Cultivation and Processing of Selected Medicinal Plants
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Medicinal plants are important for human health. These plants have been used from the prehistoric times to present day. These plants based medicines are consumed in all civilizations. It is believed that the herbal medicine can give good effect to body without causing side effects to human life. Medicinal plants are not only a major resource base for the traditional medicine & herbal industry but also provide livelihood and health security to a large segment of Indian population. Medicinal plants constitute a large segment of the flora, which provide raw materials for use by various industries. They have been used in the country for a long time for their medicinal properties. These plants are staging a comeback and herbal renaissance is happening all over the globe. The herbal medicines today symbolise safety in contrast to the synthetics that are regarded as unsafe to human and environment. Although herbs had been priced for their medicinal, flavouring and aromatic qualities for centuries, the synthetic products of the modern age surpassed their importance, for a while. However, the blind dependence on synthetics is over and people are returning to the naturals with hope of safety and security. Besides, the usage of medical plants has been increasing as an important role that can support the economic system. Ayurveda, the well known indigenous system of medicine, is still regarded as a well organised traditional health care for large sections of rural as well as urban population of India. The medicinal plants sector at present is not well organised and needs special attention. Although different Ministries and Department in the Government sector and NGOs and individuals in the private sectors are making their efforts in different directions, yet there is a need to co ordinate and systematize. The medical plants for health are used as herbal treatments and therapies that can be new habits for culture. The market is very competitive and could easily be oversupplied.

This book basically deals with therapeutic potential of medicinal plants, medicinal plants priorities in Indian medicines diverse studies and implications, recent developments of some natural products, production and management of medical plants on farms, classification, identification and naming of medicinal plants, pests and pest management in medicinal plants, Ajmalicine (Raubasine): a medicinally important alkaloid from catharanthus roseus (vinca rosea), cultivation of rutin bearing eucalyptus species, iridoids and secoiridoids of the genus swertia, studies on medico ethnobotany, tropical periwinkle, tulsi, etc. The present book covers cultivation practices of selected commercially important medicinal plants with their processing details and uses. The book is very resourceful for medicinal plants growers, professionals, researchers, entrepreneurs and agriculture universities.

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Sample Chapter:
GINSENG
HISTORY AND GEOGRAPHICAL DISTRIBUTION
Ginseng consists of roots of Panax ginseng C.A. Meyers, often referred as Korean ginseng, or P. quinquefolium L. termed as American ginseng. A third species referred as Siberian ginseng is a misnomer, as it refers to Eleutherococcus senticosus which is not true ginseng but used in Russia as a substitute for the same purpose.

Ginseng has been used in Chinese medicine for more than 4000 years. The earliest Chinese Herbal which refers use of this plant is "Shen-Nung Pen Tsao Ching". This appeared for the first time in written form in first century BC. There must have been a long previous verbal history. Chinese name of the plant has been translated in the western world as 'Man-shaped Root' or 'Man Essence'. This word is derived from the shape of the root, which resembles the form of man. It is also believed that the essence is really crystallized in human form. In old Chinese medicine the more the root resembles a human being, the more potent is its healing properties.

Knowledge of ginseng was brought to the West by a Christian Missionary who worked in China in early 1700. AFrench Jesuit Priest Pere Jartoux reported on properties of ginseng in a letter from China to a fellow priest. His description of ginseng and its properties were published in 1709 in French and translated into English in 1714 published in 'Philosophical Transactions of Royal Society', London. The recipient of the letter was Joseph Francois Lafitau, who was working with Indians near Montreal in Canada. With the help of the Indians, Father Lafitau obtained ginseng plants and sent them to his counterpart in China in 1770.

Because of widespread and indiscriminate collection of wild ginseng, the plant has been almost extinct, but because of great demand, collection of wild ginseng was practised widely in Canada and USA. By 1750, because of depletion of forests and large-scale collection and supply of ginseng to China as well as the growing demand, supply of the drug was depleted.

It was, therefore, considered desirable to cultivate this plant in USA. The first experiments of culture of ginseng from root and seed were successful in 1809. Later on, cultivation of ginseng was extended to Ohio, Kentucky, Indiana, Washington and Minnesota. US Dept. of Agriculture recommended ginseng culture in 1912. Ginseng culture was established by Polish and German settlers in 1904 in midwest USA, which have become the centre of ginseng production.

Panax ginseng is indigenous to Northern China, Korea and is cultivated in China, Korea, Japan and to a limited extent in USSR. P. quinquefolium is indigenous to Quebec, Manitoba and North-Eastern USA. It is cultivated in US in the States of Wisconsin, Georgia and Tennessee, Kentucky and North Carolina. At present, 250-300 tonnes ginseng roots are produced in USA, 2500-3000 tonnes in Korea, 150-160 tonnes in Japan, and 300-400 tonnes in China. Total value of the product is approximately 600 million US dollars.

The Siberian ginseng is used as a substitute in USSR. This plant is also used widely in Siberian part of China.

BOTANY
Panax ginseng C.A. Meyers
Plant erect, perennial herb, about 60 cm high; root short, fleshy, thick, cylindrical or fusiform, 1-2.5 cm in diameter. Leaves palmately compound; petiole rather long; leaflets usually 5, sometimes 3, upper three larger, oblong-elliptic or obovate, 4.5-15 cm long; lower two smaller, elliptic or ovate, 2-4 cm long; inflorescence umbelliform, simple. Flowers consist of 5 sepals; sepals green; petals 5, cream-yellow in colour, ovate, apex obtuse; stamens 5; filament short; anthers oblong-orÂ­bicual; ovary inferior, 2-locular; style2, united at base. Fruit, a berry-like drupe, compressed, bright red at maturity, 2 seeded.
PANAX QUINQUEFOLIUM L.
Perennial erect herb, 30-45 cm high; root fusiform, 13-16 cm long, 5 cm diam., often branched. Leaves palmatisect, long petiolate; leaflets usually 5, sometimes 6-7, petiolated, thin, obovate-oblong, serrate. Inflorescence an umbel; flowers consist of 5 sepals; petals 5, small, ovate, white or yellow-green; stamens 5, anthers small, heart shaped; styles usually 2, sometimes 3, curved, persistent; ovary rounded, bright crimson when ripe, 2 seeded.

GENETICS
P. ginseng is tetraploid with 2n = 44 (x = 11). P. quinquefolium is also tetraploid with 2n = 44. However, certain geographical races in both the species have been reported to have chromosome numbers as 2n = 48. Other than cytology, investigations on genetics and breeding of the plant have not been carried out and there are no cultivars.

SOIL AND CLIMATE
Ginseng thrives well in medium and light loam soils which are rich in organic matter. Heavy clay or very light soils are avoided for ginseng culture. Forest soils rich in organic matter and humus are ideal for ginseng culture. It is a temperate plant and requires freezing temperatures at least for 3-4 months during the period when it is dormant, and cool summers are ideal for ginseng culture. Chilling below 0°C is necessary for germination of seeds.

PROPAGATION
Ginseng can be propagated through seeds or vegetatively through roots. Most of the commercial plantations are raised through seeds. One of the most important factors for successful ginseng cultivation is shade. The plant does not grow in full sunlight. Some kind of shade has to be provided to cut off 75% day light. Shade can be natural, or artificial. For cultivation of ginseng in natural shade, forest areas having deep rooted deciduous trees are preferred. When planting ginseng in natural shade, weeds and bushes as well as undesirable trees should be removed.

