CONTENT

HISTORY, SCOPE, OPPORTUINITIES AND CONSTRAINT IN THE CULTIVATION OF MEDICINAL AND AROMATIC PLANTS IN INDIA

History

Among ancient civilisations, India has been known to be rich repository of medicinal plants. The forest in India is the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw materials to manufacture drugs, food flavouring and perfumery products. About 8,000 herbal remedies have been codified in Ayurveda [(The term comes from the Sanskrit root *Au* (life) and *Veda* (knowledge)]. The *Rigveda* (5000 BC) has recorded 67 medicinal plants, *Yajurveda* 81 species, *Atharvaveda* (4500-2500 BC) 290 species, *Charaka Samhita* (700 BC) and *Sushruta Samhita* (200 BC) had described properties and uses of 1000 and 2700 species respectively, in compounding of drugs and these are still used in the classical formulations, in the Ayurvedic system of medicine. These plants have made a good contribution to the development of ancient Indian *Materia Medica* (*Materia medica* is a Latin medical term for the body of collected knowledge about the therapeutic properties of any substance used for healing (i.e., medicines). In Latin, the term literally means "medical material/substance".). The use of medicinal plants in Ayurvedic medicine in India dates back to 1900 B.C. Medicinal plants and herbs were the first items used as medicine to cure ailments. Physicians passed the knowledge of their plant cures verbally to their students and apprentices.

In China, The Shennong Bencao Jing, a book containing information about more than 300 medicinal plants and their uses, was written around 2800 B.C.

The Sumerians were also early in documenting their use of medicinal plants and were said to be the first people to practice year-round agriculture.

Records also exist of medicinal plant use by the ancient Egyptians as far back as 1000 B.C.

Hippocrates (460 BC – 370 BC), was an ancient Greek physician and is considered one of the most outstanding figures in the history of medicine. He is referred to as the father of Western medicine), and his work has inspired much of conventional Western medicine. He also promoted the use of medicinal plants. He used plants to treat illness and listed 400 herbs useful for the treatment of wounds and sickness.

The Roman physician, Dioscorides, continued the practice and his manuscripts were the basis of European medicine for 1500 years.

Renaissance of medicinal plants

Use of plants and herbs as medicines revived during the renaissance. The printing press enabled the information to become more widely available. Medicinal plants and herbs became well known and were used by many when a physician wasn't available.

Modern Medicines

Many modern medicines use plants and herbs for their raw material. Aspirin, derived from Willow bark, is perhaps the best-known example. Eastern countries such as China and India still rely on herb and plant medicines to cure illnesses.

The Pharmaceutical Era

Pharmaceuticals became popular in Europe during the 19th century, when improvements in chemical analysis techniques allowed scientists to isolate and extract beneficial plant compounds. In contrast, traditional use of medicinal plants involves utilizing an entire portion of the plant like the root or leaf, rather than extracting a single component. Pharmaceuticals also go through extensive testing before being available to the public, although scientists report more side effects with pharmaceuticals than medicinal plants. Although less scientific evidence exists for the effectiveness of medicinal plants, research interest and investment is increasing.

Scope and opportunities in the cultivation of MAPs

The use of medicinal plants has been a central component of health care in many cultures for centuries, dating as far back as 5,000 years. The World Health Organization estimates that up to 80 percent of the world now relies on medicinal plants as their main source of health care. Currently, more than 120 pharmaceutical drugs in the market contain extracts from medicinal plants.

Most of these continue to be gathered from wild plants to meet the demand of the medical profession. Thus, despite the rich heritage of knowledge on the use of plant drugs, little attention had been paid to grow them as field crops in the country till the latter part of the nineteenth century.

During the past seven or eight decades, there has been a rapid extension of the allopathic system of medical treatment in India. It generated a commercial demand for pharmacopoeial drugs and products in the country. Thus, efforts were made to introduce many of these drug plants into Indian agriculture, and studies on the cultivation practices were undertaken for those plants which were found suitable and remunerative for commerical cultivation.

In general, agronomic practices for growing poppy, isabgol, senna, cinchona, ipecac, belladonna, ergot and a few others have been developed and there is now localized cultivation of these medicinal plants commercially. The average annual foreign trade in crude drugs and their phytochemicals is between 60 and 80 million rupees and accounts for a little over 0.5 per cent of the world trade in these commodities.

Opportunities and challenges in MAPs Opportunities

Medicinal Aromatic Plants (MAPs) can play an important role in contributing to the livelihoods of small-scale farmers and others in rural, peri-urban, and urban communities. The opportunities abound in terms of MAPs as they can contribute to:

- Farmers enhancing their knowledge, skills and capacity in terms of a new enterprise as well as enhancing their environmental awareness, especially in terms of wild harvests, and its importance to them;
- Enhancing farmer's knowledge in terms of MAPs role in traditional healthcare systems;
- The variety of products that can be derived from a single MAP;
- Farmers having more varied farm products to trade;
- Having more farm products to sell enables a more balanced flow of cash income to the farm household throughout the year, especially in terms of processed MAPs;
- Increased incomes for farmers as well as other members of communities who participate in production/ gathering of MAPs;
- Improved living standards as a result of extra income as this can pay for such matters as school fees, for example, and access to traditional medicines and health care systems, etc.;
- Farm products that can possibly have a high market value, especially if processed;
- Adding value to farm products with primary and secondary processing operations on farm enabling small-scale farmers to move down the supply chain;
- Linkages with processing enterprises and possibilities of providing pharmaceutical companies with 'raw materials;
- Participating in Fair Trade and MAPs distribution networks;
- Fostering organization among farmers and other people in local communities, especially in the case of wild harvests and provides for community social benefits;
- Cultivation/wild harvest as well as processing of MAPs by women. Thus, enabling them to enter the local economic system. **Challenges**

Many of the challenges facing MAP activities are not uncommon to many farmers. However, as MAPs represent the only source of healthcare to much of the World's rural poor, resource exploitation must be ecologically and socially sustainable to ensure the protection of millions of livelihoods. It would be wise for any development of MAP activities beyond a subsistence use, to proceed with much caution, even at local trade level, and with particular attention to sustainable harvesting. Promoting cultivation of MAPs with appropriate training and environmental sound practices is one step in the right direction.

Trading MAPs on a scale beyond local or regional level can be labour and management intensive and requires a good understanding of resource management and sustainable yields, and how markets work, and what phyto-sanitary and other legal requirements exist. As such, export markets remain largely the domain of pharmaceuticals, unless regional or national assistance can be secured to help niche marketing of products into wider domestic or even international markets. All production systems reliant largely upon wild harvest are vulnerable to sporadic yields, and indeed overharvesting leading to local, or even regional species decline. As such all natural resources must be closely monitored, and successful and sustainable trade will rely upon controls on the supply side, rather than being demand led. Where species traits make it possible, a shift from wild harvest to cultivated sources can provide a more secure supply, but moving from subsistence use to trade and marketing can be quite challenging to local harvesters and growers.

Although there are examples of highly organized supply chains associated with large scale phyto-pharamaceutical companies, much of the global MAP industry is characterised and handicapped by fragmented and uncoordinated raw material supply, lack of communication and coordination relating to demand, and limited product diversity and institutional organization. Successful businesses should empower small-scale farmers, wild harvesters, traders and traditional healers through skills transfer, helping them to accumulate wealth and income through equitable trade; achieve consistently high quality products; and source investment capital from the private sector to finance new initiatives. Achieving these goals requires a mix of institutional arrangements that promote the sustainable and profitable use of resources by encouraging investment, efficiency, and fairness in the distribution of benefits.

As such, some key constraints facing MAP activities include the following:

- Cultivation know-how and unpredictable nature of plant availability and quality, unlesss it can be cultivated or in some way domesticated, and the limited technical knowledge, and/or suitable species and land tenure system, to facilitate this;
- Poor organizational capacity and lack of political influence coupled with an absence of support services which are well equipped and reliable in providing simple but effective technical know-how, business development advice, and or credit, to smallholders;
- Poor infrastructure which acts as a general constraint for equitable market access, and economic growth in rural areas, often resulting in seasonal failures;
- A lack of research and business opportunities directed towards small-scale development of MAP activities;
- Lack of enabling policies that favour access into or encourage responsible small-scale or community based trade, which may include social and financial incentives, such as tax breaks or ecologically oriented subsidies.

Economics

Over three-quarters of the world population relies mainly on plants and plant extracts for health care. More than 30% of the entire plant species, at one time or other, were used for medicinal purposes. It is estimated that world market for plant derived drugs may account for about Rs.2, 00,000 crores.

Presently, Indian contribution is less than Rs.2000 crores. Indian export of raw drugs has steadily grown at 26% to Rs.165 crores in 1994-95 from Rs.130 crores in 1991-92. The annual production of medicinal and aromatic plant's raw material is worth about Rs.200 crores. This is likely to touch US $5 trillion by 2050.

It has been estimated that in developed countries such as United States, plant drugs constitute as much as 25% of the total drugs, while in fast developing countries such as China and India, the contribution is as much as 80%. Thus, the economic importance of medicinal plants is much more to countries such as India than to rest of the world. These countries provide two third of the plants used in modern system of medicine and the health care system of rural population depend on indigenous systems of medicine.

Of the 2, 50,000 higher plant species on earth, more than 80,000 are medicinal. India is one of the World's 12 biodiversity centres with the presence of over 45000 different plant species. India's diversity is unmatched due to the presence of 16 different agro-climatic zones, 10 vegetation zones, 25 biotic provinces and 426 biomes (habitats of specific species). Of these, about 15000-20000 plants have good medicinal value. However, only 7000-7500 species are used for their medicinal values by traditional communities.

Since the Indian subcontinent is well known for its diversity of forest products and the age-old healthcare traditions, there is an urgent need to establish these traditional values in both the national and international perspectives realizing the ongoing developmental trends in traditional knowledge. Apart from health care, medicinal plants are mainly the alternate income-generating source of underprivileged communities. The instant rising demand of plant-based drugs is unfortunately creating heavy pressure on some selected high-value medicinal plant populations in the wild due to overharvesting. Several of these medicinal plant species have slow growth rates, low population densities, and narrow geographic ranges, therefore they are more prone to extinction.

The continuous increase in human population is one of the causes for concern in meeting the daily requirements of food and medicine as the economy and livelihoods of human societies living in developing countries primarily depend on forest products. This phenomenon is leading to continuous erosion of forest and the forest products, thus making challenge to meet the requirements as well as to conserve useful bio-resources.

More than 95% of the 400 plant species used in preparing medicine by various industries are harvested from wild populations in India. Harvesting medicinal plants for commercial use, coupled with the destructive harvest of underground parts of slow reproducing, slow growing and habitatspecific species, are the crucial factors in meeting the goal of sustainability. Harvesting shoots and leaves of medicinal plants may decline their photosynthetic capacity, and as well as the potential for survival and effective propagation. Medicinal plants tolerance to harvest varies with climatic conditions as the temperate herbs become highly vulnerable to harvest of individuals. Furthermore, rising demand with shrinking habitats may lead to the local extinction of many medicinal plant species. Therefore, the need of the hour is to conserve, cultivate these valuable healers to cater the demand of ever increasing human and cattle population for better health and environmental conditions.

Status of Medicinal Plants in India

About 70 % of MAPs are found in the tropical zone, mostly in the Western Ghats and Eastern Ghats, Vindhyas, Tarai region in the foot hills of Himalayas and in the North East. The remaining 30% is found in temperate and cooler zones. Volume wise the temperate and cooler zones hold a lesser number of plants, but the plants found in these zones are of greater medicinal value.

Area and Production

According to an estimate, MAPs occupy an area of about 2, 50,000 ha, producing raw material of worth Rs. 500 crores, generating business opportunity of more than Rs 5000 crores. It generates employment opportunity for more than 600 lakhs people annually.

The Indian Scenario

India, as described earlier is a virtual treasure trove of plant species. Despite substantial pace of growth in the medicinal plant and product market, India's share in world market of medicinal plant and products is a mere 2.5 percent. The export market is growing faster than the domestic market. However, the export is being carried out in form of plants, or their parts and not as value added products. Countries that import plant and plant parts are invariably less biodiversity but are technologically advanced which show a higher capability to develop value added products from the imports.

The Indian exporters face major constraints while exporting medicinal plants. The cyclical nature of medicinal plant market makes it difficult for them to determine supply and demand in the markets. Also, competition from synthetic substitutes, non-compliance with rules and regulation of the importing countries, hoarding and manipulation by large importers, poor quality control, inadequate information on market trends, use of obsolete technology and lack of established methods for cultivation of large number of plants, etc. compound the problem of export of medicinal plants or their products from India. It is interesting to note that India has negligible patents on plant based formulations, extracts and products. The reason is not far to seek. The existing Patent Act provides only process protection and therefore only the method for preparing a formulation can be protected and not the formulation itself. The process patents are therefore less effective in cases where variations are possible without significantly changing the effectiveness.

Varietal Developed in INDIA

Multi-location evaluation trials conducted under the AICRP on Medicinal and Aromatic Plants have resulted in the identification and release of twenty five new improved varieties of medicinal plants of fourteen species and seven varieties of aromatic plants of six species.

