianaceae

Ayurvedic name	Jatamansi
Unani name	Sumbul-ut-teeb
Hindi name	Jatamansi
Trade name	Jatamansi, Spikenard
Parts used	Rhizomes and roots



Nardostachys grandiflora –
a plant

Therapeutic uses

Jatamansi is a nervine tonic, hypotensive, antiseptic, stomachic, carminative, tranquilizer, sedative, anti-bacterial, antispasmodic, and stimulant. It is useful in the treatment of insomnia, hysteria, convulsions, vertigo, and is also used as a cardiac tonic.

Morphological characteristics

Nardostachys species is an erect, hairy, perennial rooted herb, 10–60 cm high, with stout woody main root. Rootstock is thick, long, covered with remnants of petioles of withered leaves. Stems are generally pubescent upward, and glabrate below. Leaves are radical as well as cauline. Radical leaves are large (15–22 cm × 1.5–2.5 cm), six to eight in numbers, longitudinally nerved, slightly pubescent, and narrow down into the petiole, while cauline leaves are sessile, occur in two to three pairs, 2.0 cm × 0.6 cm in size, decrease in size from base to top, and are oblong or sub-ovate



Nardostachys grandiflora—
closer view

in shape. Rhizome is dark brown, tapering, and densely covered with the remains of old leaves' bases, giving the appearance of a heavy beard, and hence the name *jatamansi*. The fibrous rhizome may be 6–9 cm long with about 20–30-cm-long yellowish taproot. A single root may bear 30–50 rhizomes.

Floral characteristics

Flowering shoot is 30–40 cm high and bears 40–50 flowers at summit in three to seven condensed cymes. Flowers are campanulate, pinkish red to bluish white. Corolla tube is 6 mm long and hairy. Fruit is covered

with 4-mm-long hairs and crowned by the acute, often dentate, calyx teeth. Flowering occurs from June to August, according to elevation, while fruiting occurs from September to October. Seeds are collected in October when they turn pale brown in colour.

Distribution

The species occurs in montane and sub-alpine zones of the Himalayas, from Kumaon to Sikkim, Nepal, and Bhutan, from 3000 m to 5000 m altitude in steep open areas. It is more frequent on the western aspects in alpiners, on moist rocky and undisturbed slopes or on stones with coarse sandy loam soils, occurring usually in random forms.

Climate and soil

The plant generally grows in steep hills with 40°–70° inclined slopes and is more frequent on open, stony, and grassy slopes. It is more abundant in the western cooler slopes. Usually it occurs on primary litter and soil deposits as pioneer species. For the cultivation of *Nardostachys jatamansi*, loamy porous soil rich in organic matter like humus is considered the best. Thick humus layer promotes rapid growth and profuse branching.

Propagation material

Seeds are the best propagation material, although vegetative propagation may be undertaken to get a crop within two to three years, if sufficient mother plants are available. However, initially the planting stock has to be raised through seeds only. Seeds have 80% germination rate when sown in a mixture of soil, sand, and FYM (farmyard manure)/compost in equal quantities in styrofoam trays.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop can be grown by raising a nursery in May, from seeds or vegetative rhizomes separated from the mother plants. Seeds may be sown manually in small plots of 1 m × 1 m size or in styrofoam trays in the polyhouse. Seed germination varies between 74% and 80%, and occurs within 12–30 days when planted at a depth of 0.5 cm in sandy soil inside the polyhouse.
- *Propagule rate and pretreatment* Approximately 600 g of seeds are required for raising seedlings for transplanting in 1 hectare of land. Both seeds and rhizomes are treated with GA₃ (gibberellic acid; 100 PPM[parts per million]) and 200 PPM) for 48 hours for rapid germination/sprouting.



Nardostachys grandiflora –
crop view

Planting in the field

- *Land preparation and fertilizer application* For cultivation, land is prepared by digging or ploughing well, prior to summer season. Soil is tilled thoroughly and beds are left open for a week for solarization. After the land preparation, forest leaf litter/compost/FYM is added to the beds before seedlings or vegetative rhizomes are transplanted.

¹ Agrotechniques study carried out by High Altitude Plant Physiology Research Centre, HNB Garhwal University, Srinagar, Garhwal, Uttarakhand

Raised beds are found suitable for good biomass production at high altitudes. A minimum of about 40 quintals FYM/forest leaf litter as basal dose is required for the better growth of plants and good biomass production. Only well-decomposed FYM may be used if sufficient forest leaf litter is not available.

- **Transplanting and optimum spacing** The seedlings may be transplanted to the main field about 50–60 days after germination at a spacing of 20 cm × 20 cm or 20 cm × 30 cm. Manuring should be done about 15 days before the commencement of transplantation work. After manuring, hoeing and earthing-up may be carried out. In all, 0.2–0.25 million saplings are needed per hectare. There is considerable mortality during plantation and early growth (20%–30%).

So additional nursery plants may be kept ready for filling gaps in the second year.

- **Intercropping system** The plant is grown as a mono crop, and intercropping practices have not been found suitable due to harvesting of roots and rhizomes; hence, intercropping is not recommended.

- **Interculture operations and maintenance practices** Manure or forest litter (60–80 quintals) is recommended for 1 hectare of land. Fifty per cent manure is used during the first year and rest is applied in two divided doses during the second and third years.

- **Irrigation practices** Initially, watering should be done on alternate days at lower altitudes (2000 m) till proper rooting is developed. Later, watering is done at weekly intervals during dry season. Constant humidity should be maintained in the soil avoiding waterlogging.
- **Weed control** Manual weeding is carried out (fortnightly) during early growth season, and later at monthly intervals or as and when required to keep the crop weed-free.
- **Disease and pest control** No diseases, insects, nematodes or physiological disorders have been observed in this crop.

Harvest management

- **Crop maturity and harvesting** Maturity period of the plant depends on the propagules used. Plants raised through seeds may take three to four years to mature, while the plants raised through splitting of



Nardostachys grandiflora –
tender growth stages

rhizomes mature in two to three years and are ready for harvesting earlier. To obtain good active chemical ingredients, plants must be collected after senescence in October.

- *Post-harvest management* After harvesting in October, the roots should be washed and well dried in shade to reduce their moisture content to 8%–10%. Dried material should be filled in jute bags or wooden boxes, which can be stored in dry godowns. During storage, hairs on root separate due to rubbing, and are often used as *dhoop*.
- *Chemical constituents* The dried rhizomes are steam-distilled to yield 1.5%–1.9% of a pale yellow essential oil, commercially known as spikenard oil, emitting a pleasant odour.
- *Yield and cost of cultivation* At the experimental site at an elevation of 3600 m, the recorded yield was 835 kg/hectare dry roots; plantation was raised through seedlings. At lower altitudes (2200 m), the recorded yield was 670 kg/hectare dry weight after third year of cultivation; plantation was raised through seedlings. The yield may increase in subsequent years if the plant is not harvested for one more year. Input cost is estimated to be Rs 202 000 hectare for three years at lower altitudes.

Market trend – 2006/07

- Market price: Rs 170 per kg
- Market demand: 600 tonnes

***Operculina turpethum* (Linn.) Silva-Manso**

Syn. *Ipomoea turpethum* R. Bv.

Convolvulaceae

Ayurvedic name	Trivrit
Unani name	Turbud
Hindi name	Nishoth
Trade name	Turpeeth, Nishoth
Parts used	Root bark, root, and stem



Operculina turpethum in field

Therapeutic uses

O*perculina turpethum* is a source of a drug known as turpeth or Indian jalap. Root and root bark are cathartic and laxative. The tuberous roots are also efficacious in dropsy, melancholia, gout, leprosy, rheumatism, and paralysis.

Morphological characteristics

Nishothra is a perennial climber with latex. Root is long, slender, fleshy, and much branched. Stems are very long, fast growing, twining and much twisted, angled, and winged. Leaves are 5–10 cm × 1.3–7 cm in size, ovate or oblong, more or less pubescent on both sides, especially when young, minutely reticulate veined.

Floral characteristics

Inflorescence is a cyme with few flowers. Peduncles are stout, 2.5–5 cm long. The two bracts are large, caducous, and often pinkish. In flower, the outer



Operculina turpethum flowers

sepals are up to 2.2 cm long, accrescent, much angled in fruit, broadly ovate, mucronate, concave, and pubescent; the three inner sepals are smaller, barely 2 cm long, very thinly membranous, and glabrous. Corolla is white, 3.8–5 cm long, and campanulate. Capsules are about 1.6 cm in diameter, globose, enclosed in the enlarged, brittle sepals. Flowering and fruiting occur twice a year from September to November and then from March to May.

Distribution

The plant is found throughout tropical dry and moist deciduous regions in central and peninsular India.

Climate and soil

Sandy loam to clay loam soil in moist tropical regions is suitable for the cultivation of this species. It prefers shady and moist places.

Propagation material

The plants can be raised by vegetative propagation as well as from seeds. Stem cuttings having two nodes may either be planted directly in the field in monsoon (July) or may be rooted first in a mist chamber during March–June. April–May is the best season for seed collection when fruits mature.

Varieties

No certified varieties are available, but there are three morphological variants, white, black, and red nishoth. White nishoth is considered to be the best for medicinal purposes.

Agro-technique¹

Nursery technique

- *Raising propagules* Best method for raising the plants is to use vegetative cuttings of length 10 cm, which should have two nodes. These

¹ Agro-technique study carried out by State Forest Research Institute, Polipathar, Jabalpur – 482 008, Madhya Pradesh.

cuttings may be planted in polybags or directly in mist chamber for rooting. The potting mixture should contain sand, soil, and FYM (farmyard manure) in equal quantities. Best time for raising poly pot plants is March–June in mist chambers. Vegetative cuttings may directly be planted in the field in July. Planting stock can also be raised through seeds, which may be sown in polybags during April–May immediately after collection. Scarified seed germinates after seven days of sowing in the nursery.

- *Propagule rate and pretreatment* About 2 kg seeds are required for raising planting stock for 1 hectare plantation. Soaking of seeds in water for 24 hours followed by mechanical scarification by rubbing seed coat with sand paper gives 95% germination.

Planting in the field

- *Land preparation and fertilizer application* Land should be ploughed well followed by harrowing twice and planking for good aeration and drainage, since this species is susceptible to waterlogging. About 2 tonnes of FYM per hectare is mixed in the soil during field preparation in June.
- *Transplanting and optimum spacing* Rooted cuttings or seedlings are transplanted in the well-prepared field at a spacing of 30 cm × 30 cm. Thus, the optimum crop stand per hectare is 110 000. Planting is done on ridges to avoid mortality due to waterlogging.
- *Intercropping system* Since the species is a shade-loving twiner and needs host for support, it can be planted as an under-crop in tree plantations or near hedges and shrubs.
- *Interculture and maintenance practices* As already stated, about 2 tonnes of FYM per hectare is mixed in soil during field preparation in June before the onset of rains. No further application of any manure is required. Regular manual weeding is recommended after planting and after every 15-day interval.
- *Irrigation practices* During rainy season, irrigation is seldom required, but in dry spells, flood irrigation at an interval of five to seven days is given till December–January.



Operculina turpethum



Operculina turpethum
after two years of
plantation

Harvest management

- *Crop maturity and harvesting* Crop duration is 10–12 months. Best time for harvesting the roots, stem, and leaves is March–April when the plants begin to dry.
- *Post-harvest management* Freshly collected roots should be washed thoroughly with fresh water and dried initially in sun for two to three days, followed by drying in shade for the next 10 days till the moisture content reduces to 8%.
- *Chemical constituents* Turpeth contains 9%–13% resin, which is a mixture of α and β -turpethin, glycosides, and turpethin, besides coumarin, scopoletin, and sugars.
- *Yield and cost of cultivation* Root yield is about 1500 kg/hectare after 10 months. Stems serve as a source of future propagules. Cost of inputs for initial crop is Rs 50 000/hectare and it is Rs 25 000/hectare in following years, as the planting material is obtained from the previous crop.

Market trend – 2006/07

Market demand: About 5 tonnes per year

Oroxylum indicum Vent.

Bignoniaceae

Ayurvedic name	Shyonak
Unani name	Sonapatha
Hindi name	Sonapatha
Trade name	Sonapatha
Parts used	Root bark, stem bark, fruits, seeds, and leaves. Root bark is recommended for medicinal use, but market samples generally contain stem bark.



Oroxylum indicum

Therapeutic uses

Root bark of sonapatha is an astringent, tonic, anti-diarrhoeal, diuretic, anodyne, and is used to cure dropsy. It is an ingredient of 'dashamoolarishta' of Ayurvedic medicine. Stem bark is anti-rheumatic. An infusion of bark powder is diaphoretic. Tender fruits have spasmolytic, carminative, and stomachic properties, while seeds are purgative.

Morphological characteristics

Oroxylum indicum is a medium-sized, soft-wooded tree attaining a height of 10–16 m. Stem bark is dull brown in colour; leaves are broad, 60–120 cm in length and pinnately compound. Leaflets are ovate, wavy, and acuminate. Leaf fall occurs during winter season (January) each year. The tree is recognized by ternately bipinnate leaves.

Floral characteristics

Inflorescence is generally situated at the apices of branches and its length is about 30 cm or more. Flowers are large, fleshy, violet coloured, and foul smelling with 2.5-cm-long pedicle. Calyx and corolla are about 2.5 cm and 6.5 cm in size, respectively. Stamens are slightly exerted and base of filaments is wooly. Fruit is a follicle, 30–90 cm long and 5–10 cm broad, strap/sword shaped, compressed, and two-valved. Seeds are flattened and winged. Flowering occurs from July to August, while fruiting occurs from December to March.



Oroxylum indicum
– plant

Distribution

The species is found throughout the tropical forests of India, that is, north-eastern, central, and southern India. It is more frequent in Vindhya and southwards in mix-deciduous forests, ascending to 1000 m altitude and naturally found in forests near rivers and streams. The species is generally absent in dry climate of western India.

Climate and soil

The plant prefers tropical areas that receive well-distributed rainfall, that is, between 85 cm and 130 cm per annum. Sandy-loam fertile soil is best suited for good growth and development of the species; but it can also grow well in medium to deep black soils to sandy loam soils.

Propagation material

Seed is the best propagation material and should be collected before splitting of pods during February–March. Seed germination percentage is 80%–90% without any pretreatment.

Agro-technique¹

Nursery technique

- *Raising propagules* Before field preparation, a nursery of the plants is raised in polythene bags during second half of March for seedling establishment. The polybags should be filled with sandy-loam soil with

¹ Agro-technique study carried out by the Department of Plant Physiology, JN Krishi Vishwa Vidyalaya, Jabalpur – 482 004, Madhya Pradesh.

good quality, well-decomposed FYM (farmyard manure) added to it in the ratio 2:1. After emergence of the seedlings, the plants are watered regularly to maintain optimum moisture level.

- *Propagule rate and pretreatment* In all, 250 g of seeds are sufficient to raise stock for plantation on 1 hectare of land. The seeds should be soaked in water for at least 12 hours before sowing to ensure good germination.

Planting in the field

- *Land preparation and fertilizer application* The land is tilled to make it porous, friable, and weed-free. Pits of appropriate size, preferably 60 cm × 60 cm × 60 cm, are dug in a square planting geometry (2 m × 2 m). Approximately, 10 kg FYM, 150 g of nitrogen, and 250 g of single super phosphate are mixed in the topsoil, and the pit is loosely filled back before planting.
- *Transplanting and optimum spacing* Transplanting in the main field is done in the first week of July (with the onset of monsoon in central India). A spacing of 2 m × 2 m is considered appropriate. An optimum crop stand of 2500 plants/hectare is achieved with this spacing. Gap filling is done in September.
- *Intercropping system* The plant can be grown as a sole crop as well as in a mixed cropping pattern. Short-term seasonal herbs can be grown in the inter-spaces after first year of growth.
- *Interculture and maintenance practices* About 20 kg of well-decomposed FYM, 150 g of nitrogen, and 250 g of super phosphate are required per plant in three split doses at intervals of six months for two years after transplanting. Potash is required only in potassium-deficient soils. Normally, two weeding alongwith hoeing are considered sufficient. However, the pit area around the plants may be given more frequent manual weeding, if required.
- *Irrigation practices* In the first year, irrigation should be done at least six to eight times but more frequent irrigation during the summer months (at an interval of 7–10 days) is desirable for maximum productivity. The check basin method is found best for irrigation.



Oroxyllum indicum
– young plant



Oroxylum indicum
– seed

- **Disease and pest control** No diseases and nematode attacks have been reported. However, leaf-eating caterpillars like Bihar hairy caterpillar (*Diacrisia obliqua*) and grasshoppers damage leaves during rainy season. Besides, termite attack causes serious damage to root bark in crops grown on drier lands. These insects can be controlled by applying Endosulphan 30 EC spray @ 0.03% in water solution twice at 15-day interval as soon as the termites attack the plants.

Harvest management

- **Crop maturity and harvesting** The tree starts flowering and fruiting after three years, and forms viable seeds even in first fruiting. It takes about three to five months for fruits to attain maturity. The plants are uprooted for harvesting of root bark only after six to eight years, October–December.
- **Post-harvest management** A pit is dug around the tree and filled with water to facilitate uprooting. After uprooting, the roots are thoroughly cleaned. Thereafter, the bark is peeled off and the root is cut into small pieces, which are shade-dried to reduce their moisture level to less than 12%. The dried material is stored in moisture-proof bags.
- **Chemical constituents** The root bark contains chrysin, baicalein, dehydrobaicalein, and orozylin. Stem bark possesses flavonoids such as oroxylin, baicalein, scutellarin and 7-rutinoside, chrysin, and p-coumaric acid. Heartwood yields β -sitosterol and isoflavone-prunetin.
- **Yield and cost of cultivation** A six-year-old tree yields only 1 kg of dried root bark. Therefore, the estimated yield of root bark is about 4.0 quintals/hectare per year from sixth year onwards. An expenditure of about Rs 45 000 is incurred for cultivating crop on 1 hectare of land for a duration of six years.

Market trend – 2006/07

- Market price: Rs 20–30 per kg (per year stem bark)
- Market demand: Above 600 tonnes per year

***Picrorhiza kurroa* Royle ex Benth.**

Scrophulariaceae

Ayurvedic name	Katuka
Unani name	Kutki
Hindi name	Kutki
Trade name	Kutki
Parts used	Root and Rhizome



Picrorhiza kurroa

Therapeutic uses

Kutki is an anti-pyretic, anthelmintic, carminative, stomachic, hepatoprotector, anti-malarial, and laxative in small doses but cathartic in large doses. It improves appetite and stimulates gastric secretions. It is useful for asthma, cold, and cough, and also administered in liver complaints, anaemia, and jaundice. The plant is used as a substitute or adulterant of *Gentiana kurroa*.

Morphological characteristics

The *Picrorhiza* species is a small perennial herb. Stem is small, weak, creeping, erect at flowering, leafy, and slightly hairy. Roots are about 5–10 cm long. Rhizomes are jointed and zigzag, greyish-brown, cylindrical, irregularly curved with branching and rooting at the jointed nodes. Leaves are 5–10 cm long, almost radical, sharply serrate, turning black on drying.