Artificial shade is provided by wooden lathes, boards or propylene sheets supported with poles over the growing area. Boards and lathes can be supported on wooden poles. Shade cover should be stretched to form a canopy over the entire plantation area and it should be at least 2 m high. The shade structure should extend beyond the plantation area at least 60-90 cm to avoid excessive light at the margins of the plot, especially western and southern side. While wooden lathes or propylene sheets are used in USA, reed or grass thatch is generally used in Korea where plastic sheets are being tried experimentally.

The land should be ploughed and tilled several times during early fall to allow decomposition of organic matter and to avoid soil-borne diseases, pests and weeds. Beds should be 2 m wide with 46 cm walk-way between the beds.

In case of natural shade, initial preparation is done when trees are without leaves. Undesirable trees/bushes should be removed. The area should be marked into beds - 1.25 x 1.8 m. Beds should be raised at least 15-22 cm and should be up and down the slopes. Adequate drainage should be provided to drain off excess water. Stratified seeds or fresh seeds are planted either in fall or in spring. Seeds which are still green can also be directly planted. However, it is desirable to stratify the seeds by storing in screened containers at least for one winter. Fall seeding can be done in September-October, while spring seeding is done during March-April. Seeds should be planted at a depth of 2.5 cm and covered with 2.5-5 cm of mulch. These should be planted at a distance of 2.5 cm in rows which are 15 cm apart. 30-100 Kg seed is planted in one hectare bed area. Ginseng can also be raised using seedlings, or roots raised in nursery beds. One-year old seedlings can be planted at a distance of 12-15 cm in rows with plant to plant distance of 5-7 cm. Roots can be planted in fall or spring.

Ginseng takes 18-20 months for germination. Since in newly ripened seeds embryo is not formed and
complete embryo formation takes several months after ripening of the seeds, fresh seed planting should be avoided. It is, therefore, necessary to stratify the seeds before planting.

Experiments carried out in Russia have shown that treatment of seeds with gibberellic acid for 24 hr reduces period of germination by 2-4 months. Freshly extracted green seeds require a sequence storage corresponding to summer/winter in a damp medium, before germination can occur. Storage process is called 'stratification.' Stratification can be carried out in shaded, well-drained soils outdoors by placing the seeds in a screened container to protect them from pests, specially rodents. Small amount of seeds can be placed in aluminium containers, which are buried in 12-15 cm deep soil. Twice the amount of seeds, leaves/sand is mixed and stored in screened bottom 20-25 cm deep boxes which are buried in soil. The top should be covered with mulch to avoid drying. Some seeds germinate in first spring, which should be periodically removed and the boxes aerated periodically. In Korea stratification is carried out in wooden boxes and drained cement cylinders. Seed is mixed with sand in the ratio 1:2 and watered daily to keep proper moisture. The seeds are planted in November and germinate after 8-9 months in the following spring.

**INTERCULTURE AND WEED CONTROL**

The beds should be kept free from weeds by regular weeding/hoeing. Care is required in wooded plantings, as bushes often sprout in between plants and there is excessive competition; such bushes should be removed. Recent experiments have shown that perennial grasses can be controlled by herbicides - Fluazifopbutyl or Sethoxydim when applied as pre-emergence at 3-leaf stage. Broad leaf weeds as well as grasses can be controlled by pre-emergence application of Trifluralin and Linuron.

**IRRIGATION**

In areas having well distributed rainfall no irrigation is required. However, 3-4 irrigations are required during summers when there are no rains. Pot experiments have indicated that optimum root growth is obtained at moisture level of 60% field capacity.

**FERTILIZERS AND MANURES**

Normally, ginseng growers do not apply artificial fertilizers. Most of the ginseng is grown in fertile soils which are rich in organic matter, forest humus and compost which are applied to beds, provide enough nutrition. Very little research work has been done to find out optimum nutritional requirement for this crop. Recent experiments carried out in North Carolina have shown that phosphorus and lime can be applied in soils having low pH around 5. Application of 20-25 kg nitrogen per hectare has been found to be beneficial in USA.

**HARVESTING AND PROCESSING**

Harvesting should be started when the berries have ripened. In case of good growth, it can be harvested after 4 years. In plantations under natural shade, harvesting is delayed to 6-8 years. Yield of 1000 kg per hectare has been obtained in well managed artificial shade plantations. In natural shade yield of 500-800 kg per hectare is obtained. Prior to harvesting top of the plant and mulch should be removed. Artificial shade should be removed and the roots dug out with spade. Mechanical diggers can also be used in bigger plantations.

Roots are washed and dried in artificial drier at a temperature of 45°C. Roots should be packed in cardboard boxes and stored in cool dry atmosphere. In Korea red ginseng is produced by first steaming the roots before drying.

**DISEASES AND INSECT PESTS**

There are a number of diseases which cause serious problems in ginseng plantation. The most important diseases are Alternaria blight, Phytophthora blight, anthracnose, grey mold, and Rhizoctonia stem rot. Alternaria blight is caused by Alternaria panax. The symptoms appear as dark brown spots in the stem just above the ground level followed by appearance of dark brown spots on leaves and flowers often causing stem dieback.
death of plants. The disease can be controlled by regular spraying of Dithane Z-45, Maneb and Bordeaux mixture.

Phytophthora blight is caused by the fungus Phytophthora cactorum. The disease is characterized by appearance of water soaked patches on the stem and roots followed by rotting. The disease can be controlled by application of Metalaxyl.

Anthracnose is mostly serious in Korea and is caused by Colletotrichum panacicola. The symptoms consist of appearance of brownish black lesions dotted with black bodies of the fungus on leaves and stem. The disease can be controlled by spraying of Mancozeb, Polyoxin or Iprodione.

Grey mold caused by Botrytis cineria and can be controlled by application of Benomyl.

Rhizoctonia stem rot is caused by Rhizoctonia solani which causes appearance of black lesion on the stem near the ground level. The disease can be reduced by application of Rizolex. Other diseases reported from Korea and USA are root rot complex, Phoma blight, Ramularia blight and root knot incognita.

Some of the important insects reported from Korea are black cut worm common cut worm, dark grey cut worm, Japanese wheat wire worm, Korean black chaffer and large black chaffer. All these can be kept in check by regular spraying of Diazinon.

CHEMISTRY AND USES

Ginseng contains a number of chemical compounds. However, the activity is due to a number of saponins termed 'ginsenosides' by Japanese workers and called 'panaxosides' by Russian workers. Twelve ginsenosides named as Ra-Rbl to Rh2 have been reported. Six panaxosides have been designated as panaxosides A, B, C, D, E and F. While ginsenosides are triterpene steroidal sapogenins, panaxosides are pentacyclotriterpenoid sapogenins.

Panaxosides and ginsenosides in the two species, viz., P. quinquefolium and P. ginseng can be the same or different, but resemble each other. Other chemical compounds include steroids, vitamins, amino acids and trace elements.

In Chinese medicine ginseng is prescribed as a tonic, stimulant and aphrodisiac. The drug is used in case of neurasthenia, dyspepsia, palpitation and asthma. It is also used for controlling amnesia, headaches, convulsions, dysentery and cancer.

It has been claimed that the drug is an adaptogen and enhances natural resistance/recuperative power of the body. Although, ginseng has not been adopted in modern medicine, it is widely sold in health food shops as a tonic and aphrodisiac in the West. Recently, ginseng extract has been reported to possess some hypoglycaemic activity.