Sl No	Crop	Variety	Developed At	Year Of Release
Medicinal Plants				
1	*Chlorophytum borivilianum (Safed musli)*	JS405	Mandsaur	2004
2	*Cassia angustifolia (Senna)*	Anand Late Selection	Anand	1989
3	*Diascoria floribunda*	FB(C)-1	Bangalore	1974

4	*Diascoria floribunda*	Arka Upakar	Bangalore	1980
5	*Digitalis lanata (Foxglove)*	D.76	Solan	1991
6	*Glaucium flavum (Yellow Horned Poppy)*	H47-3	Solan	1991
7	*Glycyrrhiza glabra (Liquorice)*	Haryana Mulhatti-1	Hisar	1989
8	*Hyoscyamus muticus (Egyptian Henbane)*	HMI-80-1	Indore	-
9	*Lepidium sativum (Cress)*	GA-1	Anand	1998
10	*Rauvolfia serpentina (Sarpagandha)*	RI-1	Indore	-
11	*Papaver somniferum (Opium poppy)*	Jawahar Aphim 16	Mandsaur	1984
12	*Papaver somniferum (Opium poppy)*	Kirtiman	Faizabad	1990
13	*Papaver somniferum (Opium poppy)*	Jawahar Aphim 16	Mandsaur	1997
14	*Papaver somniferum (Opium poppy)*	Jawahar Aphim 16	Mandsaur	1998
15	*Papaver somniferum (Opium poppy)*	Chetak Aphim	Udaipur	1994
16	*Papaver somniferum (Opium poppy)*	Trisna	Delhi	-
17	*Piper longum (Long pepper)*	Viswam	Trichur	1996
18	*Plantago ovata (Isabgol)*	Gujarat Isabgol- 1	Anand	1976
19	*Plantago ovata (Isabgol)*	Gujarat Isabgol- 2	Anand	1983
20	*Plantago ovata (Isabgol)*	Haryana Isabgol-5	Hisar	1989
21	*Plantago ovata (Isabgol)*	Jawahar Isabgol-4	Mandsaur	1996
22	*Solanum laciniatum*	NH 88-12	Solan	1991
23	*Solanum viarum (Khasi Kateri)*	Arka Sanjeevani	Bangalore	1989
24	*Solanum viarum (Khasi Kateri)*	Arka Mahima	Bangalore	1992
25	*Withania somnifera (Aswagandha)*	Jawahar Asgand-20	Mandsaur	1989
26	*Withania somnifera (Aswagandha)*	Jawahar Asgand-134	Mandsaur	1998
Aromatic Plants				
1	*Cymbopogon flexuosus (Lemon Grass)*	NLG-84	Faizabad	1994

2	*C. martinii Var. Motia (Palmarosa)*	Rosha Grass-49	Hisar	1989
3	*C. martinii Var. Motia (Palmarosa)*	CI-80-68	Indore	-
4	*Jasminum grandiflorum (Jasmine)*	Arka Surabhi	Bangalore	1993
5	*Mentha spicata (Spearmint)*	Punjab Spearmint-1	Solan	1991
6	*Valeriana jatamansi (Mushakbala)*	Dalhousi Clone	Solan	1994
7	*Vetiveria zizanioides (Vetiver)*	Hyb-8	Mandsaur	-

(Source: https://dmapr.icar.gov.in/index.htm)

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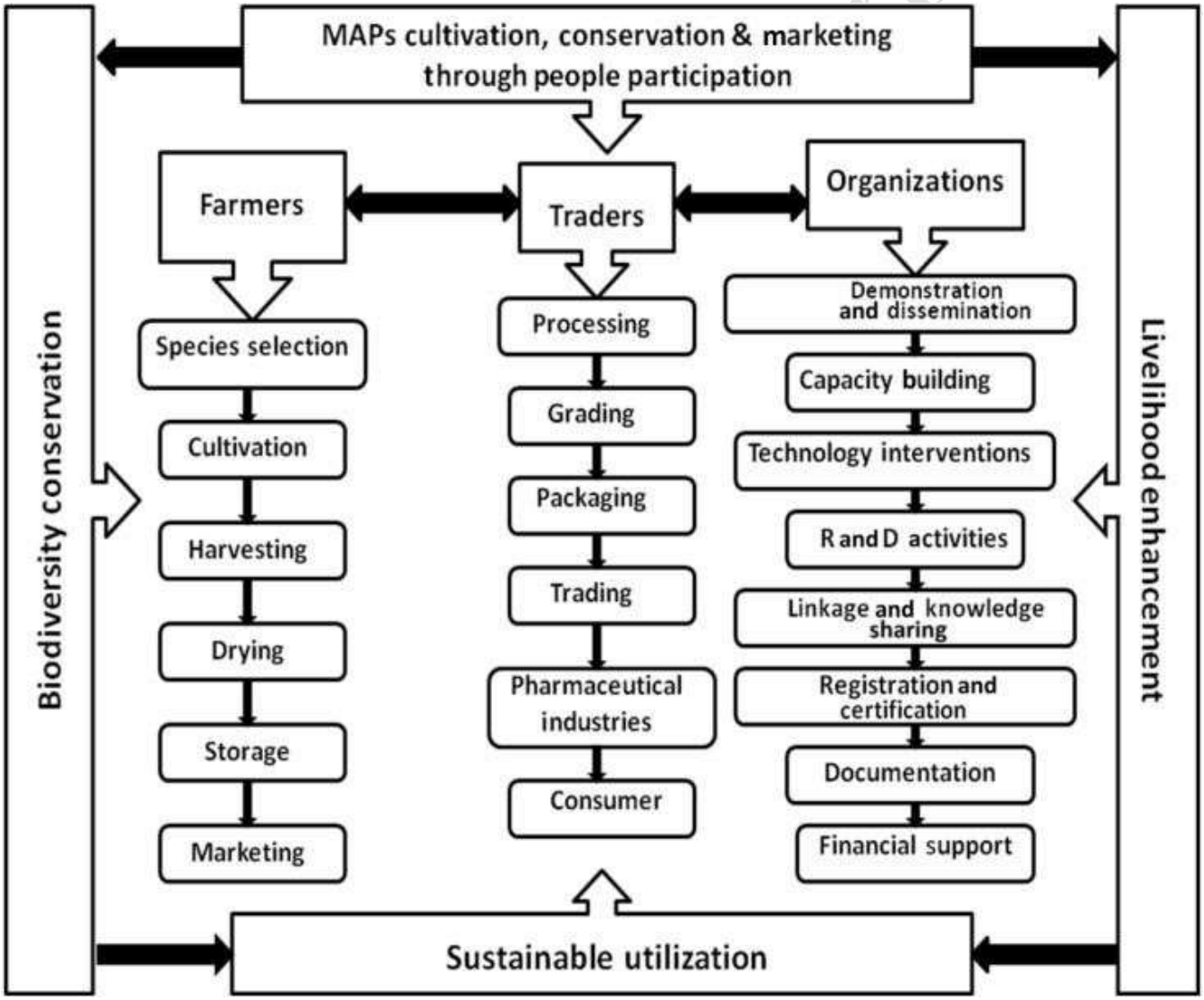
Export flow chart for Medicinal & Aromatic Crops from INDIA



World Trade Organization.

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) has provided the signatory countries the freedom to choose intellectual property protection either under a patent regime or a sui generis system or a combination thereof. An urgent shift in policy is required, if India expects to be a global player in plant based medicine and formulations. It is important to develop a sui generis system to provide grassroots innovators an incentive to disclose knowledge.

There are interrelated technological, institutional, socio-economic and ecological issues affecting the medicinal plant sector that have impeded its growth resulting in the depletion of plant diversity and resource International Journal of Engineering Technology, Management and Applied Sciences (**www.ijetmas.com January 2016, Volume 4, Issue 1, ISSN 2349-4476**)

BETEL VINE

Common Name	**BETEL VINE**
Botanical Name	***Piper betle*** Linn.
Family	*Piperaceae*

Habitat

Cultivated in warmer and damper parts of India; Assam, West Bengal, Bihar, Uttar Pradesh, Karnataka, Kerala. The betel plant originated from South and South East Asia (India, Bangladesh and Sri Lanka).

English Betel pepper.

Ayurvedic Taambula, Naagvallari, Naagini, Taambulvalli, Saptashiraa, Bhujangalataa.

Unani Paan, Tambool.

Action Leaf—stimulant, carminative (Drug causing the release of stomach or intestinal gas), astringent (*Making a body organ act*ive), antiseptic. Essential oil from leaves—antispasmodic (*Opposing spasms (sudden constriction of a hollow organ) or convulsions*), antiseptic. Used in respiratory catarrhs *(is a disorder of inflammation of the mucous membranes*). Fruit—bechic (which relieves or cures cough).

Plant Characteristics

P. betle is a dioecious plant and produces orthotropic (vegetative) and plagiotropic (reproductive) branches. The growth rates in terms of stem elongation and the number of leaves and branches produced are higher in vegetative branches compared with reproductive branches. Vegetative branches also showed higher petiole and internodal lengths. Leaves produced by reproductive branches were larger than those produced of vegetative branches. Vegetative branches had more vascular bundles compared with reproductive branches.

Betel vine requires a tropical climate with high atmospheric humidity. It can be cultivated in the uplands as well as in wetlands. In Kerala, it is mainly cultivated in arecanut and coconut gardens as an intercrop. The crop grows best on well-drained fertile soils. Waterlogged, saline and alkali soils are unsuitable for its cultivation. The crop also comes up very well in lateritic soils. Proper shade and irrigation are essential for successful cultivation of this crop. An annual rainfall ranging from 200 to 450 cm is ideal. The crop tolerates a minimum temperature of 10º C and a maximum of 40º C. Extremely low atmospheric temperature leads to leaf fall. Hot dry winds are harmful.

Varieties

The important types are Thulasi, Venmani, Arikodi, Kalkodi, Karilanchi, Karpuram, Chelanthikarpuram, Koottakkodinandan, Perumkodi, Amaravila and Pramuttan. **Cultivation**

Season

There are two important planting seasons. The Edavakodi is planted in May-June and the Thulakodi in August-September.

Preparation of land

Areas with good shade and irrigation facilities are preferred for this crop. The land is dug well and laid out into furrows of 10-15 m length, 75 cm width and 75 cm depth. Such furrows are opened at a distance of 1 m apart. Well rotten farmyard manure and leaves are thoroughly incorporated with the topsoil of the furrows, along with wood ash. High dose of organic manure (20-50 t/ha) is applied to maintain good soil structure, which is essential for the proper development of the root system.

Planting material and planting

Top portions of mature vines (2-3 years old) are used for planting. Healthy cuttings of about 1 m length with three nodes are used as planting material. For planting one hectare, 20000-25000 cuttings are required. Furrows are irrigated prior to planting. Cuttings are planted in holes 20 cm apart in furrows. While planting, one node shall be buried in the soil and the second node should be at the ground level. The soil around the planted cutting must be pressed firmly to encourage quick germination. It is necessary to provide shade to the planted cuttings. Coconut leaves are used as shading material. To prevent excess moisture in the soil, splashing water on the vines by hand is preferable in the early stages. In the absence of rain, light irrigation, four times daily, is given till establishment. Cuttings establish in three weeks time and the first leaf emerges in about a month.

Trailing the vines and weeding

The cuttings sprout and creep in about a month. At this time, they must be trailed on the standards. Bamboo standards are erected at intervals and linked by tying at heights of 30 cm and 150 cm using coir rope. In the initial stages trailing is done on coir tied for the purpose. Trailing is done further by tying the vines, at intervals of 15-20 cm along the standards loosely with the help of banana fibre. When vines come in contact with standards, they produce adventitious roots using which they cling to support. Trailing is done every 15-20 days depending on the growth of vines.

Water Management

Irrigation and drainage

Betel vine needs constantly moist soil, but there should not be excessive moisture. Hence, frequent light irritations are given. The quantity of irrigation water should be such that the standing water should not remain for more than half an hour in the bed. If water logging by heavy rains or excess irrigation occurs, drainage should be arranged immediately. The best time for irrigation is morning or evening.

Nutrient Management

Dried leaves and wood ash are applied to the furrows at fortnightly intervals and cowdung slurry is sprinkled. This is repeated till four months after planting when the crop is ready for harvest. Application of different kinds of leaves (gliricidia, mango leaves etc) at monthly intervals is found advantageous for the growth of the vines.

Weed Management

Gardens should be kept clean by weeding and stirring as and when required.

Pest Management

The insect pests include the mirid bug (*Disphincuts politus*) which de-saps the tender leaves and shoots, scale insects and mealy bugs (Lepidosaphes and Pseudococcus), which occur on the stems. Insecticidal application is not recommended to avoid toxic hazards. In serious infestations, apply fish oil soap at 1.5% against the mirid bugs and 0.025% quinalphos against the scale insects and mealy bugs. Against scale insects, restrict insecticide application on the stem only. The leaves should be harvested only after 15 days of insecticide application. The treated leaves should be consumed / marketed after thorough washing in water.

Disease Management

Among the diseases, the bacterial leaf spot caused by *Xanthomonas betlicola* is most serious in southern Kerala. The initial symptoms appear as small water-soaked regions, which enlarge and turn dark brown in the centre with yellow halo. Profuse bacterial ooze may be seen on the lower side of the lesion. In severe cases, defoliation and stem injury occur, leading to wilting of the plant. The cultivars

Karilanchi, Karpuram, and Thulasi are found susceptible to the disease. Spraying of 1% Bordeaux mixture is recommended to control the disease.

Harvesting

In about 3-6 months time, vines grow to a height 150-180 cm. At this stage branching is noticed in the vines. Leaves are removed along with the petiole with the right thumb. Once harvesting is commenced, it is continued almost every day or week. The interval of harvesting varies from 15 days to about a month till the next lowering of vines. After each harvest, manuring has to be done.

Lowering the vines

Under normal conditions, vines grow to a height of about 3 m in one-year time. When they reach this height, their vigour to produce normal sized leaves is reduced and the crop needs rejuvenation. This is done by lowering the vines down to the ground level at least once a year. Lowering is done during the months of August-September. Before lowering, all the leaves in the basal portion of the vines to a height of 15 cm are removed. Vine is untied from bottom upwards and coiled up carefully and laid flat on ground leaving 2.5 to 5 cm length of top shoots. Soil is put over the portion kept in the soil to about 5 cm thickness. Lowering is followed by light irrigation and manuring.