Floral characteristics

Flowers are very small, white or pale blue purple, in dense terminal spikes. Bracts are oblong or lanceolate, equalling the calyx. Sepals are lanceolate. Corolla units are five in number and have a cleft in the middle. Fruit is a two-celled spherical capsule. Seeds are many, white, with an oblong curved raphae. Flowering and fruiting occur from June to August.

Distribution

The species occurs in alpine Himalayas, from Kashmir to Sikkim, between 3000 m and 4500 m altitudes. It is not a very common species, but is found near springs on moist rocks, from timberline to alpinics. It prefers moist, relatively less exposed, north-west facing slopes. Narrow leaf variety is generally

found in alpine region near springs, rocky ravines, steep slopes, and on boulders; broad leaf variety is found at relatively lower altitudes (timberline/sub-alpine regions) under scrubs having moist conditions and high humus content.



Picrorhiza kurroa
– field view

Climate and soil

The plant grows well in cool and moist climate. Sandy clay textured soil is the best for its growth. It

needs porous soil layers, which facilitate horizontal spreading of the rhizomes underneath, that produce aerial sprouts from the nodes. The plant prefers sufficiently moist and shaded locations. *Picrorhiza kurroa* is a long-duration high-altitude plant and cannot be successfully propagated under montane conditions. It suffers heavy mortality during prolonged and intense rains.

Propagation material

The planting stock can initially be raised through seedlings, but can also be propagated through rhizomes/stolons/offsets. Seeds may be collected in August–September for raising nursery. Viability of seeds is more than 60% for a period of about six months.

Agro-technique¹

Nursery technique

- *Raising propagules* The nursery beds are planted using rhizomes/stolons/offsets in October–November. The planting stock may be raised in polybags, styrofoam trays or mother beds. However, sunken beds should be prepared in the nursery to conserve moisture during the period of water scarcity. Each offset or fragment of rhizome must have two to three intact nodes for better establishment in the field. Stolons and offsets are also suitable for multiplication under controlled cultivation conditions with or without hormonal treatment. Seeds can also be planted in mother beds or polybags for germination. Seeds do not show any dormancy and germinate without any pre-treatment. However, seeds treated with 100 PPM (parts per million) and 200 PPM of GA₃ (gibberellic acid) for 24 hours have 95% and 90% survival rate, respectively. When the soil surface is covered with moss, germination percentage is maximized.
- *Propagule rate and optimum spacing* About 165 000 seedlings per hectare are needed, which means 1–1.5 kg seeds are required for raising saplings for 1 hectare of land. Rhizomes planted at a spacing of 30 cm × 20 cm have been found to give best results in terms of yield.



Picrorhiza kurroa
– planting stock
in root trainer
trays

Planting in the field

- *Land preparation and fertilizer application* The land should be tilled, and made friable and porous by repeated ploughing so as to facilitate horizontal spreading of the rhizomes underneath. Field is left open for a week for solarization. Forest leaf litter or well-decomposed FYM (farmyard manure) is mixed with the soil at the rate of 6 tonnes/hectare at least 15 days before transplanting.
- *Transplanting and optimum spacing* Approximately 110 000 plants are required at the time of transplantation that is done at a spacing of

¹ Agro-technique study carried out by

- High Altitude Plant Physiology Research Centre, Hemwati Nandan Bahuguna Garhwal University, Srinagar, Garhwal, Uttarakhand – 246 174.
- Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, Himachal Pradesh.



Picrorhiza kurroa
– young plants

20 cm × 30 or 30 cm × 30 cm. If the agromomic practices are carried out properly, plant density may increase to 300 000 after the first growth season.

- **Intercropping system** Intercropping of *P. kurroa* with *Foeniculum vulgare* (*saunf*), potato, and *Digitalis purpurea* is quite successful, as these plants provide microclimate for better growth, that is, they retain moisture for longer time and provide shade for the better growth of *P. kurroa*. However, intercropping

with potato needs special care at the time of potato harvesting, as plants may be uprooted during the process. Intercropping with potato is done by raising the beds for potato cultivation, and seedlings of *P. kurroa* are planted in between the raised beds. After harvesting of potato, hoeing followed by earthing-up of soil at the plant base is necessary. While intercropping with *F. vulgare* and *D. purpurea*, these two species are planted at a distance of about 60 cm, and stolon cuttings of *Picrorhiza* species are transplanted at a spacing of 30 cm × 30 cm between these plants.

- **Interculture and maintenance practices** In the absence of FYM, urea should be sprayed at a concentration of 1.5% in July and August to fulfil the fertilizer needs of the plants. In case of heavy rains, the plots should be drained by digging channels across the fields.
- **Irrigation practices** Field should be irrigated on alternate days during summer and as and when required during winter. The field should be kept sufficiently moist at all times.
- **Weed control** Manual weeding must take place frequently at an interval of five to seven days during the first growing season. At later stages, weeding along with hoeing at an interval of one month is recommended.
- **Disease and pest control** At lower altitudes (1800–2500 m), plants are infected by powdery mildew during early growth period (March–May), which can be controlled by spraying Topsin-M (thiophinate methyle 0.1%) about 15–20 days after initiation, followed by another spray after 15 days. Powdery mildew also appears after excess manuring. At the time of flowering and seed formation, spraying of insecticide (ecalux, 0.5%) twice at 10-day interval prevents seed loss due to insects and aphids. In

the middle ranges, generally, there is no incidence of insect/pest/nematode or fungal diseases. However, there is every possibility of mortality due to heavy rains during rainy season.

Harvest management

- *Crop maturity and harvesting* This crop has a life cycle of three years. After the completion of flowering, the fruiting starts in August and continues up to September. The plant needs one year for complete maturity of the seed. The roots and rhizomes are manually harvested in September when the shoots or the aerial parts begin to wither and dry. Plants raised through stem cuttings mature almost an year earlier than those raised from the seedlings. However, to get higher active contents, plants must be collected before flowering occurs.
- *Post-harvest management* The roots and rhizomes should be dried in shade, and after proper drying, the material should be packed in polythene-lined jute bags to ensure protection from moisture.
- *Chemical constituents* Rhizome contains a brown resinous glucoside, picrorhizin, and a glycone, picrorhizetin. Root contains bitter principle kutkin, a non-bitter product kurrin, vanillic acid, and kutkoli in varied quantities.
- *Yield and cost of cultivation* The plant gives about 11 quintals/hectare of dry roots and rhizomes in the third year when the crop is raised through rhizomes; however, 10–11 quintals/hectare dry weight of roots and rhizomes are obtained in lesser period when the plant is propagated using stolons. Yield is reduced to about 6 quintals/hectare when seeds are used as propagation material. Yield proportionally increases with elevation. The cost of cultivation is high due to high maintenance costs at higher elevation. It is estimated to be Rs 112 000/hectare including the seedling cost.



Picrorhiza kurroa
– healthy crop

Market trend – 2006/07

- Market price: Rs 230–265 per kg dry roots
- Market demand: About 500 tonnes per year

Plumbago zeylanica Linn.

Plumbaginaceae

Ayurvedic name	Chitrak
Unani name	Chita, Sheetraj Hindi
Hindi name	Chitra, Chira
Trade name	Chitrak, Chitrakmool
Parts used	Roots and milky juice



Plumbago zeylanica

Therapeutic uses

Chitrak is a reputed thermogenic, astringent, anthelmintic, abortifacient, carminative, appetizer, and expectorant. Roots stimulate the central nervous system. Oil prepared from roots is useful in rheumatism, joint pain, and paralysis. Milky juice of leaves is used for external application in scabies.

Morphological characteristics

Plumbago zeylanica is a perennial undershrub, 1.5–2.0 m tall, with rambling branches. Its active growth occurs during rainy season and ceases in post-flowering stage. Leaf is simple, opposite, 4–10 cm long, 3–5 cm broad, oval, pointed, smooth, and shiny. Roots are light coloured inside, when fresh and reddish brown, when dry. Outer surface of the root is brown and striated. During summer, the plant remains almost leafless under natural conditions, but under irrigated conditions, the active growth starts in April.



Plumbago zeylanica – plants

Floral characteristics

Flowers are bisexual and white in colour. Calyx is persistent and tubular, with conspicuous viscid glands. Three different types of chitrak, that is, white, red, and blue flowered, are reported in the country. The white flowering type (*Plumbago zeylanica*) is the most common type and occurs in the moist forests. The red flowering type is *Plumbago rosea*,

while the blue flowering type is *Plumbago capensis*. Fruits are green coloured, with sticky hairs when young and become dark brown when mature. Flowering occurs from September to November, while fruiting occurs from January to February.

Distribution

The species is largely cultivated in gardens throughout India. It grows wild in South India, West Bengal, and some parts of Madhya Pradesh and Chhattisgarh.

Climate and soil

Although Chitrak can be grown in a variety of soils, ranging from red laterite soil, with very little topsoil, to deep black soil. However, it prefers well drained/deep sandy loam to clayey loam soil with high organic content. In natural habitats, the plant prefers moist soil with high organic content and partially shaded locations. Open and sunny conditions are not favourable for its growth.

Propagation material

Chitrak can easily be propagated through stem cuttings or seeds. Stem cuttings of 10–15 cm length, having at least three nodes, can be obtained from mother plants in March–April to raise the stock.

Agro-technique¹

Nursery technique

- *Raising propagules* Nursery is generally raised through stem cuttings in March–April, three to four months before planting in the field in July. These cuttings should be treated with 500 PPM (parts per million) NAA (naphthalene acetic acid) to promote quick rooting. The stem cuttings of chitrak should be obtained from base till the third node at the apex. The maximum success rate is obtained from the basal cuttings and it reduces gradually towards stem apex. Plant propagation can be done throughout the year in a mist chamber, and 80%–100% success rate is obtained from basal cuttings extending up to seventh to ninth nodes. Under open conditions, the mortality rate increases up to 70%–90% during the summer season. The prepared cuttings should be planted within 24 hours in raised nursery beds (15 cm) during rainy season and flat nursery beds during winter and summer. The beds of size 10 m × 1 m should be made under partial tree shades. In mist chamber, the cuttings should be planted in trays filled with sand. Out of three nodes, one node must be buried in the soil/sand, as the roots would sprout from this node. The cuttings should be planted in rows with plant-to-plant distance of 5 cm and row-to-row distance of 15 cm in nursery (March–April). These beds should be irrigated regularly. The cuttings start taking root within one month of planting in nursery. The sprouting percentage and growth are better in mist chamber than in the open conditions. These rooted cuttings are planted in main field during July. Seeds show poor germination percentage and should be scarified or cut at the micropylar end before sowing. They are sown in March in polybags filled with equal amounts of sand, soil, and FYM. The seeds show about 70% germination in 10–12 days. However, making the cut at the micropylar end requires expertise as the embryo may get damaged in the process.
- *Propagule planting rate* About 80 000 rooted stem cuttings or seedlings are required for planting in 1 hectare of land.



Plumbago zeylanica

¹ Agro-technique study carried out by the Department of Plant Physiology, JNKVV, Jabalpur – 482 004, Madhya Pradesh.

Planting in the field

- ***Land preparation and fertilizer application*** The crop is very sensitive to waterlogging, hence good drainage is essential. The field should be prepared by operating mould board plough once, followed by disc ploughing twice and levelling to obtain a uniform fine tilth. The field preparation should be done during May to June. Nursery-grown plants/rooted cuttings should be planted in main field at the onset of monsoon. FYM (farmyard manure) at the rate of 10 tonnes/hectare is applied 30 days before planting at the time of ploughing and land preparation. Nitrogen @ 30 kg/hectare and phosphorus and potassium @ 40 kg/hectare and 30 kg/hectare, respectively, are also applied as basal application.
- ***Transplanting and optimum spacing*** Transplanting can be done after 60–75 days of growth of cuttings. The optimum spacing recommended in the field is 50 cm × 25 cm, which produces maximum root biomass.
- ***Intercropping system*** Chitrak can be grown as an intercrop with many fruit trees, for example, guava, mango or citrus orchards. It can also be grown within *Gmelina arborea*, *Oroxylum indicum* or other medicinal tree species as ground crop.
- ***Interculture and maintenance practices*** Inorganic nitrogen at the rate of 30 kg/hectare is applied one month after transplantation. This is in addition to the basal dose of FYM (10 tonnes/hectare) and fertilizers applied at the time of land preparations. First weeding should be done one month after planting in August. Second and third manual weedings are done in October and December, respectively. Pruning can be done in May before harvesting the crop.
- ***Irrigation practices*** No irrigation is required in rainy season except during long gap. Later, irrigating the crop four to five times in November, January, March, April, and May is sufficient. Flat or flood irrigation method with 2 cm water per irrigation is required.
- ***Disease and pest control*** The plants get infested with semi-looper larvae and Bihar hairy caterpillar, which defoliate the plant heavily during active growth period. These also eat buds and young shoots and can be controlled by spraying malathion at the rate of 2 ml/litre of water twice at an interval of 15 days when they appear on the crop.

Harvest management

- *Crop maturity and harvesting* Plant attains maturity in 10–12 months after transplanting. Best time for harvesting is 12 months after sowing. About 20 000 mother plants for 80 000 cuttings are required to be maintained to make vegetative propagules for future plantation in 1 hectare of land and in successive years.
- *Post-harvest management* The roots should be dug out during a clear, sunny day in June, so that they can be shade-dried. The field may be irrigated before harvesting for easy digging. The field should be deep ploughed with mould board plough to expose the roots, which should be collected immediately. After digging, the roots must be washed in clean water, dried, and cut into pieces of length 5–7.5 cm. The roots must be dried before storage till they have 10%–13% moisture left. Cleaned and dried roots must be packed in airtight polybags for storage.
- *Chemical constituents* Chitrak root contains a yellow, crystalline, and bitter principle called plumbagin (melting point 72 °C). It can be dissolved in alcohol and ether, but is only sparingly soluble in boiling water. Maximum reported plumbagin content is 0.91%. Plumbagin content is higher in plants grown in drier locations.
- *Yield and cost of cultivation* Dry root yield varies from 12 quintals/hectare to 18 quintals/hectare under optimum conditions. The cost of cultivation is approximately Rs 8000/hectare per year.

Market trend – 2006/07

- Market price: Rs 55–95 per kg (dry roots)
- Market demand: 1000 tonnes per year

***Premna integrifolia* L.**

Syn. *P. obtusifolia*

Verbenaceae

Ayurvedic name	Agnimanth
Unani name	Arni
Hindi name	Agia, Arni
Trade name	Agnimanth
Parts used	Roots, root and stem bark, and leaves.



Premna integrifolia

Therapeutic uses

Plant root of arni is anti-inflammatory, stomachic, and anti-pyretic, and is prescribed in liver complaints, cold, obstinate fevers, flatulence, urticaria, rheumatism, and neuralgia. The roots of the plant are constituent of Ayurvedic medicine 'dashamula' and used for a various ailments.

Morphological characteristics

Premna is a scandent, erect shrub or small tree, more or less thorny on the trunk and large branches. Leaves are opposite or whorled and entire or serrate.

Floral biology

Flowers are small, irregular, arranged in terminal corymbs. Bracts are small and linear; calyx is four to five lobed or two-lipped and corolla is tubular and two-lipped. Ovary is four-celled, with one ovule per cell. Fruits (drupes) and seeds are oblong in shape. Flowering occurs in April–June and fruits appear during August–September.

Distribution

The species is common along the Indian peninsular and Andaman coast. It is also recorded as occurring in the plains of Maharashtra, Gujarat, Assam, Khasi hills, and tarai. In Orissa, it is found on land periodically covered by tides in Mahanadi delta.

Climate and soil

The plant prefers warm and humid climate. It grows well in sandy loam type of soil with good organic content.

Propagation material

At least one-year-old stem cuttings are used as planting material, which are procured from mature trees in February–March.

Agro-technique¹

Nursery technique

- *Raising propagules* Stem cuttings are used as planting material. The cuttings are planted in polybags filled with potting mixture consisting of sand, soil, and FYM (farmyard manure). Commercially available rooting hormones may be used for the cuttings. Cuttings may also be planted in sand in shade houses or mist chambers and transplanted to polybags after rooting.
- *Propagule rate and pretreatment* About 2500 rooted cuttings are required for 1 hectare of plantation at a spacing of 2 m × 2 m.

Planting in the field

- *Land preparation and fertilizer application* The land may be ploughed and harrowed using a disc harrow to bring the soil into fine tilth and make it free of weeds. Pits of appropriate size, that is, 45 cm × 45 cm × 45 cm, are dug at the recommended distance and filled with a mixture of sand, soil, and FYM in 1:1:1 ratio.
- *Transplanting and optimum spacing* About 2500 rooted cuttings are required for plantation on 1 hectare of land at a spacing of 2 m × 2 m. They are planted in the prepared pits just before or at the onset of monsoon.

¹ Agro-technique study carried out by Regional Research Laboratory, Council for Scientific and Industrial Research, Bhubaneswar – 751 013, Orissa.

- *Intercropping system* The plant is generally grown as a mono crop, but may well be intercropped with vegetables like onion and garlic, if grown away from coastal areas.
- *Interculture and maintenance practices* NPK (nitrogen, phosphorus, and potassium) fertilizers each @ 50 g per plant should be applied, preferably during rainy season. Intercultural operations include manual weeding and hoeing at regular intervals as and when required. However, three weeding in the first six months of planting are essential.
- *Irrigation practices* Irrigation is required at an interval of 15–30 days during dry season, especially in the first year, that is, from December to May.
- *Disease and pest control* No serious disease or pest or any other physiological disorder has been observed under experimental conditions.



Premna integrifolia –
harvested plant

Harvest management

- *Crop maturity and harvesting* The plant should remain in the field at least for a period of three years. Harvesting should be done thereafter towards the end of rainy season, that is, September–October.
- *Post-harvest management* The base of the plant is carefully dug up to take out the plant with roots intact. The roots are separated from the rest of the plant and the bark is peeled off. The bark and the roots are chopped into small pieces and dried in shade. The dried plant parts packed in clean polybags and stored in a dry place.
- *Yield and cost of cultivation* Dry root yield is about 500–850 g per tree, thus 1250 kg root/hectare is obtained from a three-year-old plantation. The estimated cost of cultivation is Rs 11 000 per hectare.

Market trend – 2006/07

- Market price: Rs 17–20 per kg
- Market demand: Above 100 MT per year

Pterocarpus marsupium Roxb.

Fabaceae

Ayurvedic name	Bijasar, Asan
Unani name	Bijasar
Hindi name	Vijaysar, Bijasar
Trade name	Bijasar, Vijaysar
Parts used	Heartwood, bark, leaves, and gum (kino)



Pterocarpus marsupium –
plantlet

Therapeutic uses

Hearthwood of Vijaysar is antibiotic and hypoglycaemic, and is used to control blood sugar. Kino gum, obtained from incisions in bark, has astringent, anti-diarrhoeal, and anti-haemorrhagic properties. Leaves are used externally to treat boils, sores, and other skin diseases, while flowers are febrifuge.