GUDMAR

Gymnema sylvestre R. Br.
Family-Asclepiadaceae

A woody climber with small yellowish flowers and simple, opposite, ovate - elliptic hairy leaves. It is found wild in various deciduous forests of India.

REGIONAL NAMES

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DISTRIBUTION
It is found in Uttar Pradesh, Madhya Pradesh, Maharashtra, Punjab, Haryana, Tamil Nadu, Andhra Pradesh, Kerala, Karnataka, Bihar & Bengal.

Part Used: Whole plant

MEDICINAL PROPERTIES & USES
The stem is bitter astringent, acrid, thermogenic, anti-inflammatory, anodyne, digestive, livertonic, emetic, diuretic, Stomachic, stimulant, anthelmintic, laxative, cardiotonic, expectorant, antipyretic and uterine tonic. It is useful in inflammations, hepatosplenomegaly, dyspepsia, constipation, jaundice, haemorrhoids, strangury, renal and vesical calculi, helminthiasis, cardiopathy, cough, asthma, bronchitis, intermittent fever, amenorrhoea, conjunctivitis & leucoderma. The fresh leaves when chewed have the remarkable property of paralysing the sense of taste for sweet and bitter substances for sometime.

CULTIVATION & PROPAGATION

Soil and Climate
The plant grows in a variety of soil and agro-climatic conditions in tropical and sub-tropical regions up to 600 m.

Nursery Raising and Planting
Mature seeds are collected during October-December and sown in poly-boxes/bags or small plots in nursery. The raised seedlings are transplanted in field during February-March. The plant grows well with the on-set of rainy season. The climber is given proper support for its better growth and development. It can also be planted in between trees as intercropping. The plant can also be propagated through cuttings and planted during rainy season.

Weeding and Hoeing
Periodical weeding and hoeing is required, particularly during and after rainy season.

Manure and Fertiliser
Compost or Vermicompost is preferred for application while preparing the soil for nursery and in the field plantation.

Irrigation
Periodic irrigation as and when required may be done weekly/fortnightly.
HARVESTING/POST-HARVESTING
After one-year leaves are ready for harvesting. The leaves are usually collected during October-February and are cleaned and dried in shade. The roots are collected during summer and are cleaned, washed and cut in to pieces and dried.

CHEMICAL CONSTITUENTS

**Major Constituents**
Gymnemic acid

**Other Constituents**
Gymnemic acid I, II, III and IV are isolated from leaves and their structure elucidated. Gymnemagenin a hexahydroxy triterpene was isolated from the plant.

**Active Constituents**
Various fraction obtained from the plant leaves shows Antieurodonic effects.

**Analytical Profile**
Analytical profile developed for gymnemic acid using Merck LiChrosorb RP-18 column with eluent CH3CN/2-PrOH/ H2O/ AcOH (35/10/54.9/0.1) @ 2.0 ml/min. Detector RI, Temp. 20Â°C.

**ECONOMICS (2003)**

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<td>Net income per hectare</td>
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**GUGGAL**
Commiphora wightii (Arn.)
Family-Burseraceae
Bhandari syn. Commiphora mukul
It is a shrub or small tree reaching up to 3 to 4 m. high. Leaves sessile, alternate, 1-3 foliate. Plants dimorphic, Flowers small in fascicles. Fruits are ovoid, drupe.

REGIONAL NAMES

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DISTRIBUTION
Found in Karnataka, Rajasthan, Deccan and Gujarat.

Part Used: Olio gum resin

PROPERTIES & USES
The gum is bitter, acrid, astringent, thermogenic, aromatic, expectorant, digestive, anthelmintic, anti-inflammatory, anodyne, antiseptic, nerve tonic, aphrodisiac, alterative, stimulant, liver tonic, antispasmodic, emmenagogue, haematinic, diuretic, rejuvenating, general tonic, and is useful in gout, scrofula, sciatica, facial paralysis diplegia, cough, asthma, bronchitis, pectoral and hepatic, disorders, otorrhoea, epilepsy, fever, stangury, haemorrhoids, dysmenorrhoea, amenorrhoea, wounds and ulcers, cardiac disorders, coronary thrombosis, anaemia, stomatopathy, pharyngopathy, spermatorrhoea, diabetes, skin diseases etc.

CULTIVATION & PROPAGATION

Soil and Climate
It can be cultivated in sandy to silt-loam or rocky soils, poor in inorganic matter but rich in several other minerals. The growth is vigorous in the soils, which have moisture-retaining capacity.

Nursery Raising and Planting
The plants are best raised from stem cuttings of semi-wood (old) branch. Woody stem of one meter in length and 10mm. thickness is selected and the cut end is planted in a well-manure nursery bed during June-July. The bed should be given light irrigation periodically. The cuttings initiate sprouting in 10-15 days and grow into green sprout in next 10-12 months. These rooted plants are suitable for planting in the field during next rainy season. The cuttings give 80-94% sprouting.

Seed germination is very poor (5%) but seedlings produce healthier plants, which withstand high velocity wind.

Thinning and Weeding
The plantation does not require much weeding and hoeing. But soil around the bushes should be pulverised twice in a year to increase the growth.

Manure/Fertilizer
Application of 5 kg FYM per plant per year is sufficient.

Irrigation
Requires moderate irrigation. Even limited irrigation during summer, enhances the rate of growth.

Harvesting/Post Harvesting Operation
Plants attain normal height and girth after 8-10 years of growth when they are ready for tapping of the gum by shallow incision on the bark between December and March.

Chemical Constituents

Major Constituents
Guggulsterol
Other Constituents
Myricyl alcohol and (β-sitosterol were isolated. Monocyclic diterpene-β-camphorene and cembrene isoalted from resin, allylcembrol isolated and named as-2-hydroxy-4, 8, 12-trimethyl-l-isopropyl-3, 7, 11-cyclodecatriene. Cholesterol,4,17(20)-trans-pregnadin-3, 16-dione,4,17(20)-ics-pregandin-3,16-dione and 3 new sterols GuggulsterolsI, 11, 111-isolated from gum resin. Cembrene A isolated from resin. Mukulol has also been isolated from G, glabra. Two aliphatic tetrols octadecan-l, 2, 3, 4-tetrol and eicosan-l, 2, 3, 4-tetrol from gum resin. Guggulsterol-6 and Z-guggulsterol isolated from gum resin along with 20?-hydroxy-4-pregnene-?-one, 20p-hydroxy-4-pregnene3-one, 16a-hydroxy-4,17(20Z)-pregnadin-3-one and 16a-hydroxy-4-pregnene-3-one. An unidentified compound from gum resin exhibited lipid lowering activity.

Active Constituents
Gum resin shows different pharmacological properties and clinical applications: Astringent, expectorant, aphrodisiac, demulcent, carminative, alterative, antispasmodic, emmengogue, to enrich blood, in snakebite and scorpio sting. Antifertility effect. Plant has use in Arthritis.

YIELD
Approximately 500-800 g gums are obtained per plant.

SUBSTITUTES/ADULTERANTS
Guggal is often adulterated with the oligum resin of Boswellia serrata or sometimes with resin of pinus sp. However Boswellia gum can be identified with its whitish colour and powdery appearance externally. Pinus resin is stickier and is generally in the form of paste at normal temperature.

ECONOMICS
Input cost per hectare Rs. 2,50,000/-

Output cost per hectare Rs. 5,00,000/-
Net income per hectare Rs. 2,50,000/-

**Home Remedy**
Guggulu with Cow's urine is good for oedema

**Dose:** 2 g.

**IMPORTANT FORMULATION**
Yogaraja guggulu, vatari guggulu, simhanada guggulu, kaissora guggulu, Mahayogaraja guggulu, Chandraprabha vati.