PERIWINKLE

Common Name	Periwinkle
Botanical Name	***Catharanthus roseus*** Linn. *or* ***Vinca rosea* L.**
Family	**Apocynaceae**

Habitat Commonly grown in Indian gardens.

English Madagascar Periwinkle (*Vinca major* L. Pich. and *Vinca minor* Linn. are known as Greater Periwinkle and Lesser Periwinkle respectively).

Folk Sadaabahaar, Nayantaaraa, Nityakalyaani.

Plant description

In Greek 'Kantharos' means 'pure', 'anthos' means 'flower' and 'roseus' means' pink or rose coloured'. It is an erect evergreen, ever blooming, highly branched.

Erect, smooth or slightly hairy, branched plant up to 60 cm high. Stems somewhat woody. Leaves, oblong, 4-7 cm long, rounded at tip, pointed at base. Flowers, white, pink, or red, or variegated white and red, 3.5 cm in diameter, borne in the axils of the leaves. Fruit is a hairy and cylindric follicle, about 3 cm long.

Medicinal properties

Plant pacifies vitiated diabetes, hypertension, leukemia and malignancy, the root is stomachic and tonic.

Chemical Constituents

Contains more than 70 alkaloids mostly of the indole type. It has medicinal importance owing to the presence of alkaloids like Ajamalicine, Serpentine and Reserpine, which are well known for their hypotensive and antispasmodic properties.

Useful part: Whole plant

Soil

It grows on all types of well drained soils except those which are highly saline, alkaline or soils prone to water logging. It grows wild in coastal areas. Light sandy soils rich in humus are preferred for large scale cultivation of the plant. Heavy soils are not suitable for its cultivation.

Climate

The cosmopolitan distribution of the plant shows that it has no specific climatic requirements. It is considered to be a plant of tropical and sub-tropical areas. A well distributed rainfall of 1000 mm or more is considered ideal for raising it as a commercial crop under rainfed conditions. **Propagation**

Sowing: Seeds are used for propagation. Fresh seeds should be used for sowing, as the seeds are viable for a very short period of time (8 months). Seeds are sown either directly in the field or first seedlings are raised in nursery and then transplanted to the main field. Seeds may be soaked in water for 12-24 hours to increase the germination percent. For direct sowing, 2.5 Kg/ha of seed is required for planting one hectare area. Seeds are mixed with sand about 10 times its weight (25 Kg) for even distribution and sown after the first monsoon showers in rows at a distance of 45 cm. Later the plants are thinned out, leaving a distance of 25-30 cm between the plants. For nursery sowing and transplanting, about 500 g of seed is sufficient for raising seedlings for one hectare. Seeds are sown in well prepared beds during March / April in rows about 1.5 cm deep, covered with light soil and leaf mould mixture and are watered to keep the bed moist. Germination is observed in about 10 days. TRANSPLANTING: 60 day old seedlings (height 6-7 cm) are uprooted along with the root and transplanted into the prepared field after receiving 8-10cm of rainfall at a spacing of 45x30 cm.

Fertilizer

For getting a good yield of both leaves and roots, FYM at 15 tonnes per hectare is applied. It is advisable to apply a basal dose of 20 Kg N, 30 Kg P and 30 Kg K per hectare per year. In addition, a top dressing with 20 Kg Nitrogen can be given in two equal split doses. Application of 250 Kg each of bone meal or rock phosphate and powdered Neem seeds are beneficial. **Irrigation**

The plants do not require much water due to its drought resistant nature. In areas having even distribution of rainfall throughout the year, no irrigation is required. In monsoon restricted areas, 4-5 irrigations at fortnightly intervals are needed to get good yield.

Interculture

The crop requires two weedings, first at 60 days after sowing and second after 60 days of the first. Pinching of flowers and branches when the plant is 120 days old increases the root growth. Mulching the field with cut grass or rice straw will help minimize the weed growth. **Plant protection**

It is not susceptible to any specific pests or disease. Sometime the incidence of Dieback, Leaf curl, Fusarium wilt, etc. is noticed. Pre-treatment of seeds with fungicides controls these diseases.

HARVEST AND POST HARVEST

Roots: The crop is ready for harvest of roots after 12 months of sowing. The crop is cut about 7.5 cm above the ground level and dried for stems, leaves and seeds. Later the field is irrigated copiously and ploughed. Then roots are collected, washed well and dried in the shade.

Leaves, stems and seeds: Two leaf strippings, first after 6 months and the second after 9 months of sowing is done. Third stripping of leaves can also be taken when the whole plant is harvested after one year. The plucked leaves are dried under shade by spreading it on the cement floor to avoid fungus growth and rotting. Stem portions (about 7 cm) above the ground is cut and dried. The leaves and stems should be separately collected. For seeds, matured fruits are handpicked and dried in shade and threshed lightly. By this method, mature seeds with uniform germination is obtained. However, in practice the plants are uprooted, dried in shade and threshed. The seeds obtained by this method, are not uniform in their germination.

Yield

3600 Kg/hectare of dried leaves and 1500 Kg/hectare of roots and 1500 Kg/hectare of stems on dry basis is obtained under irrigated condition. Whereas under rainfed or unirrigated condition, 750 Kg each of roots and stems and 2000 Kg of leaves (dry basis) may be obtained from one hectare. The price of dried roots is Rs.15-20/- per kg and that of leaves is Rs.8-10/-per kg.

SARPAGANDHA

Common Name	Sanskrit: Sarpagandha, Hindi: Chandrabhaga Malyakam: Sarpagandhi, Amalpori Tamil: Chivan amelpodi, Kannad: Sutranbhi, Telugu: Patalagandhi, Eng: Serpentwood
Botanical N.	***Rauvolfia serpentina* (L.) Benth.Ex. Kurz. (*Ophioxylon serpentinum* L.)**
Family	**Apocynaceae**

Habit

R. serpentina is an erect perennial shrub generally 15-45 cm high, but growing upto 90cm under cultivation. Roots nearly verticle, tapering up to 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 born in whorls of 3-4 elliptic-lanceolate or obovate, pointed. Flowers numerous borne on terminal or axillary cymose inflorscence. Corolla tubular, 5-lobed, 1-3 cm long, whitish-pink in colour. Stamens 5, epipetalous. Carpels 2, connate,

style filiform with large bifid stigma. Fruit is a drupe, obliquely ovoid and purplish black in colour at maturity with stone containing 1-2 ovoid wrinkled seeds. The plant is crosspollinated, mainly due to the protogynous flowers.

Distribution

Rauvolfia serpentina is native to India. Several species of *Rauvolfia* are observed growing under varying edaphoclimatic conditions in the humid tropics of India, Nepal, Burma, Thailand, Bangladesh, Indonesia, Cambodia, Philippines and Sri Lanka. In India, it is cultivated in the states of Uttar Pradesh, Bihar, Tamil Nadu, Orissa, Kerala, Assam, West Bengal and Madhya Pradesh. Thailand is the chief exporter of *Rauvolfia* alkaloids followed by Zaire, Bangladesh, Sri Lanka, Indonesia and Nepal. In India, it has become an endangered species and hence the Government has prohibited the exploitation of wild growing plants in forest and its export since 1969.

Properties and activity

Rauvolfia root is bitter, acrid, laxative, anthelmintic, thermogenic, diuretic and sedative. Over 200 alkaloids have been isolated from the plant. *Rauvolfia serpentina* root contains 1.4-3% alkaloids. The alkaloids are classsified into 3 groups, *viz*, reserpine, ajmaline and serpentine groups. Reserpine group comprising reserpine, rescinnamine, deserpine *etc* act as hypotensive, sedative and tranquillising agent. Overdose may cause diarrhoea, bradycardia and drowsiness. Ajmaline, ajmalicine, ajmalinine, iso-ajmaline *etc* of the ajmaline group stimulate central nervous system, respiration and intestinal movement with slight hypotensive activity. Serpentine group comprising serpentine, sepentinine, alstonine *etc* is mostly antihypertensive.

Climate

It grows in a wide range of climatic conditions but flourishes well under hot humid tropical climates in open or partial shade. Elevations of 1300 m having a temperature range of 10-38°C and annual rainfall of 250 cm are suitable to this species. Good yield is obtained in areas less prone to frost and having less severe winter. **Soil**

It requires slightly acidic to neutral soils for good growth. However, for commercial cultivation soils ranging from sandy loam to medium black cotton soils rich in organic matter with soil pH of 6-8 and good drainage facility are suitable.

Propagation

Land preparation: The land is ploughed deep in May and left for weathering. After pre-monsoon showers FYM is added followed by second ploughing and two cross harrowings to break the clods. The land is finally dressed by planking and beds are laid out. Nursery should be raised in a partially shaded

area with adequate irrigation facility. Each bed should be about 1.5m wide, 15-20 cm high and of convenient length. Beds with shallow furrows 8-10 cm apart are prepared in April and irrigated.

Sowing: About 5-7 Kg seeds are required for sowing one hectare area. Fresh seeds are preferred for sowing as their viability lasts for only 6 months. It has been observed that the seeds stored for more than a year usually fail to germinate. Therefore it is essential that seeds collected between Septembers to December should be used for planting in the next season. Seeds are treated with Thiram (2-3 g / Kg seed) after soaking it in water for 24 hours and sown from the end of April to the first week of May at a distance of 8-10 cm and 1-2 cm deep. These are covered with a mixture of FYM and soil and irrigated daily. Germination is complete in 30-35 days. The Percentage germination varies from 10-50 percent.

Planting : It can also be propagated by vegetative means using stem and root cuttings and root stumps. Root cuttings 3-5 cm long and not exceeding 12.5 cm diameter are planted in June July and are covered completely with the soil leaving only 1 cm above the surface. The cuttings sprout within 3 weeks if there is good moisture. Success percent is about 50-80 and around 100 Kg of root cuttings are required to plant one hectare area.

Stem-cuttings 15-20 cm long with 3-4 nodes are planted in the nursery in June and kept moist until they sprout. Cuttings treated with IAA (30 ppm) initiate rooting in 15 days. The success percent obtained in stem cuttings is about 65 %. In the case of root stumps, approximately 5 cm roots with a portion of stem above the collar is planted in May- June in irrigated fields. Though around 90-95 % of success is obtained in this method, only one plant can be raised from a single stump.

Transplanting: 40 - 50 day old seedlings bearing 4-6 leaves are ready for transplanting in the first week of July. These seedlings are uprooted and treated with Bavistin 0.1% for 30 minutes and then transplanted at a distance of 45 x 30 cm in the main field. This should be followed by a light irrigation. Around 10-15 % of the seedlings are retained for gap filling 10-15 days after planting.

Fertilizer

In the nursery, FYM (1/3rd of recommended dose) along with 2/3rd of soil mixed with 10 % B.H.C @ 20 Kg per hectare is required. 8-10 tonnes FYM/compost is applied at the time of land preparation in the main field. To obtain a good yield, 30 Kg of Nitrogen and 30 Kg each of Phosphorus and Potash per hectare are required. At the time planting, 1/3rd of Nitrogen and the entire dose of Phosphorus and Potash should be applied 45 cm away from the rows and 7-10 cm deep. 50 days after planting 2/3rd nitrogen is applied and the remaining Nitrogen is top dressed in the next rainy season.

Irrigation

Around 15-16 irrigations are recommended. Irrigation twice a month during hot dry season and once a month in winter may be required.

Intercropping

Rauvolfia being a long duration crop and slow in growth in the initial stages, it can be intercropped. Vegetables like Brinjal, Cabbage, Okra and Soybean may be planted in Kharif

Interculture

Two weedings in the first year and one weeding in the second year followed by one hoeing usually at the beginning of the growing season is required. Flowers appearing on very young plants should be nipped to promote root growth.

Plant protection

The major pests appearing on this crop are moth, grub, black bug and weevils. Grubs can be controlled by mixing BHC 10 % with the soil at the time of land preparation, whereas caterpillar, black

bug and weevils can be managed by spraying Asataf 10 g/10 lt. of water. Diseases like Leaf spot, Anthracnose and Dieback are known to cause damage to this crop. Leafspot and Dieback can be controlled by spraying 0.2% Dithane Z-78 or DM-45 in early June before monsoon and repeat the spray at monthly intervals until November. Anthracnose can be controlled by spraying Blitox 50WP @ 40 g in 10 liters of water.

Harvest and post harvest

The crop is ready for uprooting after 18 months of planting when the alkaloid content is maximum (1.4%). 8-10 days prior to uprooting it is irrigated and the above ground foliage is cut and roots are uprooted using sub soiler. It is cleaned, washed and dried in shade till the moisture content reduces to about 8%. As the outer skin contains about 80% of the total alkaloid, the skin should not be damaged while cleaning the roots. Brown to black coloured seeds, which appear from August to December is collected and soaked in water for some time (15-20 hours) and then rubbed with hand to remove seed coat. These seeds are washed twice or thrice and dried. Dried seeds are stored in moisture proof places for next sowing. 100 seeds weigh about 3.5-4 g.

Yield

A maximum yield of 2000-2250 Kg dry roots per hectare can be obtained using seeds. The price of these roots may vary from Rs.50 to 150/Kg. In addition to this, 30-40 Kg seeds per hectare are also obtained which is sold for Rs.300 per Kg.