Morphological characteristics

Pterocarpus species can be recognized in field by its straight bole, longitudinally fissured bark, imparipinnate and elliptic leaves, fragrant flowers in large panicles, and winged, flat pods. The tree reaches up to 30 m in height and up to 2.5 m in girth with straight and clear bole. Bark is scaly, rough, and longitudinally fissured. Leaflets are generally five to seven in number, 8–13 cm long, oblong or elliptic, or rotund, with 15–20 pairs of lateral veins. Oleo-resin obtained from tree trunk is called kino-gum, which is fragrant, brittle, almost black in colour, angular and glistening, and occurs in small flakes.

Floral characteristics

Fragrant, yellow flowers occur in about 1–5 cm long large panicles. Pods are flat, orbicular, winged, and up to 5 cm in diameter. Seeds are one to three in number, bony and convex in shape. Flowering begins in November, while fruiting continues up to March.

Distribution

The tree is found in central and peninsular India, chiefly in dry mixed deciduous tropical forests of Gujarat, Madhya Pradesh, and sub-Himalayan tracts, at up to 1000 m altitude. Natural populations have greatly reduced and often no tender young saplings can be found in the forest. This is a threatened species on account of autogenic reproductive deficiency.

Climate and soil

The tree occurs in tropical region and thrives well in open sun under moderate rainfall of 80–200 cm. It prefers fertile, deep clayey loam soil with good drainage. It can tolerate excessive temperatures in summer.

Varieties

No improved varieties are available, but provenance from Amarkantak showed better growth results during experimentation.

Propagation material

Freshly collected seeds are used for raising the plantations. Mature fruits are plucked from trees in April–May before they fall on ground.

Agro-technique¹

Nursery technique

- *Raising propagules* A nursery is raised from seeds under partial shade in April. The plantlets are maintained in the nursery till they are about two months old and then transplanted to the pits in main field during monsoons. Seedlings may also be raised in polybags or baskets. If seedlings are maintained till next planting season, it should be ensured that

¹ Agro-technique study carried out by

- The Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Krishinagar, Adhartal, Jabalpur – 482 004, Madhya Pradesh.
- Tropical Botanical Garden and Research Institute, Thiruvananthapuram.

there is no root coiling in the plants. Seed viability is very low (about 1%–2%) and hence this tree has been put under threatened species grade 'A'. Seedlings raised from tissue culture die out and their survival rate is hardly 10% in open field due to intolerance of high temperature, hence winter is a preferred season for transplantation of tissue-culture-raised plants in field.

- *Propagule rate and pretreatment* About 100 g of viable seeds are required to raise seedlings on 1 hectare of land for planting at 8 m × 8 m spacing. Before sowing, seeds are treated with Thiram @ 3 g/kg of seeds to protect them from fungal infections. Germination can be hastened by cutting across their ends and soaking them in water for two days before sowing. Freshly collected seeds should be protected from seed borers.



Pterocarpus marsupium – tree

Planting in the field

- *Land preparation and fertilizer application* Land is made into fine tilth by ploughing and harvesting in April–May. Pits of appropriate size (50 cm × 50 cm) are dug at a spacing of 8 m × 8 m. About 25 kg FYM (farmyard manure), along with 200 g of nitrogen and 150 g of phosphorus, is mixed with soil of each pit as basal dose. The pits are refilled with this mixture after weathering of soil.
- *Transplanting and optimum spacing* Transplanting may either be done in July–August (monsoon season) when the plants are two-month-old or delayed till next June–July. A spacing of 8 m × 8 m is recommended, which accommodates about 160 plants per hectare. Gap filling in the field is done in September.
- *Intercropping system* When Bijasar is planted at a spacing of 8 m × 8 m, intercropping can be done with a number of species such as medicinal plants and vegetable crops. The species can also be raised as a pure crop at smaller spacing.
- *Interculture and maintenance practices* FYM @ 25 kg per plant, nitrogen @ 200 g/plant, and phosphorus @ 150 g/plant are required every year for the first three years. The fertilizer is applied in two split doses, the first in September and the second in January. Two manual weedings, the first one in August and the second in



Pterocarpus marsupium – seeds

November, are recommended.

- *Irrigation practices* Irrigation should be done six times in the first year (preferably once a month) through check basin system or filling the basin of the pit with water.
- *Disease and pest control* No serious insect pest and disease are observed in mature stems and roots. However, seeds are prone to seed borer, which decreases seed viability. This can be controlled to some extent by proper drying (up to 12% moisture) and using carbon-di-sulphide in storage. In nursery and early growth stages, leaf-eating insects and white grub attack are often reported, which can be controlled by four sprays of Endosulphan @ 0.003% at fortnightly intervals and application of Phorate

10 G near the root zone, respectively. To keep the plants disease-free in nursery and early stages of development in the field, seed treatment with Thiram @ 3 g/kg of seed is essential.

Harvest management

- *Crop maturity and harvesting* The tree is harvested after 10–15 years for production of heartwood. Kino gum is collected through incision in the bark before logging of tree, and dried well in shade.
- *Chemical constituents* Isoflavanoids, terpenoids, and tannis are reported from heartwood. Roots contain liquid-ritigenin, garbanzol, pterosupin, pseudo-dobatigenin, and 5-deoxy-kaempferol. Kino gum contains kitannic acid.
- *Yield and cost of cultivation* Each mature tree yields approximately 500 kg of dry heartwood after 10–15 years. Thus, an estimated yield of 750–800 quintals/hectare is obtained. The cost of establishment per hectare is estimated to be Rs 55 000, with Rs 3000 per year being the maintenance cost.

Market trend – 2006/07

- Market price: Rs 70 per kg of dry heart wood

Pterocarpus santalinus Linn. f.

Pterocarpaceae

Ayurvedic name	Rakta chandan
Unani name	Sandal surkh
Hindi name	Lal chandan
Trade name	Lal chandan, Red sanders
Parts used	Heartwood and bark



Pterocarpus santalinus

Therapeutic uses

The heartwood of red sanders is used as an astringent and tonic, and is bitter, sweet, cooling, analgesic, anti-inflammatory, and febrifuge. Its decoction is given in chronic dysentery. It is also useful in vitiated conditions of pitta, burning sensation, vomiting, skin diseases, leprosy, ulcers, fistula, and haemorrhages.

Morphological characteristics

Lal chandan is a moderate-sized deciduous tree with clear trunk and dense rounded crown. It attains a height of 10 m and a girth of 0.9–1.5 m under favourable growing conditions. The blackish-brown bark is fissured and resembles crocodile skin. The inner bark, when injured or cut, oozes red coloured ‘santolin’ dye. The wood is extremely hard and dark red in colour, with a specific gravity of 1.109. The leaves are imparipinnate, petiolate, and alternate. They are simple at seedling stage but trifoliate or rarely pentafoliate later.



Pterocarpus santalinus –
tree

Floral characteristics

The flowers of the species are yellow, densely arranged in simple or sparingly branched racemes. Flowering occurs from February to April, after new leaves sprout. Pods are formed rapidly but get ripened in next February–March. Pods are obliquely orbicular, 3–4 cm in diameter, including the wing, and gradually narrow down into a short stipe. There is only one seed per pod, which is 1–1.5 cm in length and reddish brown in colour.

Distribution

The *Pterocarpus* species is distributed in peninsular India and Sri Lanka. It occurs

gregariously in patches in tropical dry deciduous forests, towards south-eastern Ghats.

Climate and soil

Well-drained red soils with gravelled loam are suitable for the cultivation of lal chandan species. It regenerates well in dry hot climate and requires rainfall ranging from 800 mm to 1000 mm annually for good growth.

Varieties

In nature, two types of rakta chandan trees are observed—wavy grained and straight. The wavy grained wood is more in demand in trade and is preferred for commercial plantation. No commercially released varieties are available.

Propagation material

The seeds retain their viability for about one year under normal storage conditions and are the best propagation material. Fruits are collected in March for the extraction of seeds. Seedlings or stumps prepared from two-year-old nursery seedlings are used for planting in the field.

Agro-technique¹

Nursery technique

- *Raising propagules* March, April or May months are suitable for raising nursery from seeds. Mature and healthy pods are chosen to collect the seeds; these are sown in raised nursery beds. It takes 10–15 days for the germination to complete. Pretreated seeds (10–12 kg) are sown per bed (10 m × 1 m) of sandy loam or loamy soil in April and covered with a thin layer of soil or hay. After one year, stumps can be prepared, which are planted in polybags in February to March, to be utilized after four to five months as stump-sprouted seedlings.
- *Propagule rate and pretreatment* About 1 kg seeds are needed to raise seedlings for 1 hectare of plantation. Seeds show only about 50%–60% germination and about 40% plant survival. Seed treatment with GA₃ (gibberellic acid)+BA (benzyladenine) @ 250 PPM (parts per million) helps in early and optimum germination. Alternatively, seeds can be soaked in cold water for 72 hours or in cow dung slurry for 72 hours.



Pterocarpus santalinus –
crop

Planting in the field

- *Land preparation and fertilizer application* The land is ploughed and harrowed repeatedly and soil is brought to a fine tilth. Pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 4 m × 4 m. The pits are filled with topsoil mixed thoroughly with 10–15 kg FYM (farm-yard manure) and 10 g lindane dust to protect the planting stock from soil-borne fungi.
- *Transplanting and optimum spacing* The best time for planting the crop in the field is end of May to June, that is, onset of rainy season. Generally, the stump-raised seedlings or stumps obtained from two-year-old nursery plants are transplanted. A plant population of about 600 per hectare is recommended with a spacing of 4 m × 4 m.
- *Intercropping system* No particular intercropping system has so far been studied in this crop; however, herbaceous rhizomatous species

¹ Agro-technique study carried out by

- Division of Horticulture, University of Agricultural Sciences, G K V K Campus, Bangalore – 560 065.
- Dhanvanthari Vana, Department of Forestry, Government of Karnataka, Jnanabharathi Campus, Bangalore University, Bangalore.



Pterocarpus santalinus – bark

may be grown as an intercrop in inter-row spaces.

- *Interculture and maintenance practices* About 10–15 kg FYM per plant per year and 150:100:100 g NPK (nitrogen, phosphorus, and potassium) per plant per year are required for at least five years. Fertilizer should be applied in 15–20-cm-deep circular trenches dug around the plant at a distance of 60 cm. Full dose of P and K along with one-third N should be applied at the end of February. The remaining N should be applied in two split doses during June–July and October–November. Application of inorganic fertilizers should always be followed by irrigation. Gap filling is done one month after planting. Weeding is done manually as and when necessary and particularly just before manuring. The soil around the basin is loosened frequently by hoeing.
- *Irrigation practices* The plants are irrigated immediately after transplantation. Thereafter, irrigation is done on alternate days up to 15 days. After the seedlings get established, irrigation may be done at an interval of 10–15 days, depending on the weather conditions.
- *Disease and pest control* Leaf-eating caterpillars have been found to damage the crop during April–May. These can be controlled by spraying 0.2% Monocrotophos twice at weekly intervals.

Harvest management

- *Crop maturity and harvesting* The fruits require almost 11 months to mature. Twenty- to twenty-five-year-old trees are used for the extraction of bark and wood. The bark may be extracted selectively by strip technique and the tree may be allowed to stand. The tree has to be felled for extraction of wood.
- *Chemical constituents* Bark, heartwood, and sapwood contain santalin A and B, isopterocarpolone, pterocarptriol, isipterocarpene, pterocarpdiolone, pterocarpol, acyl olealonic aldehyde, and acetyloleanolic acid.
- *Yield and cost of cultivation* Pod yield from 15-year-old trees is 30 tonnes per hectare. Heartwood yield per tree after felling is 250 kg. Thus, 15 000 tonnes per hectare of heartwood is expected after 15–20 years. The estimated cost of raising and maintaining the crop is Rs 55 000 for 5 years.

Market trend – 2006/07

- Market demand: Above 100 MT per year

Rheum emodi Wall. ex Meissn

Polygonaceae

Ayurvedic name	Amlavetasa
Unani name	Rewand chini
Hindi name	Rewand chini
Trade name	Revand chini, Rhubarb
Parts used	Roots and rhizomes



Rheum emodi – a close view

Therapeutic uses

Rheum emodi is a mild purgative, astringent, tonic, laxative, stomachic, and aperient. Powdered rhizomes are sprinkled over ulcers for quick healing. It is also reported to be a potent anti-inflammatory drug.

Morphological characteristics

Rewand chini is a perennial stout herb, 1.5–3.0 m tall. Roots are very stout and thick. Leaves are radical, orbicular, or broadly ovate, very large, and 30–45 cm in diameter with long petioles.

Floral characteristics

Flowers are small, dark purple or pale red in axillary panicles. The plant has three to five years of juvenile phase, followed by reproductive phase. Flowering occurs in June–July. Seeds are collected in late August–September, when they turn dark brown. Seed production potential varies from 300 seeds to 950 seeds per plant.

*Rheum emodi*

Distribution

The species occurs in the temperate Himalayas, from Kashmir to Sikkim, at an elevation of 2800–4000 m. It is found in alpine zone on rocky soil, moraines, and crevices, between boulders and near streams in specific pockets. It is sporadically cultivated in the North-eastern states for its leaves, which are used as vegetable.

Climate and soil

Rewand chini plant is restricted 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 altitudes above 1800 m in height.

Propagation material

Both seeds and top rhizome segments from mother plants may be used for propagation. Seeds are collected in September–October. They have high and quick germination rate, and require no specific pretreatment.

Agro-technique¹

Nursery technique

- *Raising propagules* 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. In temperate conditions, seeds are sown in the spring season (March–early April). Germination of the seeds is complete within one month of sowing.
- *Propagule rate and pretreatment* About 600 g of seeds are required to raise a nursery for planting at a spacing of 50 cm × 50 cm in 1 hectare of land. No specific pretreatment is required for the seeds.

¹ Agro-technique study carried out by

- S K University of Agricultural Science and Technology, Division of Floriculture, Medicinal and Aromatic Plants, Shalimar Unit, Srinagar – 191 121, Jammu and Kashmir.
- High Altitude Plant Physiology Research Centre, HNB Garhwal University, Srinagar, Garhwal, Uttarakhand.

Planting in the field

- *Land preparation and fertilizer application* The land may be ploughed and prepared to fine tilth and made aerable. Forest litter/FYM (farm-yard manure) @ 100 quintals/hectare may be used as a basal dose for soil containing 1%–1.5% of organic carbon at 2200 m, applied at the time of land preparation. At lower altitudes (1800 m), higher dose of manure (about 150–200 quintals/hectare) is desirable for maximizing the yield.
- *Transplanting and optimum spacing* Transplanting is done in May when the plants are almost three months old. The optimum spacing for the crop is 50 cm × 50 cm, which means a crop stand of approximately 40 000 plants per hectare.
- *Intercropping system* Since the crop of *R. emodi* occupies maximum soil surface, no intercropping is feasible after second year, when planted at a spacing of 50 cm × 50 cm. However, annual vegetable crops or medicinal and aromatic plants can be grown during the first year. Intercropping with *Rheum moorcroftianum* has been reported to be successful. *R. moorcroftianum* has medicinal properties similar to those of *R. emodi*.
- *Interculture and maintenance practices* While the entire quantity of FYM is applied as basal dose (10 tonnes/hectare), half 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* Irrigation is done immediately after transplantation of propagules. This is followed by light irrigation at four-week intervals. Light sprinkler irrigation during the summer season has proved to be useful for the growth of the crop. It also saves water. However, excessive watering may cause decay of underground rhizome, especially in winter months.
- *Weed control* 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.
- *Disease and pest control* The crop is often infected with *Fusarium* sp. Soil drenching with Carbendazim 50 at a rate of 2 g/litre of water is



Rheum emodi – seedlings raised in root trainer trays



Rheum emodi –
young plants in a
nursery bed

recommended as a control measure. Insects and aphides, which attack the plant at early stage, may be checked by spraying Ecalux 0.5% twice at an interval of 10–15 days.

Harvest management

- *Crop maturity and harvesting* Crop raised through seedlings needs four to five years for maturity; however, two to three years are enough when raised through rhizome segments. Flowering takes place after one year in May–June and fruiting follows in September–October. The plants attain maturity after about four growing seasons, and may be harvested after the onset of fruiting in September and October.
- *Post-harvest management* The root and rhizome are cleaned, thoroughly washed, chopped into small pieces, and dried in shade. The dried drug material is packed in airtight containers.
- *Chemical constituents* Roots contain emodin, emodin-3-monomethyl ether, chropophenol, als-emodin, rhein, sennoside, engenol, rutin, and glucoglatin.
- *Yield and cost of cultivation* The expected yield ranges from 37 quintals/hectare to 66 quintals/hectare at an altitude of 1800 m, and between 65 quintals/hectare and 108 quintals/hectare at an altitude of 2200 m, after three years. Cultivation of crop for three years involves an expenditure of approximately Rs 200 000/hectare, excluding the cost of planting material.

***Rubia cordifolia* Linn.**

Rubiaceae

Ayurvedic name	Manjishtha
Unani name	Majeeth
Hindi name	Manjitha, Manjit
Trade name	Manjit
Parts used	Roots and whole plant



Rubia cordifolia

Therapeutic uses

Manjit is a bitter, antiseptic, styptic, anodyne, depurative, and hypotensive drug. The plant is also used against blood dysentery, inflammations, and urino-genital disorders. It is also an alterative, pigment stimulator, and tonic.

Morphological characteristics

Manjishtha is a perennial, herbaceous climber with very long, cylindrical roots having a thin red bark. Stem is long, rough, slightly woody at the base, quadrangular, and glabrous. Branches climb by means of numerous prickles. Leaves are heart shaped, about 5–10 cm in size, five-nerved from the leaf base, and occur in whorls of four. Petiole is roughly triangular with many sharp recurved prickles on the edges.

Floral characteristics

Flowers are small, yellow, and scaly, and occur in terminal cymes. Bracts are ovate and leafy. Calyx is tubular, less than 1 cm long. Corolla is



Rubia cordifolia –
plant

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

Distribution

The species is found throughout the hilly subtropical to sub-temperate regions of India, between 300 m and 2000 m altitudes.

Climate and soil

Rubia cordifolia occurs mostly in loamy soil rich in humus. The rainfall is high in the regions in which this plant grows. The plant is a climber and requires support for growth.

Propagation material

The plant is propagated through seeds and two-node root cuttings. The seeds are collected during December and January. It is preferable to use seeds for large-scale cultivation, considering the cost factor and high rate of germination.

Agro-technique¹

Nursery technique

- *Raising propagules* The planting stock may be raised in nursery in January through seeds. The seeds obtained from dried ripe black fruits are sown in nursery beds either in rows or randomly by broadcasting. A thin layer of soil and organic manure is spread over the seeds, and the beds are regularly watered. After germination, seedlings with two to three leaves are transplanted in polybags for establishment. The plants can also be raised through cuttings containing two or three nodes, treated with commercially available rooting hormones or 3000 PPM (parts per million) IBA (indole-3-butyric acid) for rooting. Although cuttings give 90% success, it

¹ Agro-technique study carried out by Regional Research Laboratory (CSIR), Itanagar Branch, P O Naharlagun – 711 110, Arunachal Pradesh.

is still preferable to take up large-scale cultivation through seeds, which is economic and results in 80%–85% germination within 20 days.