**ISABGOL**
**Plantago ovata Forsk.**
**Family-Plantaginaceae**
A 10-15 cm tall short-stemmed annual herb. Leaves are born alternately on the stem. Flowers in terminal spikes; fruit a capsule. Seeds are translucent and concavo-convex.

**Common Names:** Ishagola, Isabghul, Spogel seed, Ispaghul

**Distribution:** Indigenous to the Mediterranean region and West Asia, It has been introduced in India & cultivated especially in Gujarat and some parts of Rajasthan.

**Part Used:** Husk from spikes and seeds.

**CULTIVATION**

**Soil and Climate:** It is an irrigated crop, which grows well on light soils; soil with poor drainage is not conducive for good growth of this crop. A silty-loam soil having pH from 4.7 to 7.7 with high nitrogen and low moisture content is ideal for growth of plants and high yield of seeds. ISabgol thrives well in warm-temperate regions. It requires cool and dry weather and is sown during winter months. Sowing during first week of November gives best yields. Early sowing makes the crop vulnerable to downy mildew disease, whereas late sowing provides lesser period of growth in winter along with possibility of shattering of seeds due to summer rains in April-May. At maturity, if the weather is humid, its seeds shatter resulting reduction in yield. Heavy dew or even a light shower will proportionately decrease the yield, at times leading to even total loss of the crop. The temperature requirement for maximum seed germination is reported to be 20 to 30°C.

**LAND PREPARATION**
Field must be free of weeds and clods. The number of ploughings, harrowing and hoeing depends upon the soil conditions, previous crop and degree of weed infestation. About 10-15 tonnes of FYM per hectare is mixed into the soil at the time of last ploughing. The field should be divided into suitable plots of convenient size, depending upon the texture of the soil, the slope of the field and quantum of irrigation. For light soil with even contour, plot size of 8.0 m x 3.0 m will be convenient.

**Nursery Raising And Planting**
To obtain high percentage of germination, seeds should be taken from the crop harvested at the end of the preceding crop season. Old seeds tend to lose viability under ordinary storage conditions. Seeds at the rate of 4-8 kg per hectare are sown after treating it with any mercurial seed-dresser at the rate of 3 g/kg of seed, to protect the seedlings from the possible attack of damping off. The seeds are small and light. Hence before sowing, the seeds are mixed with sufficient quantity of fine sand or sieved farmyard manure. The seeds are broadcasted because sowing in lines at different spacing does not increase the seed yield. After broadcasting, seeds are swept lightly with a broom to cover them with some soil. Broom however, should be swept in one direction only, to avoid deep burial of the seed for uniform germination. The sowing should immediately be followed by irrigation. Germination begins in four days after sowing. If delayed, it should be stimulated by another watering.
WEEDING AND HOEING
Periodical weeding and hoeing is required.

MANURE/FERTILIZER
Isabgol does not require the application of heavy doses of fertilizers. A fertilizer dose consisting of 50 kg of N, 25 kg of P2O5 and 30 kg of K2O (NPK) per hectare has given the maximum seed yield. The full dose of phosphorus and potassium along with half of the nitrogen is given as a basal dose at the time of sowing itself and the second split dose of nitrogen is applied as a top dressing after one month of sowing.

IRRIGATION
Immediately after sowing, light irrigation is essential. First irrigation should be given with light flow or shower of water otherwise, with fast current of water most of the seeds will be swept to one side of the plot and the germination and distribution will not be uniform. The seeds germinate in 6-7 days. If the germination is poor, second irrigation should be given. Later on irrigations are given as and when required. Last irrigation should be given at the time when maximum number of spikes shoots up. The crop requires 6-7 irrigations for its good productivity in medium sandy soils.

HARVESTING/POST HARVESTING OPERATION
Blooming begins two months after sowing and the crop become ready for harvest in February-March (110-130 days after sowing). When mature, the crop turns yellowish and the spikes turn brownish. The seeds are shed when the spikes are pressed even slightly. At the time of harvest, the atmosphere must be dry and there should be no moisture on the plant; harvesting will lead to considerable seed shattering. Hence, the crop should be harvested after 10. am.

YIELD
Gujarat Isabgol-1, variety yields 800-900 kg of seeds per hectare. The new variety 'Gujarat Isabgol-2 has a potential to yield 1,000 kg of seeds per hectare.

ECONOMICS

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JATAMANSI

*Nardostachys jatamansi* DC. syn.
*Family-Valerianaceae*

*Nardostachys grandiflora*
An erect perennial herb, 10-60 cm in height, with woody stout, rootstock covered with reddish brown fibres of the petioles of radical leaves. Leaves radical, longitudinally nerved; flower pale-pink or blue.
### REGIONAL NAMES

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### DISTRIBUTION

Found in alpine Himalayas from 3,300-5000m heights, hills of Himachal Pradesh, Uttarakhand, Jammu & Kashmir and Sikkim.

**Part Used:** Rhizome

### MEDICINAL PROPERTIES & USES

The rhizome is bitter, astringent, sweet, acrid, cooling, emollient, aromatic, antiseptic, anodyne, digestive, carminative, laxative, stomachic, liver stimulant, diuretic, emmenagogue, deodorant, vermifuge, expectorant,
nervine tonic, improves IQ, somniferous, aphrodisiac, sudorific, trichogenous, anti-pyretic and tonic. It is useful in burning sensation, cough, asthma, bronchitis, pectoralgia, cephalalgia, inflammations dyspepsia, colic, flatulence, hepatopathy, nephropathy, strangury, amnorrhoea, dysmenorrhoea, hypertension, grey hair, falling of hair etc.

CULTIVATION

Soil and Climate
Sandy loam and acidic soil rich in organic carbon and nitrogen is found best for germination as well as for better survival of seedlings and productivity. Moist and partial shades are found suitable for cultivation. Further moist rough wall provide suitable microhabitat for better growth. At lower altitude (1800-2200m) plain beds with slight tilt (5°-10°) are found suitable for cultivation unlike horizontal and vertical beds at alpine site.

Nursery Raising and Planting
Seeds are sown during November-December in polyhouse at lower altitude, during March-April in open beds at medium altitude and during May in alpine area. Seedlings are transplanted after six to eight weeks in the field. At lower altitude root growth as well as number and length of leaves increases rapidly as compared to higher elevation. Fibrous root formation takes place after third year of growth, when plants are raised by seedling. About 44,000 plants are planted in one acre of land. Vegetative propagation through splitting of roots is found most successful in Nardostachys jatamansi and observed better for multiplication as well as for higher production within a short period than cultivation through seedlings.

Manure/Fertilizer
For cultivation, better survival and yield of Jatamansi at lower altitude 60-70q. manure is required for one acre of land. However, the results are found best in litter treatment instead of live stock manure. The sites rich in organic carbon needed 46-60q. manure per acre for higher yield.

Irrigation and Weed Control
Beds need excessive watering/irrigation to decrease the mortality rate. Water requirement will change with respect to season like no irrigation is needed during monsoon. Water requirement also depends on the location of sites and texture of soil. During dry season i.e. May-June and September-October watering must be done at every two days interval at lower altitude. Weeding also depends on the condition of the soil and presence of weeds. Generally weeding must be done at weekly interval in the first year of growth and during the second and third year twice in a month.