Economics of cultivation (per hectare)

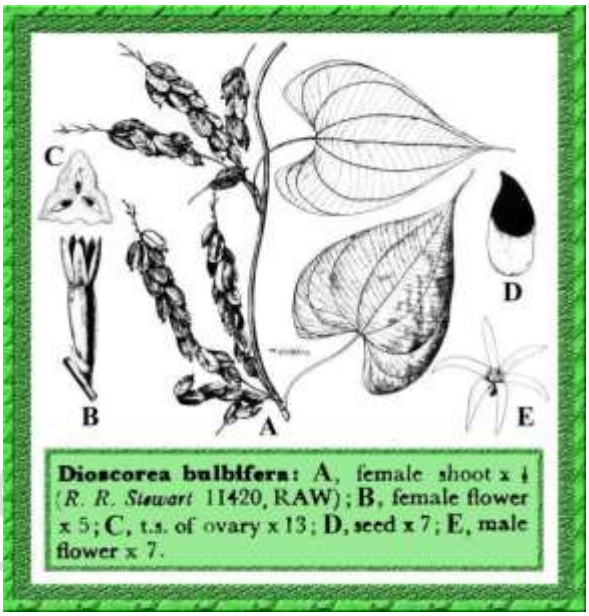
DURATION : 18 MONTHS
EXPENSES : 12000/-
GROSS RETURNS: ROOTS 2000 Kg @ Rs.100/Kg = 200000/- SEEDS
30 Kg @ Rs.300/Kg = 9000/-
TOTAL = 209000/- **NET**
RETURNS : 197000/-

MEDICINAL YAM

Common Name	Medicinal Yam; Ayurvedic name: Varahikhand, Varahi, Unani name: Zaminkand, Ratalu, Hindi name: Ratalu, Genthi, Trade name Rattalu
Botanical N.	***Dioscorea bulbifera* Linn. Syn., *Dioscorea crispata, Dioscorea Sativa***
Family	**Dioscoreaceae**

The growing need for steroidal drugs and the high cost of obtaining them from animal sources led to a widespread search for plant sources of steroidal sapogenins, which ultimately led to the most promising one. It is the largest genus of the family constituted by 600 species of predominantly twining herbs. Among the twining species, some species twine clockwise while others anti-clockwise. All the species are dioeceous and rhizomatous. According to Coursey (1967), this genus is named in honour of the Greek physician Pedenios Dioscorides, the author of the classical Materia Medica Libri Quinque. Some of the species like *D. alata* and *D. esculenta have* been under cultivation for a long time for their edible tubers. There are about 15 species of this genus containing diosgenin. Some of them are the following.

D. floribunda Mart. & Gal.
D. composita Hemsl; syn. *D. macrostachya* Benth.
D. aculeata Linn. syn. *D. esculenta D. alata* Linn. syn.
D. atropurpurea Roxb.
D. Globosa Roxb; *D. purpurea* Roxb.
D. bulbifera Linn. syn. *D. crispata* Roxb.
D. pulchella Roxb.; *D. sativa* Thunb. Non Linn.
D. versicolor Buch. Ham. Ex Wall.
D. daemona Roxb. syn. *D. hispida* Dennst.
D. oppositifolia Linn.
D. pentaphylla Linn.
D. prazeri Prain & Burkil
D. deltoidea Wall. var. *sikkimensis* Prain
D. sikkimensis Prain & Burkill, Among the above said species, *D. floribunda*, *D. composita* and *D. deltoidea* are widely grown for diosgenin production.



Dioscorea bulbifera: A, female shoot x ¼ (*R. R. Stewart* 11420, RAW); B, female flower x 5; C, t.s. of ovary x 13; D, seed x 7; E, male flower x 7.

Agrotechnology (General)

Dioscorea species prefer a tropical climate without extremity in temperature. It is adapted to moderate to heavy rainfall area. *Dioscorea* plants can be grown in a variety of soils, but light soil is good, as harvesting of tubers is easier in such soils. The ideal soil pH is 5.5-6.5 but tolerates fairly wide variation in soil pH. *Dioscorea* can be propagated by tuber pieces, single node stem cuttings or seed. Commercial planting is normally established by tuber pieces only. Propagation through seed progeny is variable and it may take longer time to obtain tuber yields. IIHR, Bangalore has released two improved varieties, FB (c)-1, a vigorously growing strain relatively free from diseases and Arka Upkar, a high yielding clone.

Three types of tuber pieces can be distinguished for propagation purpose, viz. (1) crown (2) median and (3) tip, of which crowns produce new shoots within 30 days and are therefore preferred. Dipping of tuber pieces for 5 minutes in 0.3% solution of Benlate followed by dusting the cut ends with 0.3% Benlate in talcum powder in moist sand beds effectively checks the tuber rot. The treatment is very essential for obtaining uniform stand of the crop. The best time of planting is the end of April so that new sprouts will grow vigorously during the rainy season commencing in June in India.

Land is to be prepared thoroughly until a fine tilth is obtained. Deep furrows are made at 60cm distance with the help of a plough. The stored tuber pieces which are ready for planting is to be planted in furrows with 30cm between the plants for one year crop and 45cm between the plants for 2 year crop at about 0.5 cm below soil level. The new sprouts are to be staked immediately. After sprouting is

complete, the plants are to be earthed up. Soil from the ridges may be used for earthing up so that the original furrows will become ridges and vice versa.

Dioscorea requires high organic matter for good tuber formation. Besides a basal doze of 1820t of FYM/ha, a complete fertilizer dose of 300 kg N, 150 kg P2O5 and K2O each are to be applied per hectare. P and K are to be applied in two equal doses one after the establishment of the crop during May-June and the other during vigorous growth period of the crop (August- September). Irrigation may be given at weekly intervals in the initial stage and afterwards at about 10 day's interval.

Dioscorea vines need support for their optimum growth and hence the vines are to be trailed over *pandal* system or trellis. Periodic hand weeding is essential for the first few months. Intercropping with legumes has been found to smother weeds and provide extra income. The major pests of *Dioscorea* are the aphids and red spider mites. Aphids occur more commonly on young seedlings and vines. Young leaves and vine tips eventually die if aphids are not controlled. Red spider mites attack the underside of the leaves at the base near the petiole. Severe infestations result in necrotic areas, which are often attacked by fungi. Both aphids and spider mites can be very easily controlled by Kelthane.

No serious disease is reported to infect this crop. The tubers grow to about 25-30 cm depth and hence harvesting is to be done by manual labour. The best season for harvesting is Feb-March, coinciding with the dry period. On an average 50-60t/ha of fresh tubers can be obtained in 2 years duration. Diosgenin content tends to increase with age, 2.5% in first year and 3-3.5% in the second year. Hence, 2 year crop is economical.

Parts used: Corms and tubers.

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.

Chemical constituents

Chief active ingredient of corm is diosgenin along with furanoid norditerpenes, sinodiosgenin, diosgenin ß, smilagenone, and epismilagenins.

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 (Small rounded wart like protuberance), 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.

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-technique

Nursery technique

Raising propagules

Direct planting of the corms or bulbils in the field is more effective than transplanting nurseryraised 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 pre treatment

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 pre treatment is required before sowing the bulbils.

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 is 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 water logging 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.

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.

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

Market price: Rs 16 per kg dry weight

Market demand: 3 tonnes per annum

ISABGUL

Common Name	**Isabgul**, Ashwagolam, aspaghol, aspagol, bazarqutuna, blond psyllium, ch'-ch'ientzu, ghoda, grappicol, Indian plantago, Indische Psylli-samen, isabgol
Botanical N.	***Plantago ovata* Forsk.** *Plantago afra L. P. psyllium* L. *Plantago asiatica* None. *Plantago indica* L.*; P. arenaria* Waldstein et Kitaibel, *P. ramosa* Asch. *P. ispaghula* Roxb.
Family	Plantaginaceae

Habit

An annual, acaulescent (*stemless; actually, with a very short stem that may be below ground*) herb, the stem of which is much ramified and bears linear leaves that are lanceolate, dentate, and pubescent. The flowers are white and grouped into cylindrical spikes. The sepals are characterized by a distinct midrib extending from the base to the summit; the petal lobes are oval with a mucronate (ending abruptly in a sharp point) summit. The seeds are oval and clearly carinate, measure 2–3mm, and are a light grey-pink with a brown line running along their convex side.

Organoleptic properties

Odourless with mucilage-like taste.

Geographical distribution

P. afra and *P. indica*, west Mediterranean countries; *P. asiatica,* Japan. *P. ovata*, Asia and the Mediterranean countries; the plant is cultivated extensively in India and Pakistan and adapts to Western Europe and subtropical regions.

Varieties

Patan - good yielder; Gujrat Isabgol No. 1; Gujrat Isabgol No. 2; Sale -10; EC 124; EC 345; TS-1-10; Niharika, ;Haryana Isabgol –5; Jawahar Isabgol-4 **Part used:** Husk from spikes and seeds.

Introduction

Isabgol is an important medicinal crop traditionally grown mostly in North Gujarat during winter season. The isabgol hust (epicarp of the seed) has medicinal properties and is used against constipation, irritation of digestive tract etc. In addition these are also used in food industries for the preparations of ice cream, candy etc. India is the sole exporter of isabgol husk and seed to the world market. About Rs. 160 crores is earned annually through export. In the recent years, demand of isabgol has increased substantially in domestic as well as in international markets which initiated spread of the crop to some non traditional areas of Rajasthan and north-west Madhya Pradesh. At present the crop is grown in an area over 50,000 ha.

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 a soil 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 & 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 seed 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 30^0 C.

Land preparation

Field must be free of weeds and clods. The number of ploughings, harrowing and hoeing depend 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, seed 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. Seed at the rate of 4-8 kg per hectare is 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 seed is 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.

Manures, fertilisers and pesticides

The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, Farm Yard Manure (15 tonnes /ha), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds & leaves), Chitrakmool, Dhatura, Cow's urine etc. **Chemical fertilizers:** N, P_2O_5 and K_2O, 50, 25 and 30, respectively. (Apply 50% N at sowing and the remaining 50% after one month).

Plant protection

Major insect: White grub.

Major diseases: Powdery mildew; downy mildew and rhizoctonia wilt.

Schedule

1. Application of 5% Aldrin or Lindane at 25 kg per hectare at the time of last ploughing during the preparation of land is effective in protecting the crop against white grubs.
2. To control powdery mildew, spray the crop with 0.2 per cent wettable sulphut at 15 days interval two or three times.
3. Spray Bavistin at 0.1 per cent to control downy mildew immediately after the appearance of the disease and repeat the spray 15 days later.
4. Seed treatment with Captan 5 g/kg of seed followed by drenching the soil and spraying the plants with 0.2 per cent Captan solution and repeating the same a week after first application controls the spread of rhizoctonia wilt.

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 totally 6-7 irrigations for its good productivity in medium sandy soils. **Crop rotation**

Application of nitrogenous fertilizer for cultivation of isabgol is not needed if crop rotation with legumes likes groundnut, black gram or green gram if kharif season is followed. About 15-25 kg N is supplemented by cultivaton of legumes.

Harvesting/post harvesting operation

Blooming begins two months after sowing and the crop become ready for harvest in FebruaryMarch (110-130 days after sowing). When mature, the crop turn 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.

Processing: It is done by mills. About 25% of husk is obtained by weight basis. Husk is removed by grinding pressure and separated out by fans and sieve.

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.

Price: Rs. 15-20 pe kg depending on quality of seeds.

Economics

Expenditure per ha. Rs. 25,000/- Return per ha. Rs.63000/-

Net income Rs.38000/-

AONLA

Common Name **Aonla,** Indian gooseberry **Botanical name**	
Emblica officinalis Gaerth.	
Family	Euphorbiaceae

The Indian gooseberry or Aonla (*Emblica officinalis*) has been cultivated in India since time immemorial and recognized as 'amrit phal. It finds mention in the Vedas, Ramayana, Charak Samhita, Sushrut Samhita, works of Kalidas, Kadambari and in other ancient literature. It is probably the only fruit to fill the gap of astringent food recommended by the ayurvedic system of medicine for a balanced diet and sound health. It has high value among indigenous systems of medicine in India. The fruit contains a chemical substance known as gallic acid (polyphenols) which retards the oxidation of vitamin C, hence it has antioxidant properties. The fruit is therefore, a rich source of vitamin C in both the fresh as well as in the dry or processed form. The fruit is acrid, a cooling refrigerant, laxative and diuretic. It is an important minor fruit and a crop of commercial significance. It is quite hardy, a prolific bearer and highly remunerative even without much care. Aonla is also known by its several vernacular names such as myrobalan or Indian gooseberry (in English), aonla (in Hindi), dhatri or amlaki (in Sanskrit), nelli (in Malayalam and Tamil), amlakamu (in Telugu), amla or amlaki (in Bengali and Uriya) and amolphal (in Punjabi).

Botany

Aonla is a tree of medium height, which usually grows to a height of five to six m. The plant behaves like a deciduous one in the subtropics and an evergreen in the tropics. It has phyllanthoid branching habit (*with leaves on the main axes reduced to scales called "cataphylls" and those on lateral (plagiotropic), deciduous, floriferous axes developing normally*) and bears two types of shoots : short shoot—the determinate type and long shoot—indeterminate type. The leaves look like pinnately compound leaves but actually these are simple. The stipules are oval. Flowers are green yellow in colour and appear in the axil of the leaves as axillary cymules on determinate shoots. The basal flowers are the male type followed by female type. The sex ratio (ratio of male to female, varies widely and it has been reported to be 307.9: 1 and 197: 1 in two successive years. Male flowers open between six and seven in the evening and dehiscence of anthers takes place soon after. Female flowers open in stages and complete

opening requires 72 hours. The stigma becomes receptive on the third day of anthesis. Pollination is carried out by the wind. After fruit set in March/April, the fruits enter into dormancy (zygote dormancy) and resume growth with the onset of the monsoon. The fruit is a capsule. The stones are six ribbed, separable in three parts and usually with two seeds.