- *Propagule rate and pretreatment* About 350 g of seeds are required to raise a nursery for planting in 1 hectare of land. It is advisable to treat the seeds with 0.02% Bavistin 50 WP before sowing. Sometimes, seeds may be directly broadcast in the well-prepared field or sown in rows. In such cases, much higher quantities of seeds, to the tune of 1.5–2 kg, may be required.

Planting in the field

- *Land preparation and fertilizer application* The soil is properly ploughed, harrowed once or twice, and planked lightly to make it porous and weed-free. FYM (farmyard manure) @ 10 tonnes/hectare and NPK (nitrogen, phosphorus, potassium) @ 30:40:20 kg, respectively, are applied to the soil as basal dose during land preparation.
- *Transplanting and optimum spacing* Seedlings/rooted cuttings are transplanted to the main field in April–May. An optimum spacing of 60 cm × 75 cm is recommended in the field, which gives an optimum crop stand of 22 000 plants per hectare. When the seeds are directly sown in rows or broadcast in the well-prepared field, singling is an important activity to provide optimum spacing to the growing plants.
- *Intercropping system* The plant is a climber and may be intercropped with shrubby, perennial species, serving as host/support crop.
- *Interculture and maintenance practices* FYM @ 5 tonnes/hectare or nitrogen @ 20 kg/hectare is applied 120–130 days after transplanting by top dressing. In the second and third years, NPK may each be applied @ 20 kg/hectare by top dressing with the onset of rainfall after the intercultural operation. In the first year, first manual weeding cum hoeing is done 45 days after planting, and the second one is carried out 120 days after planting. Bamboo/shrub staking is done 30–45 days after transplanting. Intercultural operations during second and third years may be carried out at least twice during each year.



Rubia cordifolia – seeds



Rubia cordifolia –
dry root

- *Irrigation practices* Irrigation may be provided as and when necessary. However, the plant may be grown as a rain-fed crop in North-East India where the rainfall is high and evenly distributed throughout the year.

Harvest management

- *Crop maturity and harvesting* *R. cordifolia* starts flowering after one year in August and seeds mature in October–November. Roots can be harvested after two years at pre-flowering stage in October or late fruiting

stage by the end of November or even in early December when seed is required for next crop. The crop can, however, be allowed to stand in the field for three years.

- *Post-harvest management* The hard roots are cut into small pieces and dried in the shade. The dried root pieces are packed in gunny bags for storage in cool and dry place.
- *Chemical constituents* Roots contain resinous and extractive matter, gum, sugar, colouring matter, and salts of lime. The colouring matter consists of purpirin, manjistin, garancin, xanthine, besides several anthraquinone derivatives.
- *Yield and cost of cultivation* About 3 tonnes of dry root is obtained per hectare of cultivated crop. The estimated cost of cultivation for a two-year crop is about Rs 100 000 per hectare.

Market trend – 2006/07

- Market demand: Above 100 MT per year

Saraca asoca (Roxb.) de Willde

Syn. *Saraca indica* Roxb.

Caesalpiniaceae

Ayurvedic name	Asoka
Unani name	Ashok
Hindi name	Asoka
Trade name	Sita Asoka
Parts used	Stem bark, flowers, seeds



Saraca asoca – tree

Therapeutic uses

Stem bark of Asoka tree is strongly astringent and a uterine sedative, uterine tonic, and styp-tic, having a stimulating effect on endometrial and ovarian tissue. The bark is also useful in dyspepsia, fever, and burning sensation. It is also used to treat menorrhagia, leucorrhoea, internal bleeding, hemorrhoids, and hemorrhagic dysentery.

Morphological characteristics

Sita Asoka is a medium-sized, evergreen tree with beautiful fragrant flowers. Leaves are alternate, paripinnate, copper red when young and green when mature, and 30–60 cm long. Bark on old stems is dark green in colour, often marked by bluish and ash white patches of lichens.

Floral characteristics

Fragrant flowers are orange or orange yellow in colour. Fruit is a four to eight seeded, flat and black coloured, leathery pod. The pod is dehiscent,

woody, and tapering at both ends. Seeds are ellipsoid–oblong and compressed. Flowering and fruiting occur from July to October.

Distribution

Asoka is distributed throughout India, naturally frequent in South India, Sri Lanka, Orissa, and Assam. The species also occurs in central and eastern Himalayas up to 750 m altitude. It is grown as an avenue tree due to its foliage and fragrant flowers.

Climate and soil

Asoka grows well in moist tropical areas with well-distributed rainfall. It also thrives well in partially shaded locations.



Saraca asoca –
flowering and
fruiting



Propagation material

Seeds are the most suitable propagation material. Mature seeds are collected from more than five- to six-year-old plants in December–January.

Agro-technique¹

Nursery technique

- *Raising propagules* The seedlings are raised in a nursery in March. The seeds are sown in mother beds or polybags of 25 cm × 20 cm size. The potting mixture consists of equal quantities of soil, sand, and FYM (farmyard manure). The seeds germinate in about 15 days.
- *Propagule rate and pretreatment* Approximately, 2 kg seeds are required for raising seedlings for planting in 1 hectare of land at a spacing of 3 m × 3 m. The seeds may be soaked in water for 12 hours before sowing, which improves the germination percentage.

¹ Agro-technique study carried out by Aromatic and Medicinal Plants Research Station, Kerala Agriculture University, Odakkali, P O Asamannoor, Dist Ernakulam, Kerala – 683 549.

Planting in the field

- *Land preparation and fertilizer application* Pits of size 45 cm × 45 cm are prepared at a spacing of 3 m × 3 m. The pits are weathered and refilled with topsoil after mixing with 10 kg FYM per pit. An additional 10 kg manure should be applied as the follow-up dose during October–November.
- *Transplanting and optimum spacing* Two-month-old seedlings are transplanted in the pits during monsoon season in June/July. About 1100 seedlings per hectare are required for planting at an optimum spacing of 3 m × 3 m for a pure crop. When intercropped with plantation crops like coconut, only about 200–250 seedlings may be planted per hectare, alternating with coconut rows. When intercropped with herbs, it may be planted at a spacing of 3 m × 6 m, requiring approximately 550 plants per hectare.
- *Intercropping system* *Saraca* performs better when grown as a mixed crop with perennial trees like coconut, which provide partial shade to the crop. Intercropping with herbs and medicinal plants can also be done for earlier economic returns.
- *Interculture and maintenance practices* FYM at the rate of 10 kg/tree/year is applied twice: first in May–June while filling the pits and again in October–November at the time of second weeding. Chemical fertilizers are not applied. First weeding is done one month after planting and the third weeding is done in December. The interspaces are kept weed-free either by hand weeding or protected by spraying of non-selective herbicides like 0.8% paraquat or 0.4% glyphosate. Partial shade along with frequent irrigation is provided to growing saplings for the first one or two years from December to May.
- *Irrigation practices* The crop is raised over high rainfall tracts. During the months without rains, the seedlings require frequent irrigation. Watering of grown-up trees is done by forming a ring channel around trees' base to hasten growth.
- *Disease and pest control* No serious pest or disease is observed in this crop.



Saraca asoca – seeds



Saraca asoca –
intercropping

Harvest management

- *Crop maturity and harvesting* Flowering in Asoka takes place in the early growth stage. The plant flowers profusely at six to eight years of age and produces fruits during July to October. The tree survives for about 50 years. It is often felled after it reaches 20 years of age for collecting bark. It is cut at a height of 15 cm from the soil level. If sufficient irrigation and fertilizers are provided, the stumps will regenerate new coppice shoots, which can be harvested again after 10 years. Alternatively, the bark can be collected without cutting down the tree. The bark is peeled off in vertical strips with 6 cm interspaces between each strip. The peeled off area is renewed with fresh bark in one to two years. Then, the bark on the other areas can be peeled off without cutting the tree. This non-destructive method should be preferred for harvesting.
- *Post-harvest management* The bark is dried in the shade, packed, and stored in containers.
- *Chemical constituents* Major constituents in the stem bark of Asoka are tannins (0.57%–7.85%), ash (2.43%–6.69%), and other extracts (5.74%–14.07%). A large variation has been observed in the quality of Asoka crude drug collected from important markets in the country. Age factor may probably be responsible for such quality variations.
- *Yield and cost of cultivation* One tonne of dry stem bark per hectare is produced from a sole crop. When grown as mixed crop with coconut, yield is reduced to 0.6 tonne per hectare. Estimated cost of cultivation is about Rs 62 500 per hectare.

Market trend – 2006/07

- Market price: Rs 10–17 per kg
- Market demand: 1800 tonnes

***Solanum indicum* Linn.**

Solanaceae

Ayurvedic name	Brihati
Unani name	Kateli
Hindi name	Jangli bhata
Trade name	Bari kateri
Parts used	Whole plant, especially roots and fruits



Solanum indicum
– plant

Therapeutic uses

The *Solanum* plant is reported to be bitter, acrid, astringent, carminative, stomachic, resolvent, demulcent, diuretic, emmenagogue, febrifuge, and cardiotonic. It is useful in the treatment of asthma, catarrh, dropsy, chest pain, chronic fever, colic, dry and spasmodic cough, oedema, scorpion stings, difficult urination, and worm infestation.

Morphological characteristics

Bari kateri is a stiff, much-branched, prickly shrub growing upto a height of 0.3–1.5 m. Prickles are sharp, often slightly recurved, short hooked, and have a broad compressed base. Stem is stout and the branches are covered with minute stellate brown hairs. Leaves are ovate in outline, sparsely prickly on both sides, and measure about 5–15 cm × 2.5–7.5 cm. They are clothed above with simple hairs and have bulbous base

intermixed with small stellate ones, while small stellate hairs cover them on the lower surface. Petioles are prickly and about 1.3–2.5 cm long.

Floral characteristics

Flowers occur in racemose, extra-axillary cymes. Pedicels are 6–13 mm long, stellately hairy, and prickly. Calyx is 3 mm long, with stellate hair and triangular teeth. Corolla is about 8 mm long, pale, purple, clothed outside with darker, purple, stellate hairs; lobes are 5 mm long, deltoid, ovate, and acute. Fruit is a globose berry, green with white lining when young and becomes yellow when ripe. Sometimes it has a few stellate hairs at the apex. Seeds are small, many, and discoid. Flowering occurs in September–October, while fruits begin to appear in October.

Distribution

The species is commonly found throughout the tropical and subtropical India.

Climate and soil

Brihati grows well in tropical regions where annual rainfall ranges from 1000 mm to 1500 mm. Sandy loam soil is found to be suitable for the cultivation of this plant. The species is xeric in nature and can grow well in shady places and in areas that receive low rainfall. This species may also be inter-cropped in tree plantation sites.

Propagation material

Seeds can be collected in May–June from mature fruits and can be sown directly in the main field. Plantlets can also be raised in nursery through seeds.

Agro-technique¹

Nursery technique

- *Raising propagules* Planting material can be raised in nursery in May–June. One- to one-and-half-month-old seedlings are planted in the field during July–August. Direct seed sowing in a plantation can also be done. Seed is sown in well-prepared nursery beds (size 10 m × 1 m) in June in shady places or in temporary mist chambers of size 10 m × 15 m. FYM (farmyard manure) @ 50 kg and poultry manure @ 2 kg are

¹ Agro-technique study carried out by the State Forest Research Institute, Polipathar, Jabalpur – 482 008, Madhya Pradesh.

mixed in soil at the time of bed preparation before sowing seed. Irrigation is done twice a day after sowing to maintain proper humidity.

- *Propagule rate and pretreatment* About 4 kg of seeds are required for sowing in the nursery for planting in 1 hectare of land. No pre-sowing treatment of seeds is required.

Planting in the field

- *Land preparation and fertilizer application* Land preparation is done in June before rains. Land should be ploughed well and made weed-free. Drainage channels should be constructed in the field. This species does not tolerate water stagnation. Five tonnes of FYM per hectare is mixed thoroughly at the time of field preparation. The FYM should be properly mixed with the soil before rains. No inorganic fertilizer is needed.
- *Transplanting and optimum spacing* Nursery-raised seedlings are planted in the field with a ball of earth. Preferably seeds are directly sown in the well prepared field. The germination commences after nine days of sowing and continues till 40 days. Generally, 20–30 days are required for optimum germination. A spacing of 30 cm × 30 cm in the field is optimum for good growth and productivity. The optimum crop stand is about 111 000 plants/hectare.
- *Intercropping system* The species can also be grown as an intercrop beneath fruit-tree orchards.
- *Interculture and maintenance practices* First weeding is done 15 days after transplantation or about a month after direct sowing in the field. Later, regular weeding is required at an interval of 20 days up to maturity of the plants.
- *Irrigation practices* There is no need for irrigation if the annual rainfall is 1200 mm or more. During the fruiting period, that is, from November to February, irrigation may be done on alternate days. Since this species is perennial in nature, irrigation in the summer months helps the plants to survive.
- *Disease and pest control* No serious diseases or insect pests have been observed in crop.

Harvest management

- *Crop maturity and harvesting* Best time for harvesting is April after the species is 9–10 months old. Follow-up crop can also be obtained if plantation is maintained for second year.

- *Post-harvest management* Plucking and collection of fruits are done in April and May. Collected fruits should be dried in shade. Dried fruits are kept in airtight containers. Roots may be dug out manually and washed in fresh water. Harvested roots should be dried in the sun for a short time and then in the shade for 10 days. Well-dried roots are stored in bags and kept in airtight containers. Disposal of the roots should be done within four months of collection, that is, before rains, to avoid fungal infection.
- *Chemical constituents* Fruits and roots contain wax and fatty acids. Alkaloids solanine and solanidine are present in the roots and leaves. Fruits contain 1.8% of alkaloids and can find use in cortisone and sex hormone preparations.
- *Yield estimates* About 800 kg of fruits and 300 kg of seeds are obtained as fresh yield per hectare. Approximately 20 quintals of dried root is obtained from a two-year-old crop.

Market trend – 2006/07

- Market price: Rs 13 per kg (dried roots)
- Market demand: Above 4 tonnes per year

Strychnos nux-vomica Linn.

Strychnaceae (Loganiaceae)

Ayurvedic name	Visamusti
Unani name	Azaraqī, Kuchla
Hindi name	Kuchla
Trade name	Kuchila
Parts used	Dried ripe seeds and stem bark



Strychnos nux-vomica

Therapeutic uses

Dried seeds of kuchila are nervine, stomachic, and cardio-tonic, aphrodisiac, and respiratory stimulant. It is used as a remedy in chronic dysentery, paralytic and neuralgic disorders, epilepsy, rheumatic arthritis, and hydrophobia. In excessive doses, *Strychnos* is a virulent poison, producing stiffness of muscles and convulsions, ultimately leading to death. It is an important drug in all systems of medicine.

Morphological characteristics

Strychnos species is a medium-sized, deciduous tree, with fairly straight and cylindrical bole and dark-grey or yellowish-grey bark with minute tubercles. Leaves are simple, opposite, orbicular to ovate, 6–12 cm long and 6–10 cm broad, coriaceous, glabrous, and five-nerved.

Floral characteristics

Flowers of kuchila are white or greenish white and fragrant. They occur in many flowered terminal cymes. Calyx is five lobed, pubescent, and



Strychnos nux-vomica –
mature tree

small, about 2 mm in size, while corolla is salver shaped and has five lobes. Corolla tube is cylindrical, greenish white inside and slightly hairy near the base. Stamens are five in number and have short filaments. Fruit is an indehiscent berry, 5–6 cm in diameter, thick shelled, orange-red when ripe with fleshy pulp. Seeds are discoid, compressed, and coin like, concave on one side and convex on the other, and covered with fine grey silky hairs. Flowering occurs from March to May and fruits mature up to December.

Distribution

The species is indigenous to India and is distributed in moist deciduous forests throughout the tropical India.

Climate and soil

The plant can grow well in dry or humid tropical areas of the country. It grows over laterite, sandy, and alluvial soils.

Propagation material

Seeds are the best material for propagation of kuchila plant. The collected seeds are dried in the sun after removing the pulp. Preferably, fresh seeds should be used. The plant can also be propagated through cuttings.

Agro-technique¹

Nursery technique

- *Raising propagules* A nursery of the plant is raised in December or January in climatic conditions of South India. Seeds are sown in polybags of size 25 cm × 20 cm, filled with soil, sand, and FYM (farm-yard manure) mixture. Seeds are directly sown in the polybags after appropriate pretreatment. The polybags are watered regularly so as to keep them moist. The seeds germinate in about 20–30 days. Sometimes the germination may continue up to 45 days. The seedling

¹ Agro-technique study carried out by Aromatic and Medicinal Plants Research Station, Kerala Agricultural University, Odakkali, P O Asamanoor, Dist Ernakulam, Kerala – 683 549.

growth is very slow but roots grow very fast. For vegetative propagation, semi-hardwood cuttings can be prepared in early summer and kept under moist conditions after treating with commercially available rooting hormones. Rooting percentage is quite low, often less than 25%.

- *Propagule rate and pretreatment* About 1 kg seeds are required to raise 1 hectare of plantation. Seeds have low germination rate and fresh seeds of *Strychnos nux-vomica* lose viability early. Germination can be increased by treating the seeds with hot water (50 °C) for 6–12 hours prior to sowing.

Planting in the field

- *Land preparation and fertilizer application* The land is ploughed with disc harrow and tillers to achieve a fine tilth and make it weed-free and arable. Pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 5 m × 5 m and re-filled with mixture of soil and manure in 1:1 ratio. Appropriate quantities of sand may be added if the soil is heavy. About 10 kg of well-rotten FYM is applied in each pit at the time of its refilling.
- *Transplanting and optimum spacing* In South India, the seedlings are transplanted with the onset of South-west monsoon in May or early June. An optimum spacing of 5 m × 5 m is recommended, which gives a stand of 400 trees per hectare.
- *Intercropping system* The plant can be grown as a pure crop or herba-ceous crops can be grown with it as intercrops after the first year.
- *Interculture and maintenance practices* About 10 kg of well-rotten FYM is mixed in the soil during refilling of pits before planting. An additional 10 kg manure may again be applied to the soil around the plants during October–November at the time of weeding. A total of 20 kg FYM/plant/year in subsequent years results in best growth of plants. This is to be applied in two split doses in June–July and September–October. Supplementary doses of inorganic fertilizers (NPK



Strychnos nux-vomica – two-year-old sapling

[nitrogen, phosphorus, and potassium]) do not lead to any significant additional growth in the young plantations. The area around the basin of the plant should be kept weed-free by frequent weeding. The interspaces can be kept weed-free by hand weeding or spraying of herbicides like 0.8% paraquat or 0.4% glyphosate.