Harvesting/Post-Harvesting
Plants should he harvested just before senescence after maturation to obtain the higher quantity of active principles. To obtain higher amount of bioactive ingredients, it must be collected during the month of September at lower altitude, while in the month of October at higher altitude. The harvesting period for this species is 3-4 years; the harvested roots are washed and dried in shade.

Chemical Constituents

Major Constituents
Jatamansin
Nardostachnone
Other Constituents
New sesquiterpene lactone-Jatamansone. \( \alpha \)-maaliene and calrene from the oil. A new terpene coumarin-jatamansin and ororselor from roots. \( \alpha \)-pinene, \( \beta \)-pinene, \( 3 \)-carene, \( \beta \)-eudesmol, elelmol, a C-30 hydrocarbon, \( \beta \)-sitisterol, jatamansin, angelicin and jatamansinol from roots. Nardol from roots. A new diethenoid bicyclic ketone-nardostachonefrom roots. Structure of jatamansic acid. Seychellene and seychellane isolated, seychellane found to be mixture of two epimers. Norseychelanone, patchouli alcohol and \( \alpha \)-patchoulenes isolated from roots. Actinidine a alkaloid isolated from rhizomes. Nardostachinol, 9-dehydroaristolone 1 (10)-dehydroaristolone, 2\( \alpha \)-maaliene and 1,2,9,10-tetrahydroaristolone identified in essential oil. 9-aristilene-1-\( \alpha \)-ol, l(10)-aristolen-2-one, \( \beta \)-sitosterol and three unidentified compounds were isolated from roots. Jatamansanonone a ketonic principle isolated from rhizomes.

**Active Constituents**

Jatamansone, the sesquiterpene shown to exert tranquillizing activity in mice and monkeys, hypothermic activity in mice and antiemetic effects in dogs.

Volatile oil of N. jatamansi was found to be active as antiarrhythmic agent in dogs. The essential oil of N.jatamansi showed anthelmintic and antifungal activity. Jatamanssanone possess neuropharmacological profile in the hyperkinetic states. Jatamansone was tested in hypertension. Valeranone shows different biological activities along with hypertension and anti-ulcerogenic effects.

**Analytical Profile**

GC Profile of volatile oil with valeranone as marker.

**Column**

OV-1 Chrom W (80-100), SS - 2m ? 3.2mm.

**Oven temp.**

Programmed from 180-220\( ^\circ \) C at a rate of 10\( ^\circ \)C/min.

**Injector temp.**

240\( ^\circ \) C

**Detector (FID) temp.**

240\( ^\circ \) C

**Carrier gas (N2)**

3.8 kg/cm\(^2\).

**SUBSTITUTE/ADULTERANTS**

The roots of Selinum vaginatum C.B.Clarke and Cymbopogon schoenanthus spring are used at times, for adulterating. However the yield of volatile oil, its physicochemical constants and a G.C profile can serve as
standards for identification of the drug and determination of its constituents there by checking the purity and strength of the drug.

**ECONOMICS**
The price of 01 kg of rhizome/root ranges from Rs. 150-160.

**HOME REMEDY**
Jatamansi is used for fumigation for warding off microorganisms.

**DOSE:** Powder - 1-3 g

**KALMEGH**

**Andrographis paniculata Wall. ex Nees**

**Family-Acanthaceae**

It is a bitter annual herb, erect, 50 cm to 1m. in height, stem quadrangular, much branched; leaves opposite, short petioled; flowers in racemes. Fruit capsule linear, oblong or elliptic; seeds approximately 12 in number, sub-quadrate, brownish or creamy yellow.

**REGIONAL NAMES**

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<thead>
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DISTRIBUTION
Widely distributed throughout the plains of India from Uttar Pradesh to Assam, Madhya Pradesh, Tamil Nadu and Kerala.

Part Used: Whole plant

MEDICINAL PROPERTIES & USES
The plant is bitter, acrid, cooling, laxative, vulnerary, antipyretic, anti-periodic, anti-inflammatory, expectorant, depurative, sudorific, anthelminthic, digestive and stomachic. It is useful in hyperdipsia, burning sensation, wounds, ulcers, chronic fever, malarial and intermittent fevers, inflammations, cough, bronchitis, skin diseases, leprosy, pruritis, intestinal worms, dyspepsia, flatulence, colic, diarrhoea, dysentery and haemorrhoids.

CULTIVATION & PROPAGATION

Soil and Climate
It can be cultivated in shady wastelands on wide range of soils from loam to lateric soils with moderate fertility.
The climatic requirement of the plant is hot and humid with ample sunshine. With the onset of monsoon, plant grows luxuriantly and starts flowering by September. Flowering and fruiting continues upto December until temperature drops drastically in Northern plains.

Nursery Raising and Planting
Propagation is through scattered seeds in nature. Vegetative propagation is also possible in certain special
cases through layering as each node is capable of producing sufficient roots. Seeds are small and remain
dormant for five to six months. For raising crop in one hectare three beds of 10 X 2 m size should be tilled,
pulverized and levelled during the month of May. Liberal use of organic manure in nursery is advised for
raising healthy seedling. Very thin layer of soil and compost mixture should cover seeds. Beds should be
covered properly by suitable mulch and irrigated regularly with fountain till seedlings emerge after 6-7 days.
Immediately after germination, mulch is removed to avoid elongation of the seedlings. After 10-15 days,
regular flood irrigation is given till it is ready for planting.
Transplanting of seedling is done in second fortnight of June at a row and plant spacing of 45 to 60 cm and
30 to 45 cm respectively. Beds should be irrigated immediately after planting.

**Thinning and Weeding**
To begin with one or two weeding/hoeing are essential to get the crop established. After establishment,
crop grows well during monsoon.

**Manure/Fertilizer**
Kalmegh can be grown on poor to moderate fertile soil. 3-6 tonnes of well rotten farmyard manure is
required for raising nursery.

**Irrigation**
Fairly distributed rainfall during monsoon is sufficient to raise annual crop in Northern states. Prior to rain 2-
3 irrigations are required. Irrigation during autumn does not show much effect on biomass yield as by that
time plant reproduces.

**HARVESTING/POST HARVESTING OPERATION**
Maximum herb biomass can be obtained in 90-100 days beyond which leaves start shedding. If the crop is
raised annually and planted during the month of May-June, it should be harvested by the end of September
when flowering is initiated. At the time of flower initiation, active principle, andrographolide is high in leaves.
Since the whole plant contains active principles, entire harvested material is dried in shade and powdered.

**CHEMICAL CONSTITUENTS**

**Major Constituents**
Andrographolide
Other Constituents
A diterpene glucoside-neoandrographolide. Crystalline mixture of four bitter substances isolated from leaves. Andrographin, panicolin, apigenin 4,7-dimethyl ether and mono-O-methylwithin from roots. Caffeic, chlorogenic an ddicaffeoylquinic acids from leaves. Ninandro grapholide is isolated from the plant. 5-hydroxy-7, 8-dimethoxy flavanone and 5-hydroxy-3, 7, 8, 2'- tetramethoxy flavone along with 7-O-methyl wogonin isolated from the roots. Cavacrol, eugenol myristic acid hentriacontane and tritriacontane isolated. Isolation of oroxylin and wogonin.

Active Constituents
Single dose of Plant leaf or Andrographolide shows marked enzymatic levels on dogs.

YIELD
A well-maintained crop grown during monsoon yields 3.5 to 4.0 tons of dried herb per hectare.