Origin and distribution

Aonla is believed to have originated in tropical southeastern Asia, particularly in central and south India. It is popular as a backyard fruit throughout the country and is often seen growing wild in deciduous forests up to an elevation of 1800 m. However, aonla is commercially cultivated in India, mainly in Uttar Pradesh and Gujarat. In UP, it is mainly cultivated in the districts of Pratapgarh, Varanasi, Azamgarh, Sultanpur, Raibareli, Bareilly etc.

Composition

Different parts of the aonla tree are of great importance. The fruit is highly medicinal, nutritive and it is the richest source of vitamin C among fruits, with the exception of the Barbados cherry. Vitamin C content (mg/100 g) varies from 467 to 1814.

Uses In Medicine

Aonla fruit is very popular for its medicinal properties recorded both in the ayurvedic and unani systems. The fruit is acidic, a cooling refrigerant, laxative and diuretic. Dried fruits are useful in treating haemorrhage, chronic dysentery, diarrhoea, diabetes, dyspepsia, cough, anaemia and jaundice. It is an important ingredient of Triphala and Chyawanpmsh in ayurveda. A fixed oil derived from the fruit is reported to have the property of promoting hair growth. Organic acids and phenolic substances of aonla are used for drugs. Several alkaloids, flavonoids, quinine, steroids and terpenoids are also isolated from aonla plants.

AS A NUTRIENT

Mature fruits contain more vitamin C as compared to developing and immature ones. The vitamin content goes on increasing with advancing maturity. Normally, one aonla fruit contains 20 times as much vitamin C, in terms of antiascorbutic value, as two oranges. Tannin, containing gallic acid, ellagic acid and glucose in its molecule, which is naturally present in the fruit, prevents or retards the oxidation of vitamin C and renders it a valuable anti-ascorbutic in the fresh as well as in dried and processed condition. The ascorbic acid content of the fruit is well conserved by preserving the fruit in salt solution or in the form of a dry powder. Aonla powder is superior to synthetic vitamin C in treating its deficiency. Probably because of these reasons, the fruit was used successfully in the treatment of human 'scurvy' in the Hissar famine (19291940) and tablets made from aonla fruit were distributed to Indian army personnel to meet the vitamin C requirement in their diets during the World War II.

AS FOOD

Aonla fruits are also rich in pectin and can be used for making jelly, and can be made into preserves (murabba), sauce, candy, dried chips, tablets, pickles, powder etc. The acridity of the fruit can be removed completely by keeping the fruit in salt solution or tamarind, lime and orange juices.

INDUSTRIAL USES

The fruits are also used in the preparation of inks, hair dyes and shampoos. Aonla is a source of tannin. Its amount varies from 28 % in fruits, stem and bark and 22 % in leaves. Tannin is a very much useful industrial item.

Species

Aonla (*Emblica officinalis* Gaerth. Syn. *Phyllanthus emblica* Linn) belongs to the family Euphorbiacae, which includes about 350 or even 500 species, mostly consisting of herbs, shrubs or trees. Other useful species are *Phyllanthus acidus* (used for pickling) commonly known as star gooseberry, otaheite gooseberry, or country gooseberry, *Phyllanthus longiflorus* and *Phyllanthus fischeri* (Syn. *Emblica fischeri*).

Cultivars

Old plantations of aonla orchard have been raised from seed; therefore, they exhibit great variability and the fruits are of inferior quality. There are three main commercial cultivars of aonla namely, Banarasi, Francis (Hathi-Jhool) and Chakaiya commonly grown in the aonla growing regions of UP but later on an attempt was made by Narendra Deva University of Agriculture & Technology (N.D.U.A. & T.,) Faizabad to select suitable genotypes for commercial cultivation, because commercial cultivars of aonla such as Banarsi, Francis and Chakaiya have some limitations. Cultivar Anand-1 grown in Gujarat area is also variable in its performance.

Banarsi: It is a seedling selection from the Varanasi district of Uttar Pradesh. The tree is semi-tall with spreading growth habit, the branches are angled with sparse foliage, it is a shy and slightly alternate bearer. The fruit is large, triangular, slightly conical at the apex with flesh of whitish green colour, nearly fibreless and soft. It is poor in keeping quality and mildly susceptible to necrosis. **Francis:** Seedling selection, it is also known as Hathi Jhool. The branches are drooping in nature. Moderate in bearing. Fruits flattened, medium in size, skin smooth, light green in colour, flesh soft, nearly fibreless and has moderate keeping quality. This cultivar is highly susceptible to fruit necrosis and hence not suitable for preserves.

Chakaiya: It is a seedling selection and has a tall, upright growth habit and bears profusely. Fruits are small to medium, flattened, round, the skin is smooth but rossetted at maturity, light green in colour. Flesh is fibrous and whitish green in colour. The cultivar is free from necrosis.

Krishna (NA-4): It is a chance seedling of Banarsi from Pratapgarh area of UP. It is an early and shy bearer. Fruits are large, triangular, and conical with a papillate basin, skin is smooth with red spots on exposed surface and keeping quality is moderate. Flesh is pinkish green, less fibrous and highly astringent.

Kanchan (NA-5): It is a chance seedling from the cultivar Chakaiya. The tree is tall and has a spreading growth habit. It bears profusely. Fruits are small to medium, flattened, oblong, the skin is smooth, yellowish in colour, keeping quality is good and it is ideally suitable for pickles.

Amrit (NA-6): This is a selection from Chakaiya. It has mid-season maturity. Fruits are medium to large sized, flattened and very low in fibre content and are most attractive and shining. This cultivar is heavy bearer and most suitable for making candy, preserves, sweets and jam.

Neelum (NA-7): It is a seedling selection from the open pollinated strain of Francis. It has mid-season maturity. Fruits are medium to large sized with conical apex and free from necrosis. Fibre content is little higher than NA-6. This is the most precocious and prolific bearer. It is considered to be very good for chyaivanprash, chutney, pickle, jam and squash.

Balwant (NA-10): This is a selection from Banarsi and has an early maturity. Fruits are medium to large sized, flattened with roundish styler ends. Fruits in the early stage of development have a pink tinged colour. Fibre content is similar to NA-7. This is also a heavy bearer and most suitable for dehydration and pickles.

Soil

Aonla trees are not exacting in their soil requirement and grow well in sandy loam to clay soils in India. It has great tolerance to salinity and sodicity and cultivated very successfully in a pH range of six to eight. However, in higher soil pH, seedling survival, growth and leaf N, P, K, Ca and Mg concentrations decreased and leaf injury due to Na toxicity above 30 Exchangeable Sodium Percentage (ESP) has been observed. In calcareous soil, fruit necrosis becomes especially problematic and such soil is considered unsuitable.

Climate

Aonla is a fruit of the subtropical region with distinct winter and summer but can be successfully grown in tropical as well as dry conditions. In India, it is being grown in the coastal areas up to 1800 m altitude. Under north Indian conditions, the tree starts shedding its leaves from February onwards and by the third week of March, it is almost devoid of foliage. This makes it a highly suitable fruit crop for arid regions.

Propagation

Seed

It is a very old practice to raise aonla from seeds but seedling plants are not true to type, take more time to bear fruit and produce small sized fruits, of inferior quality. However, for raising rootstock, seedlings are required to be raised through seeds. Seeds are collected from fully mature fruits obtained during December-January when they should be extracted and sown as early as possible for getting a high percentage of germination and embryoless seeds can be separated by floating them on water just before sowing.

Vegetative propagation

Various vegetative methods like budding, grafting, cutting and tissue culture can be utilized, in order to overcome the disadvantages of seed propagation.

Budding: Of the various budding methods (patch budding, shield budding, ring budding), patch budding has been found to be the most successful technique for commercial method of aonla propagation, when budded on one-year old aonla rootstock in mid-July.

Grafting: To a certain extent, in situ soft wood grafting is successful particularly in dry areas where mortality of budded plants is usually high. It would be advisable to raise seedling rootstocks in situ and bud them.

Cutting: Cutting can be taken with success by using Indole Butyric Acid (IBA) (1500 ppm) with bottom heat (33° C). The most important factor is the proper selection of mother plant which has a large number of fruits and the buds should be taken from a branch which has a good number of female flowers, otherwise, the plants will not bear fruit owing to the appearance of large number of male flowers.

Land preparation and planting

Planting is done after ploughing and levelling of land. Pits of 90 x 90 x 90 cm^3 are dug in normal soil and 1 x 1 x 1 m^3 in saline soils during May/June and kept open for a few weeks in the summer. The pits are then filled with 15 to 20 kg of decomposed FYM with soil upto a height of six to ten cm above the ground level. The pits are irrigated to settle down the soil. Planting of budded plants can be done in late January or February in spring (under dormant condition) and July to September in rainy season at a distance of 8 x 8 m^2 in the centre of the pit, keeping the budded or grafted joints above the soil. Plant survival and growth have been found to be better in spring season planting, with an assured supply of irrigation. Light irrigation should be given just after planting. Care should be taken during planting

because self-incompatibility has been observed in aonla; hence, two varieties such as NA-6 + NA-7 or NA-7 + NA-10 or Chakaiya + NA-7 should be planted in alternate rows for higher productivity.

Irrigation

Aonla is very drought hardy and very susceptible to water logging. Young plants require watering during summer at fortnightly intervals till they are fully established. In fruit bearing plantations, irrigation is essential during April to June at bi-weekly intervals to have higher fruit set and reduced fruit dropping and again during October to December at 20 day intervals as this helps in better development of fruits. Irrigation during flowering should be avoided.

Manures and fertilizers

Little work has been done on the nutritional requirements of aonla. The plant produces heavy crops hence, application of manure and fertilizers will be beneficial. Beneficial effects of N, P, Zn, Cu, Mn and B have been recorded and it has been that nitrogen increase the vegetative growth and female flowers, while phosphorus increase sex ratio, initial set, fruit retention and quality. A ten-year old bearing tree should be given 1.5 kg N, 1.0 kg K and 0.7 to 0.8 kg P annually under the drip of the tree where feeding roots are mostly present. A spray of 0.6% borax three times in the month of September and October at about 10-15 day intervals controlle fruit necrosis, which develope due to the deficiency of boron. Application of 10 kg FYM, 100 g N, 50 g P and 75 g K/plant to one-year old plantation should be made and this dose should be increased up to the age of 10 years in the same proportion. Half dose of N and K and a full dose of P should be applied during February (i.e. before flowering) and the remaining doses at the end of August.

Intercultural operations

In aonla, flowering takes place in February and after fruit set, the fruits remain dormant through summer until the monsoon, when fruits begin to grow and are ready for harvest in December to January, depending on the climate of the place. Therefore, in summer, the soil should not be disturbed and natural cover can be allowed.

MANAGEMENT OF DISEASES AND PESTS

Aonla rust (*Ravenelia emblicae* Syd.)—Aonla rust or ring rust appears as circular or semicircular pustules on the leaves from the beginning of August. The rust can be controlled by spraying Dithane Z-78 (0.2%) at fortnightly intervals between July and September. The most promising results for the control of *R. emblicae* var. *pinnular* and *R. emblicae* var. *fructiocolar* should be given elosal (sulphur), sulphur dust and ultra sulphur.

Fruit rot (*Penicillium oxalicum* Curie and Thorn, *P. islandicum* Supp. and *Aspergillus niger*)—Due to this disease, major loss occurs during transportation after harvest. The primary symptom of infection is seen as a water soaked lesion on the fruit surface, which enlarges in size followed by development of small pinhead size colonies of golden yellow colour. The older colonies turn olive green. The fruit shows exudation of yellowish liquid and emits a bad odour. Bruising and injury at the time of harvesting should be avoided to prevent rot and fruits showing such symptoms should not be used for packaging to distant markets. Treatment of fruit with borax and NaCl (0.1-0.5%) is useful to control the disease.

Leaf rust (*Phakospora phyllanthi* Diet.)—Leaf rust is commonly seen on leaves in the months of July and August. It can be controlled by spraying Bordeaux mixture 0.1%.

Internal fruit necrosis—This is a physiological disorder of fruits. Necrotic symptoms start with a browning of the innermost part of the mesocarpic tissues at the time of endocarp hardening in the second

and third week of September. Browning of mesocarp extends towards the epicarp resulting in brownish black areas on the fruit surface in the second and third week of October, followed by the development of gummy pockets in the fruit. Boron deficiency symptoms have been reported causing internal necrosis. Three sprays of 0.6% borax at about 10 to 15 day intervals are recommended to control the disorder.

PESTS

Bark eating caterpillar (*lnderbella tetraonis*)—Bark eating caterpillar affects the trunk and branches seriously by eating bark. Injecting kerosene oil or endosulphan (0.05%) in holes and plugging the holes with mud has been found effective in controlling this insect.

Shoot gall maker (*Betousa stylophora* Swinhoc Syn. *Hypolamprtis stylophora*)— Gall forming black caterpillar is the most important and serious pest which attacks aonla. The young caterpillars bore into the apical portion of the shoot during the rainy season (August/September) and make tunnels. The damaged region bulges outside and develops a gall-like structure, which provides space for movement of a caterpillar. Due to this, apical growth is checked, side shoots develop below the gall and subsequent growth in the following season is greatly hampered. This can be controlled by pruning the galled shoot and spraying of monocrotophos (0.05%), 0.05% quinalphos and.0.005% cypermethrin. **Leaf rolling caterpillar** (*Garcillaria acidula*)—This caterpillar rolls the leaf and feeds inside, reducing the photosynthetic capacity of leaves and subsequently the leaves drop off. Spraying of 0.04% monocrotophos or Dimethoate (30 ml in 18 L of water) has been found effective in controlling the pests.