- *Irrigation practices* The crop needs no irrigation during the rainy season and in dry weather; saplings may be irrigated on alternate days, especially in the early years of growth. For matured trees, irrigation by ring method around tree base at a distance of 30 cm during summer months is beneficial.
- *Disease and pest control* No significant pest or disease is observed on the crop.

Harvest management

- *Crop maturity and harvesting* The tree has a long span of life, that is, 50–60 years. It takes about 15–20 years for the tree to initiate flowering. The seeds are collected December onwards when they mature. Fruits can be harvested periodically for many years.
- *Post-harvest management* Mature fruits are manually collected and seeds from them are extracted, washed, dried in shade, and stored for trade.
- *Chemical constituents* Strychnine and brucine are two most important and toxic alkaloids present in the seeds (0.4% and 0.6%, respectively). Other parts of tree have varying percentages of these two alkaloids—1.7% and 2.8% in root bark, 0.3% and 0.4% in root-wood, 0.9% and 2.1% in stem-bark, 0.5% and 0.01% in stem-wood, and 0.2% and 0.5% in leaves, respectively.
- *Yield and cost of cultivation* Considering a crop stand of 400 plants per hectare and average produce range of 50–75 kg of dry seeds per tree per year, a yield of 12–20 tonnes/hectare is estimated from a 20-year-old plantation annually. The estimated cost of raising 1 hectare plantation in the first year is Rs 100 000 only, while an amount of approximately Rs 6500 per hectare is incurred per year in subsequent years.

Market trend – 2006/07

- Market demand: Above 100 MT per year

Strychnos potatorum (Roxb.) D. Willde

Strychnaceae (Loganiaceae)

Ayurvedic name	Katak, Ambuprasada
Hindi name	Nirmali
Trade name	Nirmali
Parts used	Seeds, fruits, leaves, bark, and root



Strychnos potatorum –
fruit-bearing twig

Therapeutic uses

According to Ayurveda, the seeds of nirmali are acrid, alexipharmic, lithotriptic, and cure strangury, urinary discharges, and head diseases. According to the Unani system of medicine, seeds are bitter, astringent to bowels, aphrodisiac, tonic, diuretic, and good for liver and kidney complaints, gonorrhea, and colic. Roots cure leucoderma whereas fruits are useful in eye diseases, thirst, poisoning, and hallucinations.

Morphological characteristics

Strychnos is a medium-sized, glabrous tree of height 12–13 m. Stem is fluted and covered with black, thick, square to rectangular scales. Bark is 1.3–2 cm thick, black or brownish-black, corky, with very deep and narrow vertical, thin ridges, which easily break off. Branches are swollen at nodes. Leaves are about 5–7.5 cm long, nearly sessile, sub-coriaceous, ovate or elliptic, acute, glabrous and shining, spuriously three or five nerved, with lateral nerves springing from the lower part of the mid rib, nearly reaching the tip. The base rounded or acute. Petioles are very small.

Floral characteristics

Flowers are rather large, white, arranged in short, nearly sessile, axillary cymes, with very short peduncles and pedicels. Fruit is a berry, black when ripe, globose, 1–2 cm in diameter, whitish, shining, with short adpressed yellow silky hairs. Seeds are globose in shape. Population of nirmali is depleting fast due to self-non-generative mechanism in fruits. They are often decayed and are prone to fungal attack as soon as they fall. Flowering occurs in September–October, while fruiting occurs in December.



Strychnos potatorum –
a 15-year-old
mature tree

Distribution

The species is found all over dry mixed deciduous forests of peninsular India, more particularly towards eastern coasts.

Climate and soil

The species grows well in the red alluvial soil having good aeration. It thrives in the black cotton soil as well, but the growth is slow due to prevailing moist soil conditions in the rainy season. It can grow under wide range of temperature, between the mean daily maximum temperature in May (generally the hottest month), which varies from 32 °C to 40.9 °C, and the mean daily minimum temperature in January (the coldest month of the year), varying from 11 °C to 18 °C.

Propagation material

Seed is the best propagation material for growing the crop. Fruits may be collected in March and washed well with some gentle detergent. Seeds remain viable for about a year after collection.

Agro-technique¹

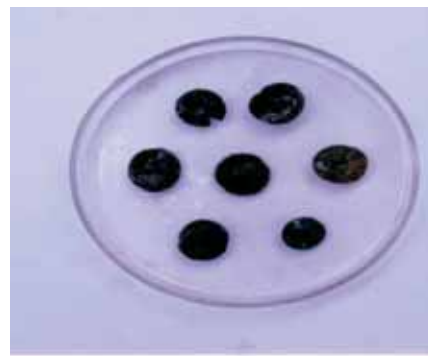
Nursery technique

- *Raising propagules* The seedlings are raised in polybags during February–March. Two to three seeds are sown in the polybags of 15 × 22.5 cm size, which are filled with the mixture of FYM (farmyard manure), soil, sand, and soilrite or vermiculite in equal quantities. It is

¹ Agro-technique study carried out by NWFP Division, Tropical Forest Research Institute, P O RFRIC, Mandla Road, Jabalpur – 482 021, Madhya Pradesh.

not advisable to sow the seeds in the beds due to the fact that the radicle grows deep down in the soil before the emergence of plumule and gets damaged during transplanting of seedlings, resulting in high mortality. The seeds of *Strychnos potatorum* require a 30–40-day period for complete germination. During the course of germination, adequate moisture must be maintained in the polybags. By adopting these techniques, 60%–65% germination of seeds can be obtained. Care should be taken to avoid root coiling by frequent shifting of polybags and other modern nursery techniques, since the tap root tends to develop very long. The seedlings so raised are maintained in the nursery for 1.5–2 years.

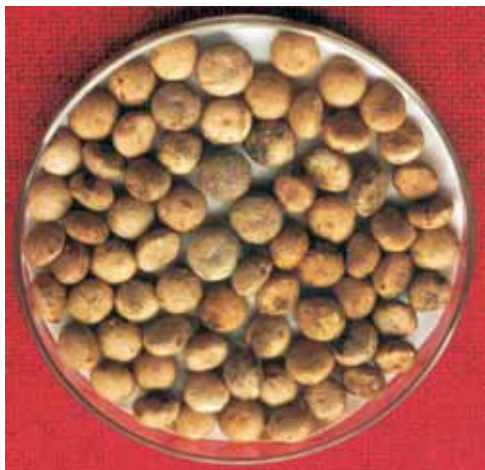
- **Propagule rate and pretreatment** Nearly 2 kg seeds are required to raise seedlings for 1 hectare of land. Fruits are washed well with some gentle detergent to remove the black coating covering the seeds. The seeds so treated are thoroughly washed with water and sown in polybags to raise planting stock. The seeds may also be washed in absolute alcohol for one to two minutes and dried at room temperature before being sown.



Strychnos potatorum – seeds with outer black coating

Planting in the field

- **Land preparation and fertilizer application** The land is prepared before plantation by removing unwanted herbs, shrubs, weeds, and so on. It is better to undertake ploughing to loosen the land mass and allow the unwanted weeds to dry up. Pits of size 45 cm × 45 cm × 45 cm are prepared during May at a spacing of 5 m × 5 m. The pits are filled with well-decomposed FYM, sand, and soil in the ratio of 1:1:1, and allowed to weather before undertaking plantations in June–July after the onset of the rainy season. Before transplanting, well-rotten FYM at the rate of 1.5–2 kg per pit is added. In the subsequent years, annual dose of 1.5–2.0 kg FYM per plant is necessary, especially for the first three years, to hasten the growth of the plants as well as for moisture conservation.
- **Transplanting and optimum spacing** The seedlings are transplanted at the plantation site during June–July. The seedlings thus raised often show dieback in the initial years of plantation and take more than three years for establishment after planting. An optimum spacing of 5 m × 5 m accommodates approximately 400 plants per hectare.
- **Intercropping system** Annual herbs of medicinal value can be grown as intercrop till the canopy of the trees is developed. Under the fully



Strychnos potatorum –
seeds washed with
detergent

grown trees, shade-loving plants like *Curcuma longa* (turmeric), *Curcuma angustifolia* (tikhur), *Alpinia galanga* (kulanjan), and essential oil-yielding grasses like lemon grass and palma rosea grass can be planted as intercrops.

- *Interculture and maintenance practices* Plants raised in the field require two timely weeding around the pits, particularly in the rainy season. Plantations in the black cotton soil require weeding and hoeing four times at monthly interval. The unwanted weeds between the rows are removed by scythe or sickle. If the tractor facility is available, cultivator ploughing is beneficial for removing the weeds as well as loosening the soil, the soil being black cotton soil.

This operation not only conditions the soil but also prevents cracking and consequent loss of moisture associated with the black cotton soil during the summer months.

- *Irrigation practices* Irrigation is required weekly in summer season and at an interval of 15–20 days in winter season. It is required only in the initial years of the establishment of plantation (that is, first two years).
- *Disease and pest control* The seeds are damaged during storage by fungi like *Alternaria*, *Fusarium*, *Aspergillus*, and *Rhizopus*, which affect the cotyledons and block the micropyle, thus reducing the germination capacity. The seeds require washing by a detergent to remove the coating of the fungal spores. The seeds are then treated with 0.5% bavistin to avoid further fungal damage. The seedlings show dieback, which can be checked by providing proper irrigation.

Harvest management

- *Crop maturity and harvesting* In natural forests, more than 15-year-old trees start bearing fruits. The production of fruits depends upon the age and the canopy of the tree. The bark can be extracted in patches from 10-year-old trees. It is extracted during November and December. Fruits can be harvested in January when they are fully matured.
- *Post-harvest management* The fruits and seeds are washed to remove the black coat, and dried in the sun. The fully dried seeds can then be packed in gunny bags. The extracted bark is washed properly to

remove the dust and other extraneous matter, and then spread on the floor initially for drying in sun and then in shade. The fully dried bark having less than 10% moisture can be packed in gunny bags and stored in well-ventilated rooms.

- *Chemical constituents* Diaboline (major alkaloid) and its acetate, brucine, loganin, strychnine, mannose, sucrose, β -sitosterol, stigmasterol, oleanolic acid, and saponin are reported from the seeds. Isomotirol, mixture of sitosterol, stigmasterol, and campesterol have been isolated from leaves and bark.
- *Yield and cost of cultivation* About 15–20 kg dried seeds are obtained from fully grown 20–25-year-old tree. This gives a per hectare yield of 6750–9000 kg of seeds. An approximate expenditure of Rs 90 000/hectare is incurred on raising the crop initially and maintaining it for 10 years.



Strychnos potatorum –
seedling establishment in
polybags

Market trend – 2006/07

- Market demand: Above 100 MT per year

***Swertia chirata* (Roxb. ex Flem.) Karsten**

Gentianaceae

Ayurvedic name	Kirata tikta
Unani name	Chirata
Hindi names	Chirayata
Trade name	Chirayata
Part used	Whole plant



Swertia chirata

Therapeutic uses

S*wertia chirata* is a bitter tonic, carminative, laxative, anti-pyretic, febrifuge, anti-periodic, anti-inflammatory, stomachic, and anti-helmintic. It is used in treating piles, skin diseases, ulcers, and diabetes.

Morphological characteristics

Chirayata is an erect, annual, branched herb, up to 1.5 m high. stem is robust and cylindrical below, but four-angled upwards. Leaves are broadly lanceolate, opposite, sessile, about 10 cm long, acute at tip, and five-nerved.

Floral characteristics

Inflorescence is a large leafy panicle. Flowers are numerous, greenish-yellow, and tinged with purple. Sepals and petals are four in number. Each petal lobe has a pair of green, honey-secreting glands. Capsules are minute, ovate, about 6 mm in diameter, and sharp pointed. Seeds are smooth and many angled.

Distribution

The species is distributed throughout the temperate Himalayas, between 1200 m and 3000 m altitudes, extending from Kashmir to Bhutan. The species may be cultivated at lower elevations in north-eastern Himalayas as compared to western Himalayas.

Climate and soil

The plant inhabits temperate regions in the Himalayas. Loamy to sand-loam, friable, and well-drained soils are suitable for its cultivation. The soil should be enriched with FYM (farmyard manure), and if soils are clayey, addition of sand is recommended. The crop can be grown in areas having mild rainfall (100 cm) in rainy season and in areas with long cold winter, receiving snowfall frequently.



Swertia chirata

Propagation material

The plant can be successfully propagated through seeds. Completely mature seeds may be collected in autumn season.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop is grown through nursery-raised seedlings. Sowing is done in October–November, as seeds sown in March–April show very poor germination and low survival rate.

Seeds of chirayata germinate well under nursery conditions in the media having FYM (farmyard manure), sand, and soil in 2:2:1 ratio. Seeds are sown in rows 10–15 cm apart and covered with 0.5-cm thick layer of sand or fine soil. It takes about 25–28 days for complete germination to take place under nursery conditions.

- *Propagule rate and pretreatment* About 200 g of seeds are required for raising planting stock for 1 hectare of land. About 50 000 plants would be planted in 1 hectare at a spacing of 45 cm × 45 cm, when planted as a

¹ Agro-technique study carried out by

- The Department of Agroforestry and Environment, College of Agriculture, CSK HPKV, Palampur – 176 062, Himachal Pradesh.
- S K University of Agricultural Science and Technology, Srinagar, Jammu and Kashmir

pure crop. Chilling treatment of seeds at 3 °C or below for 15 days is required for good germination in the nursery.

Planting in the field

- *Land preparation and fertilizer application* Land is prepared by ploughing two to three times, followed by harrowing and planking to have a fine tilth as well as conserve moisture. Application of vermicompost in the soil @ 3.75 tonnes/hectare and forest leaf litter @ 2 tonnes/hectare at the time of field preparation is recommended.
- *Transplanting and optimum spacing* Transplanting of seedlings is done in March–April, and the seedlings are planted with the ball of earth at a distance of 45 cm × 45 cm in the field.
- *Intercropping system* The plant can be intercropped with potato, as both species can be harvested within six to eight months, and the time of sowing as well as harvesting of both species is almost the same. In open fields, potato can be planted on raised beds, while *Swertia* is planted in the interspaces. However, it is often preferred as a pure crop in cultivation.
- *Interculture and maintenance practices* FYM @ 10 tonnes/hectare or vermicompost @ 3.75 tonnes/hectare and forest litter @ 2 tonnes/hectare are recommended as a basal dose. Thereafter, no other fertilizer is required. Weeding along with hoeing is done manually once in a month.
- *Irrigation practices* A proper drainage system should be ensured by digging channels around the fields, especially during rains, to protect the plant against stagnating moisture. Alternatively, raised beds should be prepared. The field should be irrigated as and when required, may be every alternate day during summers and weekly in winters.
- *Disease and pest control* No specific insect/pest and disease have been observed on the crop.



Swertia chirata –
a young sapling in
the field

Harvest management

- *Crop maturity and harvesting* Plants are collected when the capsules are fully formed during summer or in October–November. Plants flower within six to eight months, and thus provide yield and seeds for propagation every year. The whole plant is collected and dried. When

harvested early, some plants can be left in the fields so that seeds mature, which can be collected in October for the purpose of growing next crop.

- *Post-harvest management* The collection/harvesting of seeds is difficult due to their very small size. Therefore, a piece of cloth should be placed below the plant while harvesting. The seeds, after air drying, are stored in polythene-lined small jute bags to be used as germplasm for next season. After harvesting, the plants should be dried in shade and packed accordingly. However, plants harvested post-fruiting are considered to be of inferior quality with reduced active principles.
- *Chemical constituents* The plant contains a bitter glycoside chiratin, which on hydrolysis yields two bitter principles: ophelic acid, an amorphous bitter hygroscopic principle, and chiratogenin, a yellow bitter glycoside, insoluble in water.
- *Yield and cost of cultivation* About 3.75 tonnes/hectare of dried herb-age yield is estimated in cultivation in two years. The estimated cost of cultivation is Rs 82 500/hectare.

Market trend – 2006/07

- Market demand: Above 100 MT per year

Terminalia arjuna Wt. and Arn.

Combretaceae

Ayurvedic name	Arjuna
Unani name	Arjun
Hindi name	Arjun
Trade name	Arjun chhal
Part used	Stem-bark



Terminalia arjuna

Therapeutic uses

The bark of Arjun is astringent, sweet, acrid, cooling, aphrodisiac, urinary astringent, and expectorant, but, chiefly used as cardio-tonic as it improves blood supply to heart. It is also useful in ulcer treatment, fractures, cirrhosis of liver, ischaemic heart disease, and hypertension.

Morphological characteristics

Arjuna is a large deciduous tree with spreading crown and drooping branches. It attains a height of up to 35 m. Its bark is thick, grey to pinkish green, smooth, thin, coming off in irregular sheets. Leaves are usually sub-opposite, 10–15 cm long, and 4–7 cm broad; base is rounded or heart shaped, often unequal sided; veins are reticulate.

Floral characteristics

Flowers are sessile and occur in simple or paniced spikes. Calyx is glabrous and has five short triangular lobes. Fruit is a fibrous-woody

drupe, about 2.5–5 cm in size. It is dark brown when mature and has five hard, projecting, veined wings. Flowering occurs from May to June, while fruits mature from January to March.

Distribution

The species is common in mixed dry deciduous tropical forests throughout the greater part of India. It is often found along the water courses, cultivated elsewhere as avenue tree. It is a common avenue tree in many cities, such as Delhi.



Terminalia arjuna
– flowers and
seeds

Climate and soil

The plant naturally occurs in subtropical and tropical moist regions of the country. The tree prefers alluvial loamy or black cotton soils, which are loose, moist, fertile, and have good drainage and water holding capacity. River bank soils, streams, and ravines are its natural habitat. The plant also survives in open sunny and low rainfall areas.

Planting material

Propagation gives best result when seeds are used. The seeds can be collected

in early summer from trees that are more than six-year-old. Ripe fruits are collected in March either by lopping the branches or from the ground previously swept clean. The seeds are viable for at least one year when stored in sealed tins.

Agro-technique¹

Nursery technique

- *Raising propagules* Seeds are sown in nursery beds in early summer, usually just after collection. Germination commences in 8–12 days,

¹ Agro-technique study carried out by

- Centre for Advance Studies in Botany, University of Madras, Guindy Campus, Chennai – 600025, Tamil Nadu.
- Dr Panjab Rao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.

and is completed in seven to eight weeks. Germinated seeds may be transplanted in polybags with clay, manure, and sand in equal ratio. Alternatively, the pretreated fruits are directly put in polythene bags in April, with half of the fruit above the soil. Pre-germinated seeds are preferred to save time and ensure uniform germination. The seedlings are sensitive to drought during the germination stage as well as during the growth stage.

■ *Propagule rate and pretreatment*

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



Terminalia arjuna
– infestation by
insect

Planting in the field

- *Land preparation and fertilizer application* Preparatory tillage is done in the field, which should be levelled, and pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 6 m × 6 m. About 10 kg FYM (farmyard manure) and NPK (nitrogen, phosphorus, and potassium) @ 75:50:30 g are added per pit and thoroughly mixed with soil as basal dose.
- *Transplanting and optimum spacing* About 10-month-old saplings are transplanted in the field in pits in July–August at a spacing of 6 m × 6 m. In all, about 280–300 saplings are required per hectare.
- *Intercropping system* The crop can be grown as a sole plantation in early growth stage or as a border of other crops. Climbers like *Tinospora cordifolia* (Giloy), *Marsdenia tenacissima* (Moorva), *Operculina turpethum* (Trivrit), *Operculina petaloidea* (Nishoth), and *Celastrus paniculata* (Malkangni) may be planted beneath the fully grown tree that serves as host for these climbers.