SUBSTITUTE/ADULTERANTS
The drug is often substituted for or mixed with the genuine Chirata (Swertia chirata) but can be distinguished from the latter by the green colour of its stem, numerous erect slender opposite branches and its lanceolate green leaves. Kalmegh is also adulterated with Andrographis echioides Nees found in tropical India and in dry districts of Maharashtra, Rajasthan, & Tamil Nadu.

ECONOMICS
**SARPAGANDHA**  
*Rauwolfia serpentina* Benth. ex Kurz  
**Family-Apocynaceae**

An erect evergreen, perennial under-shrub, 75 cm to 1 m. in height. Root is prominent, tuberous, usually branched, 0.5 to 2.5 cm in diameter. Up to 40 to 60 cm deep into soil. The roots possess high alkaloid concentration.

**Common Names:** Candrabhaga, Chota chand, Serpentina root, Chandrika & Asrol.

**Distribution:** Foot hills of Himalayan range, up to the elevation of 1300-1400 m. and almost throughout all over the country. Lowers hills of Himachal Pradesh, Uttaranchal, Uttar Pradesh, and Jammu & Kashmir etc.

**Parts Used:** Root

### CULTIVATION

**Soil and Climate**

The plant requires slightly acidic to neutral soils for good growth with medium to deep well drained fertile soils. Clay-loam to silt-loam soils, rich in organic content are suitable for its commercial cultivation. It grows well in frost-free tropical to sub-tropical situations under irrigation.

**Nursery Raising & Planting**

The crop can be propagated by seed, stem cutting and root cuttings. Seed propagation is the best method for raising commercial plantation.

**By root cutting:** Nearly 5 cm long root cutting are planted during nearly spring season in nursery beds containing well matured Farmyard Manure, sand and sawdust. The beds are kept moist through watering. The cuttings begin to sprout within 3 weeks. These can be planted in field during rainy season after 8 to 10 cm rains are received; the seedlings are transplanted at 45 cm row to row and 30 cm plant-to-plant distance. In this manner, an estimated 100 kg of root cuttings are found sufficient for planting one-hectare area.

**By stem cuttings:** Hard wooded stem cuttings measuring 15 to 22 cm are closely planted during June in the nursery beds where continuous moisture is maintained. After sprouting and giving out roots, these plants are transplanted in the main field at given spacing.

**By root stumps:** About 5 cm of roots, intact with a portion of stem above the collar, are directly transplanted in the field having irrigation facilities.

**By seed:** Seed germination in Rauwolfia is highly variable. It is reported to vary from 5 to 30 percent even when only heavy seeds are chosen for sowing purpose. Light and heavy seeds can easily be separated by simple water flotation. Germination of heavy seeds during May-June after soaking them in water for 24 hours was 20-40 per cent and 62.77 percent germination was recorded in freshly collected heavy seed lot. In all, 6 kg of seeds are sufficient to raise one-hectare plantation.

In Maharashtra and Madhya Pradesh, April end, in West Bengal first week of May or little later, and in Jammu & Dehradun during third week of May are found to be most suitable time for sowing seed in the nursery. The nursery is prepared by raised beds of 10x10 m. dimension under partial shade made up of one-third of well matured FYM and leaf mould, and two-third amount medium of silt-loam soil. About 500 sq m. seedbeds area is sufficient for raising seedlings and enough for planting one-hectare land. The seeds are sown, 2-3 cm apart in rows in shallow furrows during April end. The furrows are then covered with a fine
mixture of soil and FYM. Keep the beds just moist by light watering. Germination starts after 15-20 days and continues up to 30 to 40 days. Seedlings are ready by mid-July for transplanting. The seedlings are transplanted at 30 cm distance within the rows spaced at 45 cm. If rains are not received during or immediately after transplantation irrigation is necessary for better growth. Rauwolfia is long duration (18 months) and slow growing crop particularly in the initial stage; thus different intercrops have been tried.

MANURE/FERTILIZER
Farmyard manure at (20 to 25 q/hectare) is required for land preparation has given good response by the crop. Fertilizer trials have made it evident that Rauwolfia responds favourably to nitrogen, phosphorus and in some part to potash application.

IRRIGATION
Rauwolfia, if grown in the areas which receive rainfall of 150 cm or above well distributed throughout the growing season such as in Assam and Kerala, can be raised and rainfed crop under subtropical conditions. It needs regular irrigation where temperature rise high combined with low rainfall during rainy season. It is suggested that 15 to 16 irrigations, at 20 days interval in summer and at 30 days interval in winter are sufficient.

WEEDING
The Rauwolfia field should be kept relatively weed-free in the early period of growth. This means giving two to three weedings and two hoeings in the first year where sole Rauwolfia crop is taken or 5-6 weeding where intercrops in Rauwolfia are practised.

HARVESTING/POST-HARVESTING
Root yields at different age and climate has shown that 18 months duration crop produce maximum root yield. Transplanting is done in July; the harvesting period coincides with the shedding of leaves during early autumn season next year. At this stage, the roots contain maximum concentration of total alkaloids. At harvest the root may be found to go up to 40 cm deep in the soil. Digging up the roots harvesting and thin roots are also collected. After digging the roots are cleaned, washed and cut into 12 to 15 cm pieces for convenience in drying and storage. The dry roots possess upto 8-10 per cent of moisture. The dried roots are stored in polythene lined gunny bags in cool dry place to protect it from mould.

YIELD
On an average, root yield vary from 15 to 25 q/hectare of dry weight under irrigation depending upon soil fertility, crop stand and management.

ECONOMICS
Expenditure per hectare Rs. 19,000/-
Return per hectare Rs.60,000/-
Net income Rs.41,000/-

SERPENTWOOD
HISTORY AND GEOGRAPHICAL DISTRIBUTION
Although, a number of species of Rauwolfia are reported to contain medicinally important alkaloids, only two species, viz., Serpentwood (Rauwolfia serpentina Benth. ex Kurz.) and African Serpentwood (Rauwolfia vomitoria Afz.) are commercially important and used for isolation of therapeutically important indole alkaloids. A third species, American Serpentwood (Rauwolfia canescens Linn.) has been used for sometime in the past as a substitute of Rauwolfia serpentina, but it is of little commercial significance today. Serpentwood (Rauwolfia serpentina Benth.) is one of those medicinal plants, which had been used in India
for more than 4000 years. It was known in folk medicine even in pre-Vedic period in India. In Ayurvedic medicine, it was used for treatment of snake-bite, insect stings and mental disorders. Later on, it was also reported to be used for treatment of epilepsy, diarrhoea and dysentery and as a uterine stimulant to facilitate childbirth in various parts of India. It has been popular with certain tribals in Bihar as 'PAGAL KI DAWA' (mad man's medicine) for several thousand years. On the basis of Ayurvedic literature and folk use, the noted Unani physician Hakim Ajmal Khan tried this drug on thousands of patients in early part of 20th century and found it to be very effective in mental disorders and hypertension. It was based on his clinical observations that he asked Dr. S. Siddiqui to start chemical investigation on this plant. Siddiqui and Siddiqui isolated a number of alkaloids which include ajmaline, ajmalicine, ajmalinine, serpentine and other alkaloids of this group. Simultaneously, Sen and Bose, based on their clinical studies, suggested Rauvolfia root as a potent hypotensive and tranquillizer. The first pharmacological evidence for hypotensive activity of Rauvolfia roots was provided by Chopra and co-workers in 1933. The first clinical trial was carried out by Dr. Vakil in 1949, who found it the most successful hypotensive drug at that time. However, the main hypotensive alkaloid - reserpine, which was part of oleoresin fraction, was isolated by Muller and co-workers only in 1952, after which the plant was adopted in modern medicine as an effective hypotensive agent and tranquillizer. Discovery of reserpine proved a major landmark in the research for drugs from plants including various species of Rauvolfia.