Aphid (*Cerciaphic emblica*)—This is not a major pest of aonla and reports have been made only from Pune. It can be controlled by spraying Dimecron (0.03%).

Mealy bug (*Nipaecoccns vastator* Mask)—Both nymphs and adults are reported to feed on the aonla tree from April to November. Monocrotophos (0.04%) or methylparathion (0.03%) are effective as sprays.

Harvesting and yield

Fruiting starts in vegetatively propagated plants four to five years after planting and the tree starts to give full commercial yield at 10 years, while a seedling tree may take 10 to 12 years to begin bearing.

Generally, aonla fruits are ready for harvest in November/December. Their maturity can be judged either by the change of seed colour from creamy white to black or by the development of a translucent exocarp. The stage of maturity at which fruits are harvested has a great effect on quality, storage life and marketability. Early and late harvesting both cause poor shelf life.

Therefore, fruits should be harvested at full maturity, which varies for each cultivar. Early varieties such as NA-10 and Banarsi should be harvested during November, while mid-season variety such as NA-6 and NA-7 should be harvested after middle of December and late variety such as CHAKAIYA during January in the eastern part of UP.

The yield varies from cultivar to cultivar. Banarsi is a slightly shy and alternate bearer, whereas cvs. Chakaiya and Francis bear profusely. The average yield from a full grown tree is between 100 and 150 kg per annum.

Storage

Aonla fruits could be stored for at least three months in 15% salt solution with minimum losses in appearance and vitamin C.

The storage of CHAKAIYA in zero energy cool chamber versus room temperature. In zero energy cool chambers, fruits could be stored for upto 12 days with acceptable minimum decay and quality loss, compared to four days at room temperature. The least weight loss and bruising were observed in both cultivars {Chakaiya and Francis) by packaging in wooden boxes lined with polyethylene during transportation by rail.

Processing

Trifala powder

Recipe: Dried aonla 1kg, dried bahera (*Terminalia bellarica* fruits) 1 kg, dried harad (*Terminalia chebula* fruits) 1 kg.

For preparing trifala powder, the seeds of aonla, bahera and harad are removed. The fruits of each kind are ground separately to make powder. Each type of powder is mixed in equal proportion. It is packed in glass bottles and polyethylene pouches and stored.

Constraints

Frost susceptibility especially of budded plants, less fruit set in hyper arids areas, long maturity periods and necrosis of fruits along with lack of value-added product range are major constraints in aonla cultivation.

HARDE

Common Name	**Harde/ Haritaki / Myrobalan**
Botanical name	***Terminalia chebula* Retz.**
Family	Combretaceae

Chebulic myrobalan has a great significant in the Indian national economy due to their immense value in different industries viz., indigenous medicines, dye and tanning of leather, etc. Its fruit extract is one of the major export items and its demand is increasing by leaps and bounds due to the superior quality of leather by it and that vegetable tans are less hazardous than the inorganic tanning materials and thus preferred all over the world.

Parts used: Mature and immature fruits and in some cases bark are also used.

Chemical composition:

Main alkaloids – Chebulin from flowers, fruits contain about 30 % astringent substance. Chebulin exhibited antispasmodic action on smooth muscle similar to papavarine.

Medicinal uses: Fruit pericarp contains 30-50% tannin used in India for a long time. Commercial extracts are prepared. Suitable for treating locomotive water, oil drilling composition, ink making, petroleum purification, cement, colouring slate-stones, and as flocculent and anti-corrosion agent. Spent pulp can be used for activated carbon, furfural [(*A liquid aldehyde with a penetrating odour; made from plant hulls and corncobs; used in making furan (A colourless toxic flammable liquid used in the synthesis of nylon) and as a solvent*)], cardboards, adhesive resins, etc. Possesses purgative, stomachic, anthelmintic, tonic and alternative properties; exhibits anti-inflammatory and anti microbial activities. The tannin when hydrolysed Chebulic acid and D-galloyl glucose are obtained. Besides, it contains anthraquinones and linoleic acid. Seed kernel yield 40 % oil. One of the constituents of "Triphala"-used as laxative and in treatment of enlarged liver, piles, stomach complaints, pains in eyes etc. The paste of this fruit can be applied externally on chronic ulcers, wounds and scalds (*A burn cause by hot liquid or steam*) or used as a gargle in inflammation of mucous membrane of mouth. The powder of the fruit is used as a dentifrice for strength of gums. Constipation, chronic ulceration ulcerated gums, bleeding piles, cough, dyspepsia, indigestion, gastric trouble, flatulence, alopecia (*loss of hair*), night blindness, asthma, dysentery, tumour, worms, colic pain, vomiting, jaundice, oral inflammation, skin diseases, mumps, vaginitis, hair disorders.

Botany

A moderate sized or large deciduous tree with round crown and spreading branches, attaining a height and girth of 20-30 m and 1.5-2.4 m respectively. Bark is dark-brown, often longitudinally cracked, exfoliating in woody scales. Stem is cylindrical, bole 4-9 m. Leaves are alternate-opposite, elliptic-ovate, coriaceous with a pair of large glands at the top of the petiole. Flowers dull white – Yellowish –white or greenish-white (cream coloured) in spikes at the end of branches. Appear in March-August; depends upon places; March to May or June in the hills, sometimes also occurs during July – August. Fruit-ellipsoidal, obovoid or ovoid, yellow to orange brown, sometimes tinged with red or black and hard drupe when ripe, 3-5 cm long, becomes 5-ribbed on drying; 140-220/kg.

Distribution

It is found throughout the greater part of India including sub-Himalayan tract from Punjab eastwards to Bengal, Bihar, Assam and Southward to Madhya Pradesh, Maharastra, Orissa, Andhra Pradesh, Tamil Nadu and Karnataka. It ascends up to 1500 m in the outer Himalayas and up to 900 m on dry slopes in the Western Ghats.

It is also found in UP, Uttaranchal, Rajasthan, and Himachal Pradesh (Kangra). It also occurs in Sri Lanka and Myanmar and to a large extent in deciduous and moist forests in rocky and dry places in the outer Himalayas.

Silvicultural character- A strong light demander; cannot tolerate shade or cramped situations. The plant is drought and frost hardy to a considerable extent and can also withstands fire well with remarkable power of recovery. Coppices well, and these shoots are often vigorous.

Soil and Climate: It is capable of growing on different soils ranging from poor rocky ground to sandy, clayey, deep or shallow loam, lateritic loam, gravelly fertile alluvium of the Indo-gangetic plains and Tarai region of sub-Himalayan tract. The plant can tolerates flooding for 10-15 days after 45 years growth. The plant thrives best in areas with an annual rainfall varying between 1500-2500 mm. Its temperature ranges are max- 35-47.5^{o}C and minimum 0 to 17.5^{o} C.

Propagation

It can be propagated through seeds. Seeds are hard, pale-yellow; can directly be sown or can be transplanted after raising seedlings in nursery. Seeds possess 60 % viability up to 12 months; need pre treatment; fermentation gives best germination or cutting the base end of the endocarp without damaging embryo and soaking for 36 hours; also alternate wetting and drying helps in germination. Treated seeds germinate on an average within 15-20 days of sowing and gets ready for planting in field within 75-90 days. Pre treated fruit is sown in nursery and transplanting of one-year-old seedling is more successful. Young plants may require watering immediately after planting and/or during the first hot weather.

Nursery raising

The depulped seeds should be treated by fermentation process and then sown in nursery beds at about 15 x 15 cm spacing. The nursery should be shaded against the sun. The fruit stones after removing the outer pulpy portion are dried and sown either in wooden boxes or in nursery beds that are covered with soil and regularly watered. Ordinary clay loam or sandy loam will suffice germination and no manuring is required. Precautions should be taken against damages that may cause by rats, squirrels and rodents.

Vegetative propagation

Grafting is commonly done to reduce the juvenile period and enhance early bearing. Bud grafting and cleft grafting would be better option. Grafting of young shoots on seedlings of the same species resulted success in root induction.

Spacing

Spacing in the main field should be between 8-9 m in all direction.

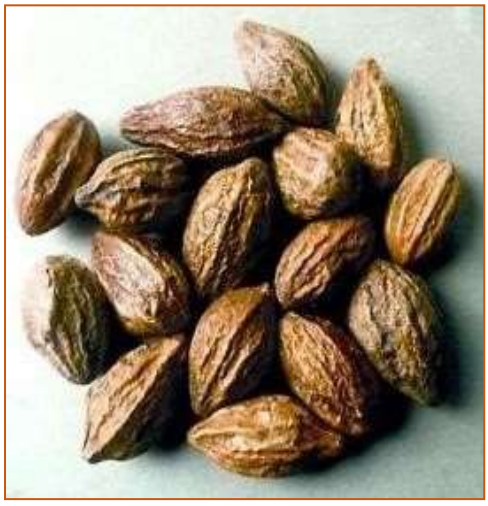
Planting time

Ideal time for planting is May-June with the onset of monsoon.

Protection

Fruits are much eaten by squirrels, rats, porcupines, hares and peacocks. Rodents do a lot of damage in nurseries. Land crabs eat off the cotyledons and cause a lot of damage. Young plants are liable to damage by cattle browsing.

Fruiting



Flowering occurs during April-August and fruiting starts from 7 -8 years after planting during Nov-January Commercial harvest starts from 10th year. The dropped fruits remain undamaged even after 5-7 days of fruit fall.

Harvesting and storage

The fruits fall on the ground soon after ripening. The crop yield varies from year to year. The fruits should be collected before maturity otherwise there is apt to be a variation in their tanning strength. The season of collection has a bearing on the tannin content and value of tannin. January is considered to be the best time for the collection in many areas, the latter collections are slightly inferior, but earlier collections are also inferior.

The collection however, starts in December and continues up to the end of March and the assembling markets also start functioning simultaneously. However, there is no conclusive data on proper stage of ripeness for best collection. Fruits are collected by shaking the tree and picking up from the ground. The harvested fruits are dried in thin layers, preferably in shade and graded for marketing.

Yield: A grown up tree (10-11 years) yields 30-35 kg dry fruits. The yield increases with age.

Economics of cultivation / ha

Total number of plants at 8-9 m distance = 125/ha
After 10 years of planting- Yield of fresh fruit = 100 -125 kg /tree
Yield of dry fruits = 30-40 kg of dry fruits/tree/year
Yield per hectare fresh 15-17 tons and dry fruit = 3-4 tons.
Sale price = Dry fruits at Rs. 60 /kg
Total cost of cultivation and maintenance up to 10th year ` 30,000/

Return / ha

Gross return @ ` 60/kg dry fruit = 240000
Net return = 240000 – 30000 = 190000

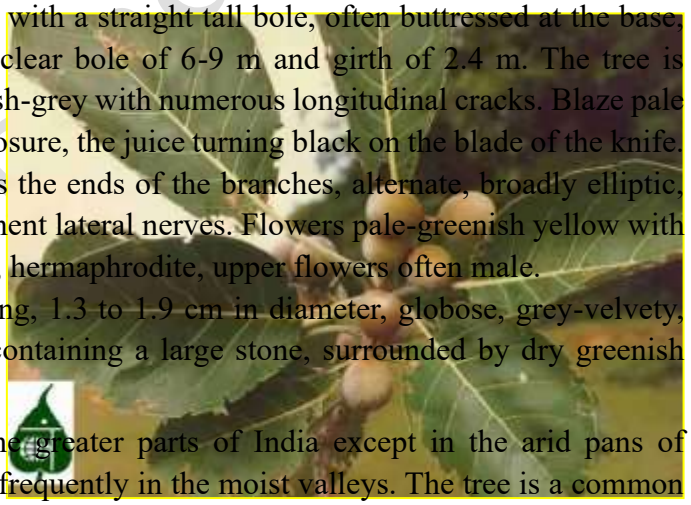
Marketing and Trade

India holds the monopoly in export Chebulic myrobalans in the form of whole fruits or in crushed form or as extracts to the world market. UK, USA, Australia, Belgium, Pakistan and Malaya Federation are the main importers of crushed myrobalans whereas Australia, Bangladesh, France, Pakistan, UK and

USA import whole myrobalan. Pakistan, New Zealand, Australia and Japan are the chief importers of myrobalan extract.

BAHEDA

Common Name	Gujarati: Baheda, Behedan, hero; Hindi: Bahera, bharla, bulla, lechara. sagona; Belleric Myrobalan
Botanical name	***Terminalia bellirica*** *Roxb.*
Family	*Combretaceae*



Description: It is a large deciduous tree usually with a straight tall bole, often buttressed at the base, usually attaining a height up to 1824 m with a clear bole of 6-9 m and girth of 2.4 m. The tree is recognized by its characteristic bark which is bluish-grey with numerous longitudinal cracks. Blaze pale dirty yellow darkening to brownish colour on exposure, the juice turning black on the blade of the knife. Leaves 7.5-20 cm by 5-15 cm. clustered towards the ends of the branches, alternate, broadly elliptic, dark green and glabrous, thick midrib with prominent lateral nerves. Flowers pale-greenish yellow with a strong offensive smell usually in solitary spikes, hermaphrodite, upper flowers often male.

Fruit a dry fleshy drupe, 2.5 to 3.3 cm long, 1.3 to 1.9 cm in diameter, globose, grey-velvety, hard, thick walled, woody, obscurely 5-ribbed, containing a large stone, surrounded by dry greenish tissue.

Distribution: The tree is found scattered in the greater parts of India except in the arid pans of Rajasthan. In the Indian peninsula it occurs most frequently in the moist valleys. The tree is a common associate of sal, teak and other important trees of the tropical moist and dry deciduous forests.