Terminalia arjuna
– bark removal

- *Interculture and maintenance practices* About 10 kg FYM + 75:50:30 g NPK per plant are applied as a basal dose at the time of transplanting. Further top dressing is given with 50 g nitrogen per tree after three months. Field should be kept weed-free.
- *Irrigation practices* Irrigation is recommended at 15-day intervals in the summer season for young plantations. Irrigation is generally not done during the winter season in the peninsular region.
- *Disease and pest control* Aphids (*Aphis* sp.) attack tender leaves and form galls on it. Spraying of biopesticides like Azadirachtin controls this pest.

Harvest management

- *Crop maturity and harvesting* The Arjun tree starts flowering from sixth year onwards. Lifespan of the tree is 50 years and above. Bark is repeatedly scrapped in winter season. The bark is removed from well-grown trees, preferably 10th year onwards, in spiral or vertical strips of not more than 5 cm width and 25 cm length.
- *Post-harvest management* The collected bark is dried in well-ventilated shade and stored in boxes or polybags in dry and airy locations.
- *Chemical constituents* The tannin cardiac glycoside is reported from bark as well as fruit. The usual range is 20%–24% in stem bark and 7%–20% in fruit.
- *Yield and cost of cultivation* About 500 kg dried bark can be obtained from 1 hectare of plantation every year from the 10th year. The cost of cultivation for the first year is Rs 11 000. The annual maintenance cost is about Rs 3000 only. Total input cost is thus about Rs 45 000 per hectare for 10 years.

Market trend – 2006/07

- Market price: Rs 8–13 per kg
- Market demand: 400 tonnes

Terminalia chebula Retz

Combretaceae

Ayurvedic name	Haritaki
Unani name	Halela zard
Hindi name	Harar, Harra, Harad
Trade name	Harar, Chebolic myrobalan
Parts used	Dried immature fruits, generally the fruit rind



Terminalia chebula – harad

Therapeutic uses

The harar fruit is antiseptic, diuretic, astringent, cardi tonic, and febrifuge in action. It is a safe and effective purgative, laxative, and alterative. It is an important ingredient of 'triphala', an Ayurvedic formulation used in the treatment of constipation, colic pain and kidney dysfunctions, eye diseases, and sore throat. Unripe fruits are more purgative and the ripe ones are astringent.

Morphological characteristics

Chebolic myrobalan is a large tree with umbrella-shaped crown and crowded branches, growing up to 25 m in height, with a bole girth of 2.5 m. Stem bark is dark brown. Leaves are sub-opposite, ovate or oblong-ovate, 8–20 cm long, and deciduous during cold season. The species is identified by dark brown bark exfoliating in irregular woody scales and by the presence of a pair of large glands at the top of the petiole.

Floral characteristics

Flowers are yellowish-white and emit a strong offensive odour. They occur in spikes arising from upper axils or in small terminal panicles. Fruit (drupe) is yellowish-green, obovoid or ellipsoid, hard, and five to six ribbed when dry. Seed is globose, generally 2–6 cm long, and pale yellow in colour. Flowering occurs in May–June, while fruiting occurs in winter (November–March).

Distribution

The species is found mostly in mixed dry deciduous forests and is frequent in tropical and subtropical zones, mostly in hilly tracks. The plant prefers tropical environment, ascending in the sub-Himalayas zones up to an elevation of 1500 m.

Climate and soil

In the natural habitat of the species, temperature ranges between 36 °C and 45 °C, and rainfall ranges from 1200 mm to 3000 mm per annum. It is capable of growing on different types of soils, but attains best development on loose well-drained soils, such as sandy loam as well as clayey loam. It grows in open areas in the forest, forming top to middle canopy.

Propagation material

Seed is the most appropriate material for this plant's propagation. Fruit is collected in summer in May–June. Generally, two good years are followed by one or two poor ones. Fruits are collected when they turn yellow. The seeds can be collected as soon as they fall on the ground, and are dried under shade. The seeds can be stored in gunny bags for one year, but fresh seeds germinate quicker.

Agro-technique¹***Nursery technique***

- *Raising propagules* The saplings are raised from seeds in a nursery in July with the onset of monsoon season. Seeds may be sown in prepared beds or polybags. Germination is slow, but may be improved by pretreating the seeds. The soil in beds and polybags should have

¹ Agro-technique study carried out by Dr Panjab Rao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.

sufficient proportion of organic manure, at least in the ratio of 2:1. Sometimes, pre-germinated seeds are used for sowing to get better survival rate. Generally, large-sized polybags, at least 35 cm × 22 cm, are used, since the root growth is comparatively faster and the seedlings are required to be kept in the nursery for at least one year. However, the growth of the seedlings is quite slow. The nursery should be partially shaded against the sun.

- *Propagule rate and pretreatment* About 5 kg seeds are required for raising stock for planting in 1 hectare of land. The depulped seeds should be either treated by fermentation process for a period of 15–20 days, or the seeds may be clipped at their broad end and then soaked in water for a period of two days before sowing in the nursery beds. Alternatively, seeds may be mixed with cow dung slurry and kept in pits for one to two weeks.

Planting in the field

- *Land preparation and fertilizer application* The land is tilled and levelled properly to make it porous and friable. Pits of size 60 cm × 60 cm × 60 cm are dug at a spacing of 6 m × 6 m. The soil of each pit is mixed with 15 kg FYM (farmyard manure) and a mixture of NPK (nitrogen, phosphorus, potassium) @ 75:30:30 g and refilled before transplanting of seedlings.
- *Transplanting and optimum spacing* Transplantation of one-year-old saplings is done in the next monsoon. A spacing of 6 m × 6 m enables a crop stand of 280–300 plants per hectare.
- *Intercropping system* Since this is a long-term crop, intercropping with short duration crops is preferable, particularly with climbers like Gudmar, Malkangni, Guduchi, Ratti, and so on as in *Terminalia arjuna*. Shade-loving crops like *Curcuma*, *Zingiber*, and *Alpinia galanga* may also be intercropped.
- *Interculture and maintenance practices* A small dose of organic manure may be added every year for the first three to four years to ensure good growth of young plants. Compact soil of pits is made porous by hoeing and well-decomposed FYM @ 3 kg per plant is mixed in soil. Only manual weed control is recommended. The weeds may be kept in check with the help of scythes or tractor-operated cutters.
- *Irrigation practices* Irrigation in pit areas is required in the initial three to four years, depending on the soil moisture and season. The plants may be irrigated at least once a week in summers.

- *Disease and pest control* The plants are able to survive attacks of seasonal insects and pests. Anti-termite treatment with Chlorpyrifos 20% EC should be given in termite-prone areas.

Harvest management

- *Crop maturity and harvesting* Flowering and fruiting generally commence after 8–10 years of planting in the summer season. The tree starts yielding fruits at this time. The trees live for more than 50 years and continue to yield fruits every year.
- *Post-harvest management* The collected fruits are well dried in shade for a few days, with moisture content not more than 10%, and stored in well-ventilated containers/baskets in damp-proof, cool rooms.
- *Chemical constituents* The main constituents are anthraquinone glycoside, chebulinic acid, tannic acid (20%–40%), and vitamin C in fruits. Arachidic, behenic, linoleic, palmitic, and stearic acids are also found in the fruits.
- *Yield and cost of cultivation* Approximately 40–50 kg of dry fruits are obtained per tree per year after it attains six years of age. This gives an average yield of about 12.6 quintals/hectare. The estimated cost of cultivation is Rs 40 000 per hectare in the first year.

***Tinospora cordifolia* (Willd.) Miers ex HK. f. & Th.**

Syn. *Menispermum cordifolium* Willd.

Menispermaceae

Ayurvedic name	Amrita, Guduchi
Unani name	Giloe
Hindi name	Giloe, Gurcha
Trade name	Giloe
Parts used	Stem, root, whole plant



Tinospora cordifolia –
a close view

Therapeutic uses

Giloe is a tonic and has alterative, diuretic, and aphrodisiac properties. It is a febrifuge used in malarial and chronic fever. It is also a liver tonic. The plant is used in general debility, loss of appetite, fevers, urinary disorders, diabetes, rheumatism, and dyspepsia. Fresh plant is more efficacious than dried plant.

Morphological characteristics

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

Floral characteristics

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

Distribution

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



Tinospora cordifolia –
plant

Climate and soil

The plant grows in subtropical and tropical climate. Light medium sandy loam soil rich in organic matter, and with adequate drainage, is suitable for its cultivation. It does not tolerate high rainfall or waterlogged conditions.

Propagation material

Stem cuttings are the best planting material for raising commercial crop. The cuttings can be obtained from mother plants in June–July.

The plant can also be raised using seeds. Seeds take almost more than double the time to mature and yield the same quantity of drug.

Agro-technique¹

Nursery technique

- *Raising propagules* The stem cuttings are sown directly in the field. Cuttings are obtained from older stems with nodes. Cuttings should be sown within 24 hours of their removal from the mother plant. Meanwhile, they should be half-dipped in water vertically.
- *Propagule rate and pretreatment* About 2500 cuttings are required for plantation in 1 hectare of land. No specific treatment is required before sowing.

¹ Agro-technique study carried out by Jamia Hamdard, Hamdard Nagar, New Delhi 110 062.

Planting in the field

- *Land preparation and fertilizer application* The land is ploughed, harrowed, and made weed-free. A basal dose of FYM (farmyard manure) @ 10 tonnes per hectare and half dose of nitrogen (75 kg) are applied at the time of land preparation.
- *Transplanting and optimum spacing* The stem cuttings with nodes are sown directly in the field. An optimum spacing of 3 m × 3 m is recommended for better yield. The plant requires support to grow, which can be provided by raising wooden stakes or trellis. Already growing shrubs or trees can also support the plant.
- *Intercropping system* Being a large twiner, it needs a host to twine and covers the host in a very short period. If the stem cuttings with aerial roots are thrown over trees, they start growing and strike roots in the ground.
- *Interculture and maintenance practices* Follow-up dose of 10 tonnes of FYM with 75 kg nitrogen (20% nitrogen content) is recommended. About two to three weeding and hoeings are required for good growth of twiner. The inter-row spaces between plants should be kept weed-free by frequent weeding and hoeing, as the plants may get suppressed by weeds, especially during early stages of growth.
- *Irrigation practices* The crop is grown under rain-fed conditions. However, occasional irrigation during extremes of cold and hot weather may help the crop survive adverse conditions.
- *Disease and pest control* No serious insect pest infestation or disease has been reported in this crop.



Tinospora cordifolia –
crop view

Harvest management

- *Crop maturity and harvesting* The stem is harvested during autumn when it develops to a diameter of more than 2.5 cm. Basal part is left for further growth.
- *Post-harvest management* The stem should be cut into small pieces and dried in shade. It can be stored in gunny bags, and kept in cool and



Tinospora cordifolia –
fruits and flowers



airy storage godowns. Stem bark peels off even by touch, thus stem should be cut very cautiously as peeled stem decays very soon.

- *Chemical constituents* The stem contains bitter substances, of which tinosporine, a bitter principle, is a marker compound. Other compounds include gilonin, gilosterol, gilenin, and furano-diterpenes.
- *Yield and cost of cultivation* The plant yields about 1500 kg of fresh woody stem, reduced to 300 kg of dry weight per hectare in about two years. The per hectare cost of cultivation is estimated to be Rs 27 600 per hectare.

Tylophora indica (Burm. f.) Merr.

Syn. *Tylophora asthmatica* Wight & Arn.

Asclepiadaceae

Ayurvedic name	Arkaparni
Unani name	Antamul
Hindi name	Antamool, Damabuti
Trade name	Antamool, Indian ipecac
Parts used	Aerial parts (mostly leaves), roots



Tylophora indica

Therapeutic uses

Antamool is used in treating bronchial asthma and allergic rhinitis. It has diaphoretic and expectorant properties. The dried leaves and roots are often used as substitute for Ipecacuanha (*Cephalis ipecacuanha*).

Morphological characteristics

The *Tylophora* species is a profusely branching climber, which attains a length of 15 m or more. It has short, knotty, 3–4-cm-thick rootstock. The roots are numerous, fine, up to 15 cm long, very brittle and consist of fibres or fibrils. Leaves are ovate to orbicular, elliptic–lanceolate, shining green, leathery cordate at base, and 3–10 cm long. The climber can be recognized by its ovate–oblong, shiny leaves and divaricated fruits.

Floral characteristics

Flowers are small, greenish yellow outside and purplish within. They are arranged in umbellate racemes. Calyx is coarsely hairy outside. Corolla is greenish-yellow or greenish purple, 5–6 mm long. Fruit is a striated, divaricated follicle up to 10 cm long and 1–2 cm broad. Seeds are ovate and elongate into 2–2.5-cm-long coma. Flowering is usually abundant, but fruit setting has scarcely been noticed under North Indian climatic conditions. Flowering and fruiting occur from October to December.



Tylophora indica –
young plant

Distribution

The species is common in peninsular India, extending to Bihar, Orissa, West Bengal, and north-eastern states. It is found growing wild mostly in forests in plains and hills up to a height of 1000 m throughout the eastern and southern parts and subtropical regions.

Climate and soil

Annual rainfall of about 1000–1500 mm is ideal for *Tylophora* plant. It prefers partial shade conditions of the forests and soil rich in humus. It needs the support of host vegetation for climbing to a sunny location. It does well when cultivated in plains. For its cultivation, loamy soil rich in organic matter is preferable. However, it can grow on soils ranging from sandy to clayey

and supplemented with FYM (farmyard manure). Ambient conditions of temperature and sunlight are desirable for the growth of the plant.

Propagation material

The seeds have a high germination percentage (more than 90%) but fruit set is rare. Vegetative propagules as cuttings from stem coppices or ground layering can be prepared in spring season. Success rate of these propagules is high. The mature follicles containing seeds can be collected at the end of the cold season.

Agro-technique¹

Nursery technique

- *Raising propagules* Plants can also be raised through seeds or using stem cuttings, ground layering, and root coppices from the mother plants in March. Seeds should be sown in well-prepared nursery beds or polybags containing fine soil with good organic content. Seeds start germinating in 10 days and germination is completed within three weeks. Vegetative propagules sprout in three to four weeks.
- *Propagule rate and pretreatment* About 250 g of seeds are required to raise a nursery for planting in 1 hectare of land. These seeds are sufficient to be sown in six beds of size 10 m × 1 m to raise about 20 000 seedlings. Seeds should be treated with Dithane M-45 before sowing.

Planting in the field

- *Land preparation and fertilizer application* Land is ploughed and harrowed twice to turn the soil and bring it to a fine tilth. Once it is made weed-free, it can be planked for transplantation of the crop. The entire quantity of FYM (farmyard manure; 20 tonnes per hectare), phosphorus (50 kg per hectare), potash (40 kg per hectare), and half of nitrogen (45 kg per hectare) are applied as basal dose at the time of field preparation.
- *Transplanting and optimum spacing* Three-month-old plantlets are ready for transplanting in the main field. Transplanting is done during the rainy season. The crop gives maximum yield if row-to-row and plant-to-plant distance is maintained as 75 cm × 75 cm. About 17 500 propagules per hectare are required as a pure crop, while about 10 000–14 000 plants may be required in an intercropping system.
- *Intercropping system* *Tylophora* is a perennial crop, which can last for at least five years in the field. Hence, ideally, it can be intercropped with non-climbing summer and winter vegetables. Summer vegetables like



Tylophora indica –
flowering and
fruiting

¹ Agro-technique study carried out by National Institute of Pharmaceutical Education and Research, Sector 67, S A S Nagar, Mohali, Punjab –160 062.



Tylophora indica –
transplanted crop

okra and brinjal and winter vegetables like cauliflower, radish, spinach, turnip, and coriander can be successfully grown between the rows of the plant. Provision of host may be made through trees or stakes. *Jatropha* and guava have been found to be the best hosts.

- *Interculture and maintenance practices* Besides the recommended basal dose, rest of the nitrogen (45 kg per hectare) should be applied in two equal split

doses, one in March and the other after six months, that is, in September. Broadcasting is the best method of manure application. Fertilize application should always be followed by irrigation. Staking should be done to the crop to allow support for the growth of the plant. Weeding is required once a month. Plants should be earthed up and stakes should be checked after every three months. The first dose of yearly nitrogen supply should be given in early spring while the second dose should be applied after harvesting leaves in September/October.

- *Irrigation practices* It is evident from the field experiments that *Tylophora* can tolerate drought up to some extent. It requires 15–18 irrigations per year at an interval of 20 days, depending upon the moisture availability and water holding capacity of soil.
- *Weed control* Atrazine 50% WDP @ 0.1% is mixed in soil at the time of land preparation or before weed emergence. At least two to three manual weeding are required in the crop at an interval of one month. However, weeding is required more frequently during the monsoon season.
- *Disease and pest control* Insects of the order Coleoptera seriously affect the crop. The insects feed on the young leaves when the temperature and humidity are high. They can be taken care of by spraying the crop with methyl parathion @ 2 ml/litre of water. About 1 litre of the insecticide is sufficient to control the disease in 1 hectare of land.

Harvest management

- *Crop maturity and harvesting* The flowering appears in the second year of growth. The leaves should be harvested once a year when the plant attains a height of 1.5–2.5 m. It is, however, not economical to harvest

a plant of less than one year of age, as it adversely affects the plant growth and subsequent yield. The crop is cut 10–15 cm above-ground level with the help of sickle. October is the best time for harvesting.

- *Post-harvest management* The harvested crop is spread out on HDPE (high density polyethylene) sheets in open sunny locations for a day. Thereafter, the material is dried in shade for 8–10 days. The dried material should be stored in clean gunny bags and kept in well-ventilated space. Storage for long periods may lead to the deterioration in the quality of the raw material.
- *Chemical constituents* *Tylophora indica* contains 0.2%–0.3% alkaloids but the alkaloid content (w/w) in commercial samples is standardized to about 0.1% of tylophorine in the sun-dried material.
- *Yield and cost of cultivation* Gross maximum dry matter yield of aerial parts averages about 3.25–3.75 tonnes/hectare. The cost of cultivation is approximately Rs 88 000 per hectare per annum in the first year. From the second year, the cost reduces to Rs 10 000 per hectare per annum.



Tylophora indica –
staking

Uraria picta Desv.

Fabaceae

Ayurvedic name	Prisni parni
Unani name	Dabra
Hindi name	Pithavan, Dabra
Trade name	Dabra
Parts used	Root and whole plant



Uraria picta

Therapeutic uses

The *Uraria* species is useful in quick healing of bone fractures. It is used as a cardio and nerve tonic and has anti-inflammatory, expectorant, and diuretic properties. The root of the plant is one of the ingredients of 'dasamoola' in Ayurveda.