Rauvolfia serpentina is indigenous to moist deciduous forests of S.E. Asia including India, Bangladesh, Burma, Sri Lanka, Malaya, Andaman Islands and Indonesia. Most of the supply of this drug is obtained from wild sources in India, Thailand, Bangladesh and Sri Lanka. The drug is cultivated on small scale in India and Bangladesh. It is exploited to a very limited extent in Nepal and Indonesia.

Rauvolfia vomitoria is a native to the forests of West Africa from Senegal and Congo to Mozambique. All the supply of this drug is obtained from wild sources in Zaire, Mozambique and Rwanda. Zaire is the largest producer and exporter of the drug to Europe. As the wild material is available in sizable quantities in various countries of Africa, no cultivation methods have been developed.

BOTANY

Rauvolfia serpentina is an erect, perennial shrub, generally 15-45 cm high, but growing up to 90 cm under very favourable conditions. Roots nearly verticle, tapering, as much as 15 cm thick at the crown and long giving a serpent-like appearance, occasionally branched or tortuous developing small fibrous roots. Roots greenish-yellow externally and pale-yellow inside, extremely bitter in taste. Leaves borne in whorls of 3-4, deciduous, elliptic-lanceolate or obovate, pointed, green on the upper surface, pale-green underneath, 7.5 x 20 cm in size. Flowers numerous, borne in terminal or axillary, long-stocked clusters, tubular, 5-lobed, 1-3 cm long, whitish pink in colour. At the onset of fruit/seed, calyx pedecel and flowering stock become bright red. Fruits in pairs, obliquely ovate, 7.5 mm in size, purple black and bluish when ripe, with stone containing 1 or 2 seeds.

Rauvolfia vomitoria is a shrub or small tree, 2-6 m high, with bitter, white latex. Branches are quadrangular, roots are 5 cm or more in diameter. Leaves in whorls of 3-4, may be oblong, obvate, lanceolate or ellipse with pointed apex, 7-17 cm long, 2.5-7 cm wide, shining green. Flowers are fragrant, tubular, 5-lobed, 1-3 cm long, somewhat hairy at the mouth, 8.5 mm long, white, numerous, borne in terminal clusters. Fruits in pair or single, ovoid, smooth, 8.5 mm in size and bright red when ripe.

GENETICS

R. serpentina is a diploid (2n = 22) species. However, variation in chromosome morphology is frequent. Chromosomal translocations are reported to have played a vital role in intraspecific differentiation. Owing to its cross pollination nature due to protogynous flowers, and long duration crop, not much work has been done with respect to its genetic improvement. Studies carried out so far are related to evaluation of genetic variation for both vegetative characters as well as alkaloid content in natural populations of R. serpentina
collected from diverse geographical regions of India. While the range of variation for alkaloid content in Indian stocks was from 0.95% to 2.73%, that in Sri Lankan material was from 0.7% to 2.10%. Besides, a number of tetraploids were also produced. Majority of them were slow growing, sturdy, relatively dwarf, large flowers and low fruit set per plant. Tetraploids superior in total alkaloid content (2.28% against 1.54% of diploids) were also reported. But none of them could be commercialised. Attempts were also made to regenerate R. serpentina through in vitro culture for further exploitation.

SOIL AND CLIMATE
The plant thrives well in deep fertile soils which are rich in organic matter. It prefers slightly acidic soils (pH 4-6.3). Although, the plant is a native of tropical humid climate, it grows in tropical and subtropical areas which are free from frost.

PROPAGATION
The plant can be propagated through seed or vegetatively by root or stem cuttings. However, commercially multiplication through seed is advisable. Vegetative multiplication can be used where there is a shortage of planting material and where it is desirable to multiply a particular genetic clone or variety.

Seed propagation: When multiplication is done through seed, plants are raised in nursery. Seed germination in Rauvolfia is very poor and variable. Various workers have reported germination as low as 10% and as high as 74%, depending upon the viability of seed, time of seed collection and period of storage, etc. Most of the variable results regarding germination have been obtained because large number of seeds collected from commercial plantations do not contain embryo and are non-viable. It is, therefore, desirable to use freshly collected seeds. Seeds collected during September-November give good results. It is advisable to soak the seeds in 10% sodium chloride solution and only those seeds which sink to the bottom should be used. Seeds which float on the solution are generally non-viable. It is preferable to treat the seeds with seed-dressing fungicide before planting in nursery to avoid pre- and post-emergence damping-off caused by fungi. Nursery beds should be located in a shady place with adequate irrigation facilities. The land should be cleared off weeds and brought to a fine tilth. Well-rotten farmyard manure and leaf compost should be mixed in top 22 cm of the soil. Seeds should be dibbled or planted about 6-7 cm apart at a depth of 1 cm. Ideal time for raising the nursery in north India is May-June just before the onset of monsoon, while in south India seeds can be planted with the onset of monsoon. About 5-6 kg seeds are required for planting a hectare. Seedlings can be transplanted in the field in July-August after 8-10 weeks growth. Seedlings are planted at a distance of 30 cm in rows which are 30-60 cm apart. Density of plant is selected depending on the fertility of the soil and climate of the area where the crop is to be grown.

Propagation by root cuttings: Root cuttings of 2.5-5 cm size are planted in sand horizontally and irrigated frequently. Ideal time for planting is March-June. Treatment of cuttings with hormone has been found useful. Cuttings take 1-2 months for rooting and establishment. About 100 kg root cuttings are required for planting one hectare.

Propagation by stem cuttings: About 12-20 cm long woody stem cuttings having at least 2 buds are planted in sand. Treatment with hormone gives better results. Ideal time for planting stem cuttings is June-July.

INTERCULTURE AND WEED CONTROL
The inter-row spaces between plants, both in the field and nursery, should be kept free from weeds by frequent weeding and hoeing, as the plant suffers from weed competition specially during early stages of growth. Manual hand weeding or tractor- drawn implements can be used.

FERTILIZERS AND MANURES
Only a limited number of fertilizer trials have been carried out. It has been observed that 20 kg nitrogen, 30 kg phosphorus and 30 kg potash per hectare applied as basal dose before planting gives good results. 20 Kg nitrogen should be applied as top dressing twice during the cropping season. Both nitrogen and phosphorus have been found to increase the root yield. It has also been observed that use of farmyard
Manure, nitrogen and phosphorus gives better results as compared to chemical fertilizers. Top dressing at the rate of 40 kg nitrogen per hectare should be repeated during second year.

Irrigation
Irrigation of seedlings just after planting is good for crop establishment. Although Rauvolfia serpentina can be cultivated as a rainfed crop under humid tropical conditions, irrigation every month or alternate months is required during March-June in those areas where there is no rain during this period. Monthly irrigation has been found to increase the yield of roots over unirrigated plots.

Harvesting and Processing
Under irrigated conditions serpentwood gives optimum yield only after 2-3 years of planting. However, under ideal conditions the crop can be harvested even after two years. The ideal time for harvesting the crop is November-December when the plant becomes dormant and the alkaloid content in the roots is the highest. Harvesting is done by digging up the roots by trench holes. Roots are lifted, washed and dried up to 10-12% of moisture content. Dried roots are stored in airtight containers at a cool place. An average yield of 1000 kg roots per hectare is obtained. However, under certain conditions yields of more than 2 tonnes per hectare have also been obtained.