Site Factors

Climate: In its natural habitat, the absolute maximum shade temperature varies from 35-47 and the absolute minimum from 0° to 17.5^0 C. The normal rainfall ranges from 900 to 3800 mm or more.

Geology, Soil and Topography: The tree attains its best dimensions in the fertile and moist valleys having some depth of soil. In the sub-Himalayan tract, it is found on shale, mica schist tertiary sandstones, shales and conglomerates of the Shiwalik ranges flanking the Himalaya In the trap and laterites of Deccan Peninsula the tree does not attain large sizes. It occurs in the plains and hill forests upto 900 m elevation in the sub- Himalayan tract and South India.

Phenology: In Northern India, the leaves fall from November to January depending upon the locality, the leaf falling early in the dry areas and vice versa. The new foliage appears from April to May. In South India, leaf fall commences from December till March. The new foliage is often tan colourd.

The spikes of small greenish-white flowers appear from April to June. The flowers strongly scented. The fruits ripen from November to February, they hang on the tree for sometime and fall down during the cold and hot seasons. The fruits are greedily devoured by monkeys, squirrels, pigs, deer and goats. The ruminants, disgorge the seed without detriment to its germinative capacity, however, the insects and rodents greatly damage the seed. Immature fruits are damaged by several insects such as Mecobaris terminaliae on the tree and on the ground. The hard nuts are bored by the insects while lying on the ground. The nuts are also broken open for the sake of kernels inside, by squirrels, pigs and other animals.

Silvicultural Characters: The tree is a light demander, though the young seedlings can tolerate fairly heavy shade. It is decidedly sensitive to frost, but somewhat drought hardy, although it does not occur in very dry localities. It coppices fairly well but pollarding power is poor.

In spite of the fact that the tree bears abundant seed crops, has high germinative capacity, quick and easy germination and the seedlings have the ability to thrive under shade for the one or two years, the natural regeneration is never abundant.

This is probably due to the fact that the seed and even the emerging seedlings are subject to attack of insects, animals and birds and sometimes the embryos get killed due to drought. Under natural conditions the outer fleshy portion is rotten or eaten by the white ants and buried wholly or partially in the process.

A considerable amount of moisture appears to be necessary to stimulate germination and the subsequent establishment of the seedlings. Unlike other Terminalias the young plants do not assume the straggling habit. One year old seedlings may reach 10-20 cm in height but develop thick tap root measuring about l m deep. In Northern India, the season's growth stops November-December and new growth starts in March. Heavy shade suppresses the growth of seedlings, and the frost scorches the leaves.

Artificial Regeneration: The tree can be raised by direct sowing, planting out entire Lsplants or by stump-planting.

Seed Collection and Storage: The fruits ripen from November to February. Freshly fallen fruits are collected off the ground, previously swept clean. The pulp is removed immediately and the seeds are dried in the sun before storing. The seeds store well for a year. Fresh fruits with pulp weigh 66 to a kg. The depulped seeds after drying weighs 440 to a kg. The germinative capacity of the seed varies from 54 to 69 % and plant percent from 36 to 58.

Nursery Technique: The seed is sown from March to May in lines 20 cm apart, the seeds being 5 cm apart. Seeds are soaked for 24 hrs in water before sowing. They may be treated with conc. H_2S0_4 for 12 minutes for better results. Germination commences in about 2 weeks and completes in one month. About 2-4 month old seedlings can planted out in July. For road-side planting 14-16 months old plants can be planted. The small seedlings can be raised in the polythene containers.

Planting Technique: Two to four month old seedlings can be planted best during July as winter planting is not successful. Tall plants are difficult to manage. Small seedlings give 96 % survival if weeded and protected properly. The seedlings cannot tolerate frost and killed back in the first and second year. Weeding and watering accelerate the growth of the plant. Once it rises above frost level, it develops rapidly and satisfactorily. Growing of caster oil plant in between the, crops has been suggested for frost protection when grown in taungyas. The tree has also planted successfully on poor soils. It has been tried in alkaline soils with little success.

Direct Sowing: Direct sowing can be done in lines or trenches in June or even earlier in south India. It is better to hold some seed in reserve for re-sowing in case of failure. Weeding and watering have a

marked effect on the establishment of crop. In the weeded crop the seedlings attain 75-76 cm in the second season, 1.3 - 3.0 m in the third season and 3.9 m in the fourth season.

Stumps are prepared from 12-15 months old plants which are planted in pits or crowbar holes in JulyAugust. Stump-planting gives as good results as compared to planting entire plants.

Pests and Diseases: The larvae of *Trabala Vishnou* feed on the plant, *Lamida carbonifera* DEFOLIATES this plant by skeletonising and eating in irregular patches. The beetle and larvae of *Thamnurgides indicus* and *T. opacifrons* bore in the bark. Freshly felled timber is attacked by Aeolesthes holosericea Fab. *T. vishnou*

The prophylactic measures in the post-harvest, debarking of logs immediately after felling, storage of logs in open exposed to direct sunlight are the methods suggested to control it.. The sawn timber is heavily attacked by powder-post borers (Coleoptera, family Bostrychidae, including Lyctidae.

Among the fungi, *Puccinea terminaliae* causes woody galls on branches and leaves. *Phyllactinia terminaliae* causes powdry mildews, Fomes fastuosus F. robineae, F. senex and Ganoderma applanatum causes heart rot and *Trametes lactinia* causes white spongy rot.

Rate of Growth: The rate of growth is slow in the early stages, but moderately rapid later on. Ring countings estimate a mean annual girth increment of 1.3 cm to 4.1 cm. In Java, on good soil a height growth of 2-2.5 m at the end of 2 years, and of 7 m at the end of 6 years has been recorded. In a plantation in Siwalik Division (U.P) irrigated earlier, and measured at the age of 49 years gave an average diameter of 53.3 cm, corresponding to a mean girth annual increment of 1.8 cm.

Properties of wood: The wood is lustrous when freshly cut, odourless, hard, strong, moderately heavy to heavy (sp. gr. 0.6 to 0.77), fairly straight-grained, sometimes curly-grained in the radial plane and very coarse-textured.

Uses: The timber is locally used for constructional work, planking, rafting, boards, packing cases, rough shafts, carts, side planks of boats, etc. Due to its non-durability, it is not extensively used except for manufacture of heavy packing cases, tea chests commercial plywood for general purposes and block boards. The wood, in mixture with other hardwood species has been found suitable for the manufacture of chemical pulps for writing, printing and wrapping paper.

The fruit is a well known commercial myrobalan called beleric myrobalan. The flesh of full grown but not over-ripe fruits contains 21.4% tannin, while the stone contains 14 %. It is also used for dyeing cloth and leather.

Fruits a constituent of the ***Triphala*** in the native medicine. The fruit is astringent,-the kernels of the fruits are eaten but are narcotic. The kernels yield non-edible oil used in the manufacture of soaps after blending with other oils. The leaves are highly valued as fodder for milch cattle. The leaves are also fed to tasar silkworm. The tree yields a copious gum. The bark contains 12.25 to 19.77 percent oxalic acid. Grass production under its canopy is also very high i.e. 6.20 tonnes/ha

LONG PEPPER

Common Name	*Long Pepper* San: Pippali; Hin, Ben, Pun: Piplamul; Kan, Mal: Thippali; Tam: Thippili; Mar: Pimpli; Tel: Pipppaloo; Ass: Piplu
Botanical Name	*Piper longum* Linn.
Family	*Piperaceae*

Introduction

Long pepper is a slender aromatic climber whose spike is widely used in ayurvedic and unani systems of medicine particularly for diseases of respiratory tract. *Pipalarishta, Pippalyasava, Panchakola, Pippalayadilauha,* and *Lavana bhaskar churan* are common ayurvedic preparations made out of the dry spikes of female types. *Ittrifal fauladi, Angaruya-i-kabir* and *Majun khadar* are well known *unani* preparations of long pepper. Its roots also have several medicinal uses. The root is useful in bronchitis, stomach ache, diseases of spleen and tumours. Fruit is useful in asthma, bronchitis, abdominal complaints, fever, leucoderma, urinary discharges, tumours, piles, insomnia and tuberculosis. Root and fruit are used in gout and lumbago. The root and fruit decoction are used in acute and chronic bronchitis and cough. It contains alkaloid “piperine” which has diverse pharmacological activities, including nerve depressant and antagonistic effect on electroshock and chemo-shock seizures as well as muscular in-coordination.

Distribution

The plant is a native of Indo-Malaya region. It was very early introduced to Europe and was highly regarded as a flavour ingredient by the Romans. The Greek name *"Peperi*", the Latin *"Piper"* and the English *"Pepper*" were derived from the Sanskrit name *"Pippali*". It grows wild in the tropical rain forests of India, Nepal, Indonesia, Malaysia, Sri lanka, Rhio, Timor and the Philippines. In India, it is seen in Assam, West Bengal, Uttar Pradesh, Madhya Pradesh, Maharashtra, Kerala, Karnataka and Tamil Nadu. It is also cultivated in Bengal, Chirapunchi area of Assam, Akola-Amravati region of Maharashtra, Anamalai hills of Tamil Nadu, Orissa, Uduppi and Mangalore regions of Karnataka. Bulk of Indian long pepper comes from its wild growth in Assam, Shillong and West Bengal, supplemented by imports from Sri Lanka and Indonesia.

Botany

The plant is a glabrous perennial undershrub with erect or sub-scandent nodose stem and slender branches; the latter are often creeping or trailing and rooting below or rarely scandent reaching a few metres height. Leaves are simple, alternate, stipulate, and petiolate or nearly sessile; lower ones broadly ovate, cordate; upper ones oblong, oval, all entire, smooth, thin with reticulate venation; veins raised beneath. It flowers nearly throughout the year. Inflorescence is spike with unisexual small achlamydeous densely packed flowers and form very close clusters of small greyish green or darker grey berries. Female spikes with short thick stalk varying from 1.5 to2.5 cm in length and 0.5 to 0.7 cm in thickness.

A number of geographical races are available in different agroclimatic regions of India; the most popular being Assam, West Bengal and Nepal races. *Piper officinarum* DC; syn. *Chavica officinarum* Miquel, *Piper pepuloides* and *Piper chaba* Hunter are the other related species of importance.

Properties and activity

The spike of long pepper contains 4-5% piperine, piplartin, piperolactam, N-isobutyl deca trans-2-trans-4dienamide and piporadione alkaloides, besides 0.7 % essential oil. Roots gave the alkaloids piperine, piperlongumine (piplartine) and piperlonguminine; sesamine, methyl 3, 4, 5trimethoxy cinnamate. Stem gave triacoutane 22, 23 - dihydrostigmasterol. Fruit essential oil contains piperidine, caryophyllene and sesquiterpene alcohol.

The root is hot, stomachic, laxative (Stimulating evacuation of feces), anthelmintic and carminative (Relieving gas in the alimentary tract (colic or flatulence or griping)).

The fruit is sweetish, pungent, hot, stomachic, aphrodisiac (Exciting sexual desire), alterative (Tending to cure or restore to health), laxative, antidysenteric, emmenagogue (promotes menstrual discharge), abortifacient (causing abortion), diuretic (tends to increase the flow of urine, which causes the body to get rid of excess water) and tonic. The essential oil is antimicrobial and anthelmintic (expelling or destroying parasitic worms). N-isobutyl-deca-trans-2-trans-4-dienamide is antitubercular. Piperine is hypotensive, antipyretic, analeptic (Stimulating the central nervous system), and nerve stimulant.

Agrotechnology

Climate and Soil

Long pepper is a tropical plant adapted to high rainfall areas with high humidity. An elevation of 100-1000 m is ideal. It needs partial shade to the tune of 20-30% for best growth. It can be grown as an under crop in Coconut and Arecanut gardens. The natural habitat of the plant is on the borders of streams. It is successfully cultivated in well drained forest soils rich in organic matter. Laterite soils with high organic matter content and moisture holding capacity are also suitable for cultivation.

Propagation

Land preparation: The field is ploughed 2-3 times, brought to a fine tilth by harrowing and leveled so that water doesn't stagnate in the field for long time. Then the field is divided into convenient sized

plots and pits are opened at a distance of 60 x 60 cm. The pits are filled with soil mixed with 100g well decomposed FYM. In order to protect it against sun and dew, field should be covered/shaded using dry bushes and leaves.

Planting: Pepper is propagated through rooted stem cuttings or suckers in the month of FebruaryMarch. 8-10 cm long stem cuttings bearing 3-6 nodes and about 2-3 leaves treated with root hormones are planted in 8x15 cm polythene packets. It is essential to give light irrigation daily in the nursery. The cuttings planted in March will be ready for transplanting in May.

Transplanting: The rooted cuttings are planted with the onset of monsoon at the rate of 2 cuttings per pit and gap filling of the pits is done a month after planting. 100 per cent establishment of these cuttings is recorded. Around 27,660 cuttings are needed to plant an area of one hectare. Climbers of long pepper are trained on support plants. Long pepper may also be grown as an inter-crop with Eucalyptus, Coconut and Arecanut.

Fertilizer

During land preparation, 40-50 tons of compost and 20:40:40 Kg per hectare of Nitrogen, Phosphorus and Potash respectively are added. A month after sowing, 100 Kg per hectare of Diammonium Phosphate (DAP) and again in July -August 40 Kg /ha of DAP is required to enhance the yield. At the time of irrigation prior to the commencement of rains 20 tons/ha of compost/FYM should be incorporated. **Irrigation**

Irrigate lightly soon after planting. Subsequent irrigations in the case of a pure crop should be once in 3-5 days. Incase the crop is grown as an intercrop, the irrigation provided to main crop is sufficient. Irrigations during summer induces continuous spike formation during off-season. **Interculture**

Timely hoeing and weeding is also essential. During first year of planting, weeding is done as and when weed growth is noticed and earthing up is done every year after adding FYM. The growing climber should be trailed on the support trees. Dry leaves or straw can be used for mulching the beds during summer months to avoid moisture loss from soil surface.