Morphological characteristics

Dabra is an erect, undershrub, 60–75 cm tall, with several branches. Leaves are generally three to five in number, up to nine-foliate. Leaflets are imparipinnate, linear-oblong, obtuse, mucronate at apex, white clouded above and pubescent below.

Floral characteristics

Purple flowers occur in dense, cylindrical racemes with bracts; calyx teeth are lanceolate and the corolla is papilionaceous. Pod (fruit) has three to

six joints. Flowering occurs from July to September, while fruits mature in December–January.

Distribution

Uraria picta is not a very common species, but occurs throughout tropical India, extending up to 300 m altitude in Tarai region of the Himalayas.

Climate and soil

The plant can grow well in tropical and subtropical areas. Loam to clay-loam soil is suitable for its cultivation. It can tolerate a soil pH up to 8.5.

Propagation material

The crop can be raised successfully by seeds, which can be collected in December–January.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop can be raised by sowing seeds in nursery in April–June, as direct sowing in field results in very poor crop stand and yield. The seed may be broadcast in well-prepared nursery beds of appropriate size (10 m × 1 m). The beds should be watered lightly and regularly. The seeds germinate easily, and the germination is completed within 10 days.
- *Propagule rate and pretreatment* About 4–5 kg seeds are required for raising stock for planting in 1 hectare of land. Overnight soaking of seeds in water before sowing improves germination.

Planting in the field

- *Land preparation and fertilizer application* The land should be prepared by deep ploughing followed by harrowing twice and levelling. Organic manure, preferably FYM (farmyard manure), is recommended @ 10 tonnes/hectare at the time of field preparation. DAP (di-ammonium phosphate) @ 100 kg/hectare is also recommended as basal dose. Mycorrhizal association has been found to be beneficial for the crop. Proper drainage should be ensured in the field to avoid waterlogging, which causes death of plants.

¹ Agro-technique study carried out by National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226 001, Uttar Pradesh.

- *Transplanting and optimum spacing* Transplanting of 50–60-day-old seedlings is done in the well-prepared field on ridges. Approximately, 111 000 saplings are accommodated in 1 hectare of land at an optimum spacing of 30 cm × 30 cm.
- *Intercropping system* It can be grown as a mixed crop with *Desmodium gangeticum* and other herbs in inter-row spaces. In case of intercropping, spacing and row distance are increased.
- *Interculture and maintenance practices* Manual weeding is recommended twice at 25, 45, and 90 days after transplantation. Earthing-up of plants is done at the time of second weeding.
- *Irrigation practices* Irrigation may be provided immediately after transplanting. Thereafter, it may be repeated at an interval of 12–15 days in summer (May–June), depending on monsoon rains.
- *Disease and pest control* No serious disease or insect pest has been observed in this crop. The plants show physiological stress due to low temperature (in extreme winter) and water stagnation due to excess rain, which may cause stunted growth, curling, and browning of leaves. The plants easily recover after the stress period is over.

Harvest management

- *Crop maturity and harvesting* The plant roots can be harvested in December or May after flowering, which occurs twice. However, for good yield, roots may be dug/harvested in May–June after about 10 months of growth. Watering the crop is stopped three weeks before the intended harvest time. Whole plants are dug out with spades. Roots are separated from the rest of the plant and cleaned well.
- *Post-harvest management* The washed and cleaned root parts are dried in shade. The dried produce is packed in gunny bags and stored in humidity-free conditions.
- *Yield and cost of cultivation* The yield of dry roots is approximately 3–4 quintals/hectare, while the dry weight of herbs is about 4–5 quintals/hectare. An estimated expenditure of Rs 80 000 per hectare is incurred on the cultivation of the crop with 10 months' duration.

***Valeriana jatamansi* DC**

Syn. *Valeriana wallichii* DC

Valerianaceae

Ayurvedic name	Tagar
Unani name	Tagar
Hindi name	Mushkbala, Tagar
Trade name	Mushkbala, Tagar
Parts used	Dried roots and rhizome



Valeriana jatamansi

Therapeutic uses

Rhizomes and roots of tagar have antipyretic and diuretic properties, and are used as hepatic and nervine tonic. They are cooling, stimulant, hypotensive, and sedative. They are useful in epilepsy, hysteria, hypochondriasis, nervous unrest, and skin diseases.

Morphological characteristics

Valeriana is an aromatic herb up to 50 cm high. Rootstock is thick, with 6–10 cm thick, long fibrous roots knotted by uneven circular ridges. The plant has several stems, that are 15–45 cm long. Leaves are of two types, radical and cauline. Radical leaves are cordate–ovate, 2.5–8 cm, toothed or sinuate, long stalked, while cauline leaves are few, small, entire or lobulate.

Floral characteristics

Flowers are white or tinged with pink and occur in flat-topped corymbose clusters on erect, nearly leafless peduncles. Flowers are

unisexual; male and female flowers appear on different plants. Corolla is funnel shaped with five lobes. Fruits are crowned with a persistent papus-like calyx. Flowering and fruiting occur in March–April. Seeds ripen in April–May.

Distribution

The species is frequent in temperate Himalayas, from Kashmir to Bhutan and Khasi Hills. It grows naturally at altitudes of 1800–3000 m in north-western Himalayas and between 1200 m and 1800 m in Assam and North-East India.

Climate and soil

The plant prefers a temperate climate. It grows well in moist loamy soils having partial shades of trees like deodar and banj oak on north-facing hillocks. It can grow over a wide range of soils, with slopes up to 20%, provided that it gets sufficient water and nitrogen nutrient. However, it thrives best in humus-rich, heavy loam soils, with adequate moisture and good drainage. To harvest roots in an easy and efficient manner, a relatively loose soil with low clay content is desirable. Water stagnation in the beds should be avoided, as the roots of the plant are sensitive to rotting.

Propagation material

Valeriana can be propagated through seeds or by using portions of the root-stock, preferably during rainy season. It is normally advisable to raise the crop through suckers because crop raised through seeds takes more time to mature. Seeds can be collected in April–May and sown immediately in nursery.

Agro-technique¹

Nursery technique

- *Raising propagules* For raising the crop through rootsuckers, a separate mother nursery should be maintained. Fresh rooted suckers can be

¹ Agro-technique study carried out by

- NBPGR (National Bureau of Plant Genetic Resources), Research Station Shimla, Himachal Pradesh.
- Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh.
- Dr Y S Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.

taken from the mother nursery and planted in the field. New suckers should be planted in the nursery in June or with the onset of monsoon. Rooted suckers taken from mother nursery are planted in the field in rows at a depth of 4–5 cm. If the crop is to be raised through seeds, then nursery is prepared separately in April–May. Seeds germinate in 15–20 days and are pricked into polybags for further growth. The seedlings are ready for planting in about three months' time.

- *Propagule rate and pretreatment* About 2.5–3 kg seeds are required to raise planting stock for 1 hectare of land. No specific treatment of seeds is required. However, rootstock is preferred as propagules.

Planting in the field

- *Land preparation and fertilizer application*
In order to have optimum root yield, pulverization of the soil is necessary. A minimum of three ploughings are recommended. If the crop is to be raised through rhizomes/rootsuckers, first ploughing is done with soil-turning plough in June. The field should be left fallow for 15–20 days so that crop residues buried in the soil get rotten and the soil also receives appropriate sunlight. Before second ploughing, well-decomposed FYM (farmyard manure) should be spread uniformly and properly mixed in the field. Second ploughing should be done in the end of June and third ploughing should be done with first showers of monsoon. Planking and harrowing should be done after second and third ploughing to break the clods and make the soil friable with good tilth. When the crop is raised through seeds, the preparation of land should be deferred by about one month. The crop requires fertile and humus-rich soil. A dose of 35–40 tonnes/hectare of FYM, applied in split doses, is found to be the best. The first dose of about 25–30 tonnes is applied at the time of field preparation and the rest is applied in the following months of June–July when earthing-up is done. The FYM dose is kept slightly higher because no inorganic fertilizer is applied to the crop.



Valeriana jatamansi
plant with roots

- *Transplanting and optimum spacing* The rooted propagules are planted in the field in June–July, while seedlings are transplanted in August at higher elevations and in October at lower elevations. Seedlings should be transplanted when they attain a height of 8–10 cm and planted immediately after uprooting, so that they establish early and remain healthy. Planting in rows 40–50 cm apart and 20–30 cm spacing between plants in a row are recommended. Approximately, 75 000–85 000 plants are required for 1 hectare of plantation.
- *Intercropping system* Tagar can be raised as an intercrop in the fruit orchards. Experimental trials conducted on intercropping in a peach orchard show that the crop can yield about 12–15 quintals/hectare of fresh root mass in the second year, indicating that Valerian may act as a good supplementary crop in fruit plantations.
- *Interculture and maintenance practices* The crop requires fertile and humus-rich soil. A dose of 35–40 tonnes of FYM is found to be the best. No studies about the use of inorganic fertilizer are available. Manual weeding is recommended at an interval of 25–30 days. Once established, the plant shows good resistance against weed invasion, and because of its vigorous upright growth and dense foliage, weeds are smothered under its canopy.
- *Irrigation practices* Irrespective of whether the crop is raised through seeds or rhizomatous suckers, fresh plantings need irrigation almost daily till they are established. Subsequently, depending upon the slope and water-holding capacity of the soil, irrigation interval may vary between one and two weeks.
- *Disease and pest control* The crop is relatively free from pests and diseases. But occasionally, rhizome rot has been observed for which drenching with 0.2% Dithane M-45 is recommended.

Harvest management

- *Crop maturity and harvesting* The crop may be kept in the field for one or two years. It can be harvested in the first as well as second year, but yield is much lower in the first year. Crop attains physiological maturity in August but requires some more days for complete maturity. Digging and harvesting of roots are done in September–October.
- *Post-harvest management* The best method of drying should prevent enzymatic breakdown of the constituents. The harvest should be dried as rapidly as possible without overheating. The maximum preservation

of the valepotriates is achieved when drying is done within the range of about 35–40 °C. Dried rhizomes are best stored in gunny bags/bamboo baskets.

- *Chemical constituents* Roots yield 0.5%–2.12% of volatile oil. Maliol is the main marker component isolated from the essential oil.
- *Yield and cost of cultivation* *Valeriana* can be harvested both in the first as well as second year but less yield is obtained after the first year. Therefore, it is advisable to harvest the crop in the second year. Harvesting done in the first year gives 35–40 quintals/hectare yield of fresh root mass and 8–10 quintals/hectare of marketable dry roots. The crop gives almost double yield when harvested in the second year—70–75 quintals/hectare of fresh root mass and 20–25 quintals/hectare dry rhizomes and roots. The difference in yield is due to both size and number of the rhizomes. The rhizome represents only 25%–30% of the weight of underground parts (root mass). The estimated input cost is about Rs 60 000 per hectare.

***Vigna trilobata* (Linn.) Verd.**

Syn. *Phaseolus trilobus* (Linn.) Schreb.

Fabaceae

Ayurvedic name	Mudgaparni
Unani name	Mugwan
Hindi names	Banmoong
Parts used	Whole plant especially roots



Vigna trilobata

Therapeutic uses

Banmoong is anti-oedema, anti-inflammatory, sedative, and used in urinogenital disorders. The roots and whole plant (panchang) are used as *tridosh shamak*, especially against *vat* and *pitta*, urogenital disorders, and intermittent fever.

Morphological characteristics

Phaseolus trilobus is annual, spreading, and herbaceous runner. Numerous deep purple stems emerge out from a woody rootstock, which reach the length of 50–60 cm. The stem is prostrate, wiry, slender, not twining, glabrous or somewhat hairy. The leaves are trifoliate, 4–8 cm long with grooved petiole. The leaflets are about 1.5–2.5 cm long, as broad as long, and usually shallowly three lobed. In the initial stages of growth, the trifoliate leaflets are ovate in appearance, but with advancement in growth, they become trilobed.

Floral characteristics

Flowers arise in few flowered racemes at the apex. Bracts are ovate, acute, and deciduous. Calyx is campanulate and about 3 mm long, usually linear-anceolate. Corolla is much exerted, 5–6.5 mm long, yellow in colour; stamens are found in two bundles (diadelphous – 9 + 1). Pods are 2.5–5 cm long, slightly recurved, green when immature and turn black on maturity, dehiscent, with small, black, blue or sometimes whitish seeds. Flowering and fruiting occur from September to October, extending to November.

Distribution

The species is found in tropical and subtropical areas in ruderal and ravine habitat up to 2000 m altitude in the Himalayas, extending southwards up to sea level.



Vigna trilobata – flowers

Climate and soil

Phaseolus sp. requires warm climate for its growth and can tolerate drought to some extent, but waterlogging conditions are detrimental to the crop. It is a kharif crop grown under hot and moist climate and high rainfall condition in open as well as partial shade. The crop can be grown in a variety of soils including red lateritic soil, black cotton

soil, and sandy loam soils. However, well-drained, rich in humus, sandy loam soils are most suitable for its growth.

Varieties

Mudgaparni has been domesticated in cultivation. No systematic efforts have been made to develop specific crop varieties. However, the domesticated strain has been named as Mudgaparni. Pant PT-1.

Propagation material

Seed is the most suitable material for propagation. Seeds are collected in November after the colour of the pods changes to black or brownish black in September–October. Seeds remain viable for up to two years.

Agro-technique¹

Nursery technique

- *Raising propagules* The plant is raised as a rainy season crop and is sown directly in the prepared field. Availability of irrigation facility is important for the growth of the plant. Seeds are sown in the furrows and covered with a thin layer of soil. The field is divided into beds of convenient size with the help of bund-maker to facilitate irrigation, drainage, and intercultural operations.
- *Seed rate and pretreatment* Seed requirement rate is 15–20 kg per hectare. The seeds are sown on ridges/rows at a spacing of 20 cm × 15 cm. Before sowing, seeds should be treated with thiram or captan or carbandazim at the rate of 3 g/kg of seeds to protect them from soil-borne fungi.



Vigna trilobata –
crop field

Planting in the field

- *Land preparation and fertilizer application* Field is prepared in the first week of May or June by deep ploughing once. About 10 tonnes of FYM (farmyard manure)/compost per hectare is mixed uniformly in the field and harrowed twice to mix it well in the soil. After exposing the field for 15–30 days, the field is harrowed twice or thrice and levelled to get a good tilth and facilitate proper drainage. Manures and fertilizers as basal dose, at the rate of 30 kg of nitrogen and 60 kg phosphorus per hectare, are applied at the time of sowing, if sufficient FYM is not available. Alternatively, 100 kg per hectare of DAP (di-ammonium phosphate) may be applied. Integrated nutrient management studies conducted at Pantnagar suggest that FYM @ 10 tonnes/hectare + 75% of recommended NPK (nitrogen, phosphorus, potassium) can be used in marginal soils. Experimental results suggest highest biomass yield with 30:60:40 kg per hectare of NPK.
- *Germination* Germination is completed within 10 days of sowing. Seed germination is good during early rainy season. Germination varies between 50% and 60%. With a spacing of 25 cm × 15 cm, about

¹ Agro-technique study carried out by Department of Agronomy, College of Agriculture, G B Pant University of Agriculture and Technology, Pantnagar – 263 145.



Vigna trilobata –
root nodules

0.27 million seedlings are accommodated per hectare.

- **Irrigation practices** Banmoong is a rainy season crop. Irrigation is not needed, but efficient drainage is essential because the plant is sensitive to waterlogging. However, if no rains occur, the soil must be kept wet by irrigating the field. After sowing, irrigation is essentially required at the time of germination. Similarly, soil moisture is

desirable to produce high green yield when the crop is 25–30 days old and is at flower bud initiation stage.

- **Weed control** A critical period of crop–weed competition is up to 30 days of sowing. After this period, only perennial weeds need to be removed; other weeds are smothered by the growing canopy. In all, two weedings are required—first at 20–25 days and second at 35–40 days after sowing.
- **Disease and pest control** Red hairy caterpillar, galerucid beetle, and aphids damage this crop, whereas leaf spot caused by *Circospora*, and seed and seedling rot are serious diseases. Hairy caterpillar devours the leaves of the plant. Infestation can be controlled by dusting 10% aldrin dust at the rate of 25–30 kg per hectare or spraying 0.2% solution of Ekalux or endosulfan twice at an interval of 10 days. Galerucid beetle is a serious pest, which causes more damage during evening and night; during day time, it hides under debris and loose soil. The adult beetle stipples the leaves with small and more or less numerous circular holes, leading to restricted growth and development of crop. Aphids suck the sap from the leaf and the damage is more severe when the plants are young. The aphids and galerucid beetle can be controlled by basal application of Thimet 10% granules @ 10 kg per hectare, or by spraying 0.2% solution of endosulfan or metasyston as soon as holes on the leaves are noticed. Spraying of this mixture twice at an interval of 10 days checks the infestation. *Circospora* causes small circular spots of violet-red colour on the leaves and pods. Two sprayings of 0.2% solution of Endosulfan M-45 at 10-day intervals control the pathogen. Seed and seedling rot is caused by fungi like *Fusarium* sp., *Macrophomina phaseoli*, and *Pythium* spp. The disease is difficult to control. The use of healthy seeds treated with carbandazim @ 3 g/kg

seed prior to sowing is the best preventive measure. However, application of 10% carbandazim or thiram dust @ 25 kg per hectare in soil before sowing seed also controls the incidence of this disease.

Harvest management

- *Crop maturity and harvesting* Flowering starts after 40–45 days of sowing. Within four to five days of flowering, fruiting also starts. Flowering and fruiting continue till October–November. For ‘panchang’ production, 65–70-day-old crop is harvested by uprooting the plants. Pods are collected in October for collecting seeds. The best time for collection of seeds is when pods turn black in colour.
- *Post-harvest management* The roots are washed and the whole plants are tied into bundles such that leaves, pods, and roots remain intact. These bundles are allowed to dry under shade till 8%–10% moisture is left. These fully dried bundles are packed in gunny bags and stored in a dry place. Pods may be removed from the plant after it dries up.
- *Chemical constituents* The chemical constituents include friedelin, epifriedelin, stigmasterol, tannins, epifriedelinos, and γ -glutamylphenylalanine (in seeds).
- *Yield and cost of cultivation* A well-managed crop yields 30–40 quintals per hectare of dry herbage. A seed yield of 2.5–5 quintals per hectare has been recorded when the species is cultivated in *tarai* area of Uttarakhand. The average cost of cultivation is Rs 25 000 per hectare.

Market trend – 2006/07

- Market price: Rs 40 per kg (seeds)
Rs 10 per kg (dried plant–panchang)

Viola serpens Linn.

Violaceae

Ayurvedic name	Banafsha
Unani name	Banafsha
Hindi name	Banafsha
Trade/Unani Name	Banafsha
Parts used	Whole plant, preferably flower



Viola serpens

Therapeutic uses

V*iola* species is antipyretic, diaphoretic, diuretic, aperient, antipyretic, and febrifuge in action. It is useful in respiratory track congestion, asthma, sore throat, cold, coryza, and cancer of the throat. It is also very useful in bleeding piles, constipation, fever, headache, and skin diseases. In the Unani system, this plant is the main ingredient of Joshanda, consisting of a mixture of drugs, used mainly for cough and cold in the form of a decoction.