Diseases and Insect Pests
A number of leaf spots in Rauvolfia serpentina caused by fungi have been reported. These include Cercospora leaf spot, target leaf spot, leaf blotch, Alternaria leaf blight, anthracnose, die back, powdery mildew, and fusarium wilt. Root knot and mosaic of Rauvolfia have also been reported.

A number of insect pests have been reported from small experimental plantations. These include pyralid caterpillar, sphingid moth, cockchafer grab and hay grub.

Chemistry and Uses
More than 50 alkaloids have been reported from Rauvolfia serpentina. The most important alkaloids isolated from the roots are ajmaline, ajmalicine, ajmalinine, alloyohimbine, chandrine, deserpidine, isoajmaline, yohimbine, r-yohimbine, isoyohimbine, 11-methoxy-delta-yohimbine, methylreserpate, neoaajmaline, papaverine, corynanthine, isorauhimbine, 3-epi-alpha-yohimbine, raunatine, rauvolfinine, rauwolscine, reserpiline; reserpine, rescinnamine, reserpinine, reserpinoxide, sarpagine, serpinine, serpentine and serpentinine. Total alkaloid content in the plant varies between 1.49-2.38%.

Most important alkaloids used in medicine are reserpine, rescinnamine and deserpidine. Other alkaloids which are found in this plant but are not isolated commercially are ajmaline, ajmalicine and serpentine. Reserpine is used as a hypotensive agent as well as tranquillizer. Recently, it has been reported to be associated with breast cancer, and as such, its demand has gone down in the world market. Deserpidine and rescinnamine are also used as hypotensive and tranquillizer. Because of toxic nature of reserpine, recent trend has been to use total extract and powdered root extract as therapeutic agents in various countries as a hypotensive as well as sedative.

Roots of Rauvolfia vomitoria also contain a large number of alkaloids, most important of which are ajmaline, alstonine, isoreserpiline, mitoridine, purpeline, rauvanine, rauvomitine, rescidine, reserpiline, reserpine, reserpinine, rescinnamine, sarpagine, seredamine, serpentinine and yohimbine. However, out of these alkaloids, only ajmaline and reserpine are isolated commercially from Rauvolfia vomitoria. Total alkaloid content in R. vomitoria varies between 0.2-1.6% in the whole root. However, the root-bark contains up to 9.7% total alkaloid with 3.0% ajmaline and 0.98% reserpine. While reserpine is used as a hypotensive and tranquillizer, ajmaline is used as antiarrhythmic agent.

Tulsi
Ocimium sanctum Linn.
Family-Lamiaceae
An annual plant, 30-60 cm high, much branched; stem and branches usually purplish, sub-quadrangular; leaves 2.5-5 by 1.6-3.2cm, elliptic oblong-obtuse, pubescent on both side and minutely gland-dotted. Flowers are in racemes.

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DISTRIBUTION
Found thought India.

Part Used: Whole plant

MEDICINAL PROPERTIES & USES
The drug has numerous pharmacological activities like hypoglycaemic, immunomodulatory, anti-stress, antiulcerogenic, anti hypertensive, CNS depressant, radioprotective, antitumour and antibacterial. Tulsi is aromatic, carminative, antipyretic, diaphoretic and expectorant. It has been found to be very effective in treatment of viral encephalitis and tropical pulmonary, eosinophilia in children. The plant is also used in snakebite & scorpion sting.

CULTIVATION & PROPAGATION

Soil and Climate
Thrives well on variety of soils. Rich loam to poor laterite, saline and alkaline to moderately acidic soils are well suited for its cultivation. Well-drained soil helps better vegetative growth. Water logged condition can cause root-rot and result in stunted growth. The plant can be grown under partially shaded conditions but with low oil content. It flourishes well under moderate rainfall and humid conditions. Long days and high temperatures have been found favourable for
plant growth and oil production. Topical and sub-topical climate (at attitudes upto 900m) is suited for its cultivation.

**Land And Preparation**

The land is brought to fine tilth and laid out into plots of convenient sizes for irrigation. It is preferable to add 15 tonnes of farmyard manure per hectare during the preparation of land and mixed well with the soil.

**Nursery Raising and Planting**

The nursery can be raised in the third week of February and transplantation is generally started by mid April. Seeds are used for propagation. Raised seedbeds of 15” x 4’9” size should be thoroughly prepared and well manured by addition of farmyard manure. About 200-300g seeds are enough to raise the seedlings for planting one hectare of land. The seed should be sown 2cm below in the nursery beds. The seeds germinate in 8-12 days and the seedlings with 4-5 leaves are ready for transplantation in about 6 weeks. The seedlings are transplanted at 40 ? 40cm and 40 ? 50cm to get high herbage and oil yield per hectare.

**Weeding and Hoeing**

First weeding is done after one month after planting and the second four weeks after the first. One hoeing after two months of planting is sufficient.

**Manure/Fertilizer**

Compost/Vermi compost and organic manure is preferred.

**Irrigation**

Irrigation depends upon the moisture content of soil. In summer three irrigations per month are necessary and in rainy season no irrigation is required. About 12-15 irrigations are enough during the year.

**HARVESTING/POST HARVESTING OPERATION**

The crop is harvested at full bloom. The first harvest is obtained after 90-95 days. Then it may be harvested at every 65-75 days interval. Harvesting is done usually on bright sunny days for good oil yield and quality. It is not desirable to harvest the crop if there was rain in the previous day.

**CHEMICAL CONSTITUENTS**

**Major Constituents**

Eugenol
It contains phenolics such as carvacrol and eugenol; non-phenolics such as methyl eugenol, methyl chavicol and caryophyllene etc. The flavonoids include apigenin, luteolin, vicenin-2, orientin, isoorientin, vitexin, isovitexin, cirsilineol, isothymusin, rosmarinic acid and caffeic acid.

Petroleum extract of the Leaves found to contain beta-carotene, sterols and fatty acids. Triglyceride, 1,3-Dilinoleoyle-2-palmitin also been reported.

**Active Constituents**

Of all the Ocimum species, O. sanctum is most widely studied for its pharmacological properties. Traditionally, it has been used as diaphoretic, expectorant and hepatoprotective. It has been studied for its immunomodulatory, anti-hyperglycemic, antioxidant, anti-inflammatory, anti-stress, radioprotective. Its anti-ulcer and anthelmintic activities also been reported. It has also been studied for chemopreventive, anti-cryptococcus and cardioprotective activities.

**Analytical Profile**

TLC of Tulasi oil (obtained by steam distillation) shows eugenol and caryophyllene Rf values 0.7 and caryophyllene runs to solvent front giving orange brown and reddish violet respectively, standards matching with the oil at given Rf of standards. Plate was developed in mobile phase Toluene: Ethylacetate (93:7) and plate Silica gel 'G'.

![Chemical structures and analytical profiles](image-url)
YIELD
About 5 tonnes of fresh herbage can be obtained twice or thrice a year per hectare.

SUBSTITUTES/ADULTERANTS
The leaves of other species of Ocimum are often adulterated with the genuine drug.

ECONOMICS

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<td>Net income per hectare</td>
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HOME REMEDY
Local application of tulsi juice is an excellent remedy for urticaria.

DOSE:

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<tr>
<td>Juice</td>
<td>5-10 ml</td>
</tr>
<tr>
<td>Powder</td>
<td>1-3 g</td>
</tr>
</tbody>
</table>