Morphological characteristics

Banafsha is a small perennial herb with a short semi-subterranean fleshy stem (rootstock). The older parts bear fibrous roots. The upper younger portion is marked with close circular scars of the leaves of the previous years, and gives off elongated, rather fleshy, leafless runners. Leaves are ovate and crenate-serrate.

Floral characteristics

Flowers are borne on long, slender, axillary stalks (scapes) exceeding the leaves. Flowers are lilac, blue, white or purple in colour and borne on the main stem, the larger ones being 6–12 mm in diameter. The flowers from the axils of the cauline leaves are minute. The cleistogamous (underground) flowers are only about 1 mm across. Fruit is a few seeded, globose capsule. Flowering occurs during February–March, while fruiting occurs during April–May.

Distribution

Viola species is found throughout the temperate Himalayas up to an altitude of 2000 m and extending eastwards to hills of Meghalaya, Nagaland, and Manipur.



Viola serpens – plants

Climate and soil

The plant grows well in cool and moist climate but heavy and frequent rain is fatal during blooming. Sandy loam soil is best for its cultivation.

Propagation material

The plant is generally propagated through separation of the new plantlets that develop from the runners. As much as 50–60 new plantlets may be separated from one mother

plant. This crop is also propagated through seeds that show about 80% germination.

Agro-technique¹**Nursery technique**

- *Raising propagules* The planting stock can also be easily raised through division of mother plants, which are directly planted in the field. To raise the planting stock through seeds, they are sown in the nursery in March–April, 10–15 cm apart from line to line. About 80% seeds germinate within three weeks. Sowing of the seed directly in the field is not recommended, as the seed size is very small.

¹ Agro-technique study carried out by the Department of Agroforestry and Environment, Himachal Pradesh Krishi Vishwavidyalaya, Palampur – 176 062, Himachal Pradesh.

- *Propagule rate and pretreatment* About 110 000 plantlets are required for planting in 1 hectare of land. When seeds are used as propagation material, about 1–1.5 kg seeds per hectare are required. No seed treatment is required before raising the nursery, as the seed coat is not very hard.

Planting in the field

- *Land preparation and fertilizer application* Field should be well prepared through two to three ploughings, followed by planking to make the soil suitable for the transplanting of the plantlets. Bed should be raised or oriented in such a way that there is proper drainage and no water stagnation, especially due to heavy rains in the rainy season. Exposure to frequent and heavy rains is very damaging for the flowers. In places of water scarcity, sunken beds may be prepared to conserve moisture. Well-decomposed FYM (farmyard manure) @ 12 tonnes/hectare should be applied to the soil before transplantation of the seedlings to obtain maximum yield. The seedlings are planted at a spacing of 30 cm × 30 cm.
- *Transplanting and optimum spacing* The crop is grown in kharif season during May–June, with the onset of pre-monsoon rains. This is the best period for establishment of plantlets in the field. When the crop is propagated through division of the mother plants, the separated plantlets can be planted directly in the main field in May–June. About one-month-old seedlings can be transplanted in the main field, at an optimum spacing of 30 cm × 30 cm.
- *Intercropping system* The crops can be grown in orchards where partial shade conditions prevail, provided no waterlogging takes place.
- *Interculture and maintenance practices* Only organic manure @ 12 tonnes/hectare is recommended as a basal dose. The field should be free from weeds, especially at the initial stages of plant establishment. Field should be drained well by digging channels across the field, especially during the rainy season. Irrigation should be provided as and when required during hot weather. For promoting the growth of the plants, 50 PPM (parts per million) solution of GA₃ (gibberellic acid) may be sprayed at an interval of one month from September to May.



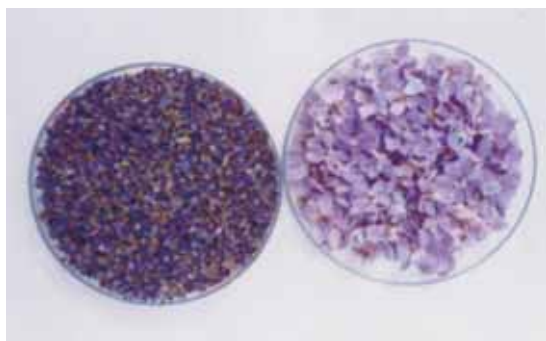
Viola serpens –
seeds

Manual hoeing and weeding once in a month are recommended to control the weeds.

- *Disease and pest control* Browning and blotching of the leaves with dead areas having distinct black margins may occur during rains. These infected leaves should be collected and either burnt or buried deep in the soil to check the further spread of the disease. Pesticides or fungicides should never be used.

Harvest management

- *Crop maturity and harvesting* Leaves can be harvested after two months of establishment of the crop and subsequent harvesting may be done at an interval of one month till December. The plant starts flowering after 9–10 months of growth during February–March, corresponding with the increase in temperature. Fruits can be harvested in April and May. Flowers and seeds should be harvested either in February–March or April–May, depending on the climatic conditions of the area.



Viola serpens –
fruits and flowers

- *Post-harvest management* Flowers and seeds should be air-dried in shade and packed in polythene bags. The flowers should be packed in airtight polythene bags and stored in dark place at room temperature. The seeds retain viability for long periods when stored in airtight containers.
- *Chemical constituents* Voiline, ionone, and ionine are the main active principles of the plant. Roots, leaves, and blossoms also contain methyl-salicylate in the form of a glucoside. Leaves of *Viola* contain rutin content in the range 0.15%–0.45%.

Zanthoxylum armatum DC

Syn. *Zanthoxylum alatum* Roxb.

Rutaceae

Ayurvedic name	Tejovati, Tumbru (fruit)
Unani name	Kabab-e-Khanda
Hindi name	Tejbal, Nepali dhaniya
Trade name	Timru, Timur
Parts used	Stem bark, fruits, and seeds



Zanthoxylum armatum

Therapeutic uses

Fruits, seeds, and bark of tejbal are used as aromatic tonic in dyspepsia and fever. Fruits and seeds are beneficial in dental troubles, thus used to prepare dental paste and powder. Tender twigs are used to brush teeth and used as a remedy for toothache. The essential oil from fruits (known as Wartara oil) has deodorant and antiseptic properties.

Morphological characteristics

Timru is an evergreen, thorny shrub or small tree, attaining a height up to 6 m. Leaves are 4–20 cm long, imparipinnate, pungent, and aromatic with glabrous, narrowly winged petiole having two stipular prickles at the base. Leaflets are lanceolate, glabrous on the underside, and occur in two to six pairs. The plant can be recognized by its shrubby habit, dense foliage, with pungent aromatic taste, prickled trunk and branches, and small red, sub-globose fruits.

Floral characteristics

Flowers occur in dense terminal or sparse axillary panicles and are green to yellow in colour. Calyx consists of six to eight sub-acute lobes. Stamens are about six to eight in number. Ripe carpels or follicles are usually solitary, pale red, and tubercled. Seeds are globose, shining, and black. Flowering occurs from March to May, while fruiting occurs from July to August.

Distribution

The species is found in hot valleys of subtropical Himalayas, from trans-Indus areas to Bhutan, up to an altitude of 2400 m, and between 700 m and 1000 m in the Khasi Hills. It also occurs in the hills of Ganjam and Vizagpatnam at an altitude of about 1500 m.



Zanthoxylum armatum – plant

Climate and soil

The plant is adapted to subtropical climate of lower warm valleys of the Himalayas with sufficient rainfall. It grows well in open pastures and secondary scrub forests. Loamy or clayey soil rich in organic content is preferred for its cultivation.

Propagation material

Freshly harvested seeds are best for the large-scale cultivation of *Zanthoxylum* species. Mature seeds can be collected in June–July. In the absence of sufficient seeds, terminal stem cuttings may be used as propagules.

Agro-technique¹

Nursery technique

- *Raising propagules* The crop can be raised by developing a nursery or by directly sowing in the main field. The seeds are sown in August–September in polybags (nursery) or main field. Stem cuttings may also be planted in the nursery during monsoon in July–August. The

¹ Agro-technique study carried out by

- Regional Station, National Bureau of Plant genetic Resources, Dist Niglat, Nainital, Uttarakhand.
- RRL, CSIR, Itanagar, Arunachal Pradesh

seeds germinate in 20–30 days after sowing. The seedlings attain a height of 20–30 cm by June–July, when they can be transplanted to the main field.

- *Propagule rate and pretreatment* About 2–3 kg seeds are required to raise a nursery for plantation on 1 hectare. Direct sowing may require about 30–50 kg seeds per hectare at a spacing of 50 cm × 50 cm. No seed treatment is necessary before sowing. However, stored seeds may require cold stratification for up to three months and may germinate in February– March.

Planting in the field

- *Land preparation and fertilizer application* Land may be ploughed two to three times using disc harrow and cultivator to make it friable and weed-free. About 10–12 tonnes per hectare of FYM (farmyard manure) should be mixed with the soil as a basal dose before transplantation.
- *Transplanting and optimum spacing* After 10–12 months of growth in the nursery, transplanting in the field can be done during May–June if irrigation facilities are available. Otherwise, it is done in July–August (monsoon season) under rain-fed conditions. A spacing of 50 cm × 50 cm is recommended, which accommodates about 40 000 plants per hectare.
- *Interculture and maintenance practices* Weeding should be carried out during the initial establishment phase, 30–45 days after transplanting, and again at 60–80 days after transplanting. Later, weeding may be carried out only as and when required.
- *Intercropping system* The plant can be grown as a mono crop as well as a mixed crop with herbaceous species.
- *Irrigation practices* The plant requires frequent irrigation during the establishment stage. Once established, the plants are able to survive in rain-fed conditions and only life-support irrigation is required during the summer months.
- *Disease and pest control* The crop is generally free from any disease, insect or nematode attack, and physiological disorders.



Zanthoxylum armatum –
nursery

Harvest management

- *Crop maturity and harvesting* Flowering appears on five-year-old plants in March–May. Fruiting occurs in July–August. The crop, thus, takes five to seven years to mature. Fruits are collected in May–June. Stem pieces, if needed, may be cut during January–February before the flowers appear.
- *Post-harvest management* The herbage and fruits should be dried in shade. The fruits may be cut into pieces for drying and extracting seeds. Well-dried seeds are stored in damp-proof containers.
- *Yield and cost of cultivation* The yield of fresh and dry fruits is approximately 20 quintals per hectare and 6.50 quintals per hectare, respectively. Cost of cultivation is estimated to be Rs 30 000 per hectare.

Glossary

Glossary of botanical terms

- Achene** Single seeded, unicellular, dry, indehiscent fruit also called caryopsis
- Acuminate** Long, pointed, gradually tapering towards apex
- Amplexicaule** Encircling of the node by leaf bases
- Apex** Tip, uppermost part
- Apices (apex)** Top
- Aristate** Ending in bristle or awn
- Articulate** Jointed
- Bracteole** A small bract or leaf structures below perianth in a flower
- Bulbils** Vegetative propagative spherical structure arising at the leaf base (as in *Dioscorea bulbifera*)
- Caducous** Falling soon
- Campanulate** Bell-shaped
- Capitulum** Head-shaped inflorescence, as in Asteraceae
- Cauline** Arising from stem
- Cladodes** Modification of dwarf branches into leaf-like structure
- Clasping** Wrapping
- Comose** With long, white bunch of hair
- Cordate** Heart-shaped
- Coriaceous** Thick, stiff
- 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
- 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
- Diadelphous** Stamen divided into two groups 9+1 as in Fabaceae
- Didymous** Two-sized (filament of stamens)
- Dioceous** Male and female flowers on different plants
- Discoïd** Disc-shaped

Ellipsoid	Eclipse-shaped
Emarginate	Deeply and irregularly notched at apex
Entemophylous	Pollinated by insects
Entire	Even margin, complete margin, no cut or lobation on margin (of leaves)
Epigynous	Ovary seated above perianth
Exstipulate	Without stipule, a leafy structure at the base of leaf
Extrose	Facing outward
Fascicled	Clustered at one point
Fluted	Hollow
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
Gregarious	Very long – robust, profuge
Gynaecium	Female part of flower having ovary, style, and stigma
Heart wood	Central hardest part of wood/trunk
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
Lanceolate	Shape of convex lens
Latex	Oozing milky sap
Lenticellate	Slit-like raised cortical structure on the branches
Linear	Very narrow, like a line
Lomentum	Single seeded cell of pod, septate, and constricted between two seeds
Moniliform	Beaded in a row like a garland
Monoecious	Unisexual, male and female flowers on the same plant
Mucronate	Small projection at the apex (acume)
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

Pedicel	Stalk of flower
Pedicillate	Stalked flowers
Peduncle	Stalk of inflorescence
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
Pinnate	Compound leaf with leaflets arranged on same rachis at length
Polyhedral	Many faced, many angled
Procumbent	Creeping on ground then rising up
Pubescent	Carpeting of small soft hair
Radical	Arising from stem base (leaves or branches)
Reniform	Almost kidney-shaped
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
Sarmentose	Growing among bushes, with long flexuous runners
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
Staminode	Barren stamen (infertile anthers)
Stellate	Star-shaped arrangement of short stiff hair (trichomes)
Stipitate	Stalked
Striate	Marked with vertical lines
Succulent	Thick, soft, and juicy
Suffruticose	A herb becoming perennial at base and herbaceous at apices
Syncarpous	Fused carpels
Terete	Lined
Terrestrial	Growing in soil
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
Villous	Long soft shaggy hair
Whorl	Arising more than two from one node (leaf or branches)
Zygomorphic	Asymmetrical plain of flowers not divisible into equal halves

Glossary of medical terms

Abortifacient	A drug that induces foetus expulsion
Alexiteric	Developing resistance against infectious diseases
Alterative	A drug that alters body condition by improving metabolism; used against long effect of a medicine
Amenorrhoea	Failure of menstruation
Analgesic	Pain killer
Anodyne	A drug used to allay pain
Antacid	To neutralize acidic effect in abdomen
Anthelmintic	A drug used to expel or destroy intestinal worms
Antibronchial	Working against respiratory track infection and congestion
Antiemetic	A drug used to control vomiting
Antihistaminic	A drug used for controlling skin irritation and itching caused due to increase of blood histamine
Anti-inflammatory	A drug used to cure swellings
Antiperiodic	A drug that prevents recurrence of a disease. Used against malarial fever
Antiphlogestic	An agent used for reducing or subsiding inflammations
Antipyretic	A drug or a medicine used to lower body temperature in fever
Anti-rheumatic	A drug used against joint pain and swellings
Antirrhinitis	Clearing of nasal mucous by subsiding nasal membrane inflammation
Antiseptic	Prevention of putrefaction or sepsis of wounds and cuts
Antispasmodic	A medicine that releases nervous irritability and reduces spasm or convulsion

Antitussive	A drug controlling cough
Aperient	Mild laxative/cathartic
Aphrodisiac	Drug increasing the sexual desire and longevity
Appetizer	Increasing digestion and hunger
Aromatic	An agent that emits sweet smell
Astringent	A drug that contracts the muscular membrane
Bronchodilator	A drug that widens the trachea, thus easing congestion
Carminative	A drug that releases intestinal gases or flatulence
Catarrhal	Mucous membrane inflammation with excessive secretion of mucous
Cathartic	Drastic purgative, totally expelling rectal stool
Cholagogue	A drug inducing excessive secretion of bile juice
Colic	Severe spasmodic and gripping pain in colon region
Demulcent	Soothing medicine for digestive function
Depurant	Purifier
Diaphoretic	Drug inducing perspiration
Diuretic	Increasing urination frequency
Dysmenorrhoea	Painful menstrual flow
Dyspepsia	Indigestion with gastric pain
Emmenagogue	A drug that restores regularity in menstrual cycle
Epilepsy	An affection of the nervous system resulting from excessive or disordered discharge of cerebral neurons
Expectorant	A drug expelling phlegm from trachea
Febrifuge	A drug used to cure fever
Galactagogue	Increasing and activating mammary gland
Geriatric	Pertaining to old age
Gleet	Chronic discharge from vagina
Gonorrhoea	Inflammation of the gentio-urinary passage with pain and discharges
Gout	A purine metabolic disease with raised level of serum uric acid (blood urea)
Gynaecological	Pertaining to female genital organ
Haemophilic	Loss of blood coagulation property in which blood continues to flow on cuts
Haemoptysies	Spitting of blood
Haemorrhage	Bleeding piles
Haemostatic	Blood coagulant, preventing bleeding
Hydrogogue	Promoting expulsion of water or serum

Hyper lipidemia	Reducing fat on joints
Hypoglycaemic	Lowering blood sugar
Hypotensive	Lowering blood pressure
Hysteria	Neurotic attack with unusual activities and symptoms
Insomnia	Sleeplessness
Lactagogue	Increasing milk secretion
Laxative	Smoothening rectal wall and loosening the stool
Leucorrhoea	White fluid discharge from vagina
Menorrhagia	Excessive menstrual flow
Neuropathy	Diseases related to CNS (central nervous system)
Oedima	Inflammation
Ophthalmic	Pertaining to eye diseases like conjunctivitis
Orchitis	Inflammation of testis with hypertrophy and pain
Paraplegia	Paralysis, loss of ability to move or feel in the lower part of body
Phlegm	Mucous secretion in respiratory track
Post-natal	After child birth
Pruritus	Skin itching
Purgative	Loosening stool to help exersion, thus curing constipation
Refrigerant	Cooling effect
Rejuvenative	Antiageing, prolonging life
Resolvant	Causing resolution of a tumor or swelling
Rubifacient	Producing counter effect on external application
Scrofula	Tubercular cervical adenitis, with or without ulceration
Sedative	Central nervous system depressant in which a person is made calm or asleep
Stomachic	A drug used for improving digestion
Styptic	Blood purifier
Thermogenic	Producing heat offer metabolism
Thrombosis	A blockage preventing the flow of blood in the body caused by clot
Tranquilizer	A drug used to calm a person and reduce mental activity
Urticaria	Nettle rashes on skin
Vermifuge	Expelling or destroying intestinal worms
Vertigo	Dizziness, a feeling of spinning

Considering the global trade practices, it is important to cultivate superior strains of a particular medicinal plant to make the product price competitive and also acceptable to the buyer for required constituents. Ensuring cultivation of a plant after proper verification of botanical identity is also a necessity for safety and quality of raw medicinal plant material and finished product. Further, cultivation of medicinal plants is considered the only way to promote conservation of biodiversity and its protection, and sustainable availability for health care.



The present publication addresses all these issues and covers the agro-techniques of some selected medicinal plants, which have been developed by the various R&D institutions and universities. This is an endeavour of the NMPB (National Medicinal Plants Board) towards promoting cultivation of medicinal plants, through standardized agro-techniques so as to make available to the industry raw material of quality and standardized chemical ingredients. This book is a storehouse of rich information, and cultivators, researchers, and alternative health practitioners will find this book to be of immense use.