Plant protection

Major pests like mealy bugs and Helopeltis can be controlled by spraying Rogar @ 0.2% and Neem seed kernel extract @ 2.5 ml per litre of water respectively. Diseases like leaf and vine rotting, yellowing and crinkling of leaves can be controlled by spraying 1% Bordeaux mixture twice or thrice during the month of May or drenching vine with Cantaf 20 ml and Calphomine 30 ml /10 litre subsequently during rainy season. **Harvest and postharvest:**

Climber starts flowering 4 -5 months after planting and fruits mature during October - November. The spikes are ready for harvest 2 months after their formation on the plants. Spikes are picked when they are blackish green and most pungent. Spikes can be picked as and when they mature. The harvested spikes are dried in the sun for 4 to 5 days until they are perfectly dry and stored in moisture proof containers. 10 Kg of green spike reduces to 1.5 Kg dry spike. After harvesting, the plant is pruned and after some time new leaves begin to arise. These pruned twigs can also be used as planting material.

Post harvest technology:

The harvested spikes are dried in sun for 4-5 days until they are perfectly dry. The green to dry spike ratio is 10:1.5 by weight. The dried spikes have to be stored in moisture proof containers. Stem and roots are cleaned, cut into pieces of 2.5-5 cm length, dried in shade and marketed as piplamool. There are three grades of piplamool, based on the thickness. The commercial drug consists 0.5-2.5 cm

long, 0.5-2.5 mm thick, cylindrical pieces dirty light brown in colour and peculiar odour with a pungent bitter taste, producing numbness (Partial or total lack of sensation) to the tongue.

Yield

In the first year dry spike yield is about 400 Kg per hectare and thereafter yield is 1000 -1500 Kg per hectare up to 3 years. The crop may be grown as a perennial, however after 3rd year the productivity of the vine decreases and should be replanted. Besides spikes, parts of stem and roots can be uprooted, cleaned, cut and sold in the market. 500 Kg/ha dry roots is also obtained.

Economics of cultivation (AS AN INTERCROP IN COCONUT GARDEN) **Duration**: 8-9 MONTHS

COSTS PER HECTARE

Particulars	**Man days required**	**C st (Rs.)**	
		I Year	**II(also III)yr**
Site clearing	5 MD	200	-
Land preparation	30 MD	1200	-
Cost of stakes & installation	1000stakes @Rs.2/stake	2000	-
Cost of 3000 plants/ha	@ Rs. 5/plant, (plant/stake)	15000	-
Cost of planting	15MD	600	-
Cost of FYM & application	Rs.200/ton	7500	5000
Weeding	25 MD	1000	1000
Irrigation		2500	2500
Harvesting		650	1250
Miscellaneous	-	1000	500
TOTAL COST		31650	10250

Returns per hectare

	I YEAR	II YEAR	II YEAR
Average Yield Of Spike (Kg)	400	600	1000+500(Root)
GROSS RETURNS @Rs.80/Kg Spike	**32000**	**48000**	**80000+75000(Root)***
NET RETURNS	**350**	**37750**	**144750**

* Income from sale of roots at the end of third year (500Kg/ha @ Rs.150/Kg) **Production and Trade**

USA is the largest buyer of Pepper in the world market. Fluctuations in the import of pepper by USA have a direct impact on the world pepper trade. During 2008, USA has imported a total quantity of 55,000 MT of pepper (Black & White) as against their average import of about 60,000 MT per annum. It is reported that, due to economic slowdown, the major US companies are keeping low inventories resulting in low import volume.

In recent years, Indian production is stagnant around 50,000 MT due to low productivity of aged and disease affected pepper plantations. Our competitors like Vietnam with an annual production of almost double that of India has now become one of the major suppliers of pepper in the international markets. However, Indian pepper fetches a premium price in major markets because of its preference and intrinsic qualities. During the year 2008-09, India has exported a total quantity of 25,250 tonnes of pepper valued Rs.413.74 crores as against 35,000 tonnes valued Rs.519.50 crores of last year, registering a decline of 28% in volume and 20% in value.

Our exports to all major destinations like USA, EU etc. has declined during the year. In 2008-09, USA continued as our major market for pepper and has imported 10,050 MT, accounting for 40% of our total export of pepper.
The other major buyers are UK (1475 MT), Italy, (1290 MT), Canada (1265 MT) and Germany (1200 MT). The average fob export price of Pepper has gone up from Rs.148.43 per kg in 2007-08 to Rs.163.86 per kg in 2008-09.

CHHOTI ELAICHI

Common Name	Chhoti Elaichi Alaicha, bach dau khau, bastard cardamom, chota elaich, elachi, elayachi, elchi, Elettarie, illlachi, malabar cardamon, Malabar Cardamonen.
Botanical Name	*Elettaria cardamomum* (L.) Maton *Amomum repens* Sonn. *A. cardamomum* Lour. , *Alpinia cardamomum* Roxb.
Family	Zingiberaceae

Geographical distribution

Native to India and introduced to Sri Lanka

Description

A perennial zingiberaceous herb attaining a height of 2–4 m, with lanceolate leaves borne on long sheathing stems. Flowers numerous, borne on horizontal racemes (*Usually elongate cluster of flowers along the main stem in which the flowers at the base open first*) that arise from the rhizome and run horizontally along the ground. The fruit is inferior, ovoid or oblong, nearly ellipsoidal, capsule plump or slightly shrunken, the seeds of which are covered by an aril (*Fleshy and usually brightly coloured cover of some seeds that develops from the ovule stalk and partially or entirely envelopes the seed*).

Plant material of interest:

Dried seed (nearly dried fruit)

General appearance

Usually in agglutinated groups of 2–7 seeds. Each irregularly angular, 3- to 4-sided, oblong, ovoid; 2–4 mm long, up to 3 mm broad; pale orange to dark reddishbrown; usually enveloped by a thin colourless membranous aril externally, transversely wrinkled but not minutely pitted; hilum (*a scar on a seed indicating its point of attachment*) depressed; raphe (*ridge that forms a seam between two parts*) indicated by a channel extending on one side from base to apex; hard; internally, whitish, showing a thin dark testa (*Protective outer layer of seeds*), a whitish starchy perisperm (*nutritive tissue outside the sac containing the embryo*) grooved on one side, and in the centre a small yellowish translucent endosperm (*Nutritive tissue surrounding the embryo within seed*), surrounding a paler minute embryo.

Fruit: Inferior, ovoid or oblong, nearly ellipsoidal, capsule plump or slightly shrunken; 8–20 mm, but most fruits are 10–15 mm long, 5–10mm in diameter; green to pale buff, sometimes yellowish-grey, mostly 3-sided; externally, smooth or longitudinally striated; base, rounded and may bear the remains of the stalk; apex, more or less blunt and sometimes crowned by a short beak formed of the remains of the floral parts; interior longitudinally divided into 3 loculi, each loculus (*Locule: a cavity of the ovary which contains the ovules*) is an adherent mass of two rows of 3–7 small seeds attached to the axile placenta (*That part of the ovary of a flowering plant where the ovules form*).

 Four varieties of fruits are available: "Mysore", "Malabar", "Mangalore" and "Alleppy".

Organoleptic properties

Odour: aromatic; taste: aromatic, pungent and slightly bitter.

Major chemical constituents

Contains 2–8 % essential oil, the major constituents of which are 1,8-cineole (20–40%), (+)-α terpinyl acetate (30–42%), α -terpineol (4–45%), limonene (6%), and smaller amounts of linalool and linalool acetate, among others. The structures of 1,8-cineole, (+)-α –terpinyl acetate and α-terpineol.

Medicinal uses

Uses described in pharmacopoeias and well-established documents: Orally for the treatment of dyspepsia.

Uses described in traditional medicine: Treatment of asthma, bronchitis, colic (*A severe spasmodic griping pain*), coughs, fainting, fever, rheumatism, stomach cramps and urinary stones. Also used as an aphrodisiac, appetizer, diuretic and emmenagogue.

Cultivation

Climate and Soil

Small Cardamom is cultivated as an under storey crop in the tropical ever green forests of western Ghats of South India in the altitude ranging from 500-1500 m above MSL with an average annual rainfall between 1500 to 6000 mm and annual lowest and highest temperature varying from 10º to 36º C. India is the second largest producer of cardamom in the world and the major part of the production is consumed with in the country. The contribution of Kerala to India's total production is about 60 per cent.

Propagation

May be raised from seed, which require 2-3 months to germinate. Sites must be sheltered from direct sun and strong winds. Clearings in forest often provide such sites. It is more usually started from selected rhizomes or bulbs 1.5 to 2 years old and with at least 2 growing stems; mature plants can be divided after fruiting.

Interculture and Harvesting

Flowers are said to be self-sterile, so it is necessary to plant a mixture of clones. In India, the fruits are harvested from August through December, as they ripen; dividing and planting is done later. Plants are set 3-4 m apart. Manual labour is generally used to keep weeds down during the first 2 years. Plants should be periodically cleaned of dried leaves and damaged or decaying stems.

Raised alone in monoculture or with pepper and/or coffee. If a swampy site runs through a coffee plantation. Plants mature in 2-3 years, ripening more slowly at higher elevations.

Ripe fruits must be severed carefully with scissors so as not to injure the flowers and unripe fruit. Fruits are picked green (yellow ones split and shatter = shed their seeds). Yields all year round in the humid tropics, but chiefly during dry period. Crop is gathered every 2-3 weeks.

Postharvest

In India and Sri Lanka, fruit is prepared for market by: (1) sulfur bleaching — sulfur fumigation, alternated with soaking and drying, carried out in four stages with a final sun drying; whole process takes from 10-12 days to complete, and bleached cardamoms are creamy-white; (2) green curing — cardamoms are dried on trays in a heated chamber or over an open charcoal fire in a closed chamber. These cardamoms are green. Stalks and calyxes are removed from dried cardamoms by cutting or grating, then sorted and graded according to size.

Yield

Capsule Yield (kg ha-1) (Dry)	
With NPK 0:0:0	156.03
With NPK 125:125:200 kg/ha	306.56
With Neem cake 0.5 kg plant-[1]	161.51

CLOVE TREE

Common Name	Eng: Clove tree, Cloves; Hin: Lavang, Laumg; San: Lavangam, Devakusumam, lauang, laung, lawang, Nägelein, osaragbogo-eze, qaranfal, qoranful, qronfel
Botanical Name	***Syzygium aromaticum* (Linn.) Merrill & Perry** *Caryophyllus aromaticus* L., *Eugenia aromatica* (L.) Baill. *E. caryophylla* Thunb. *E. caryophyllus* (C. Spreng.) Bull. et Harr., *Jambosa caryophyllus* (Spreng.) Nied. *Myrtus caryophyllus* Spreng.
Family	Myrtaceae

Geographical distribution

The clove tree is a native of some islands of the Malay Archipelago (*archipelago between mainland South-eastern Asia and Australia*), especially Moluccas. It is cultivated in Zanzibar and Pemba (Tanzania), Indonesia, Penang, Malagasy and to a lesser extent in the Seychelles, Reunion, Mauritius and Sri Lanka (Ceylon). Currently cultivated in many tropical areas including Africa (e.g. Madagascar and United Republic of Tanzania)

In India, it is grown in Tamil Nadu (the Nilgiris, Courtallam and Kanniyakumari) and Kerala (Kottarakara, Chengannur, valleys of Pamban and Manimala rivers, and gardens of Pidavoor and Kottayam areas).

Description

Small evergreen trees, 10–20 m high. Leaves opposite, petiolate, lanceolate, pinkish to dark green, with translucent, aromatic glands, have a pungent odour when young. Inflorescence occurs as racemose panicles and bears buds that take on the form of nails before blossoming. Flowers red with 4 concave, overlapping petals that drop off as soon as the flower opens; stamens numerous; 4 calyx lobes. Fruit dark red, fleshy drupe. Buds readily exude oil when pressed or scratched with a fingernail.

Plant material of interest: DRIED FLOWER BUDS

General appearance

Flower bud 10–20 mm long, bright reddish-brown to dark brown; lower part (the hypanthium, *cuplike or ring like or tubular structure of a flower which bears the sepals and stamens and calyx*) solid, cylindrical, somewhat flattened, 4-sided, tapering towards the base and bearing at the apex 4 thick, triangular, divergent sepals, alternating with 4 rounded, fragile, unexpanded, membranous, imbricated petals (*overlapping, like shingles on a roof*) forming a pale, nearly spherical head that encloses numerous stamens, curved inward and inserted on a small disc, and a stiff, slender, erect, single style arising from a depression in the centre. Externally wrinkled; internally, hypanthium contains in its upper portion a 2-celled inferior ovary (*one that is situated below the point of attachment of the sepals and petals, and possibly below the point of attachment of all other flower parts and embedded in the floral stem*) with numerous ovules attached to the axile placenta; has very large outer zone with numerous shining, oval

oil glands near the periphery, numerous vascular bundles in the centre and a dark, lacunose layer abutting on the central zone and columella.

Organoleptic properties

Odour: characteristic, strongly aromatic; taste: pungent, spicy, followed by slight numbness. **Major chemical constituents**

The major constituent (up to 20%) is an essential oil, which is characterized by the presence of eugenol (60–95%), eugenol acetate (2–27%), and a- and b-caryophyllene (5–10%). **Medicinal uses**

Uses described in pharmacopoeias and in traditional systems of medicine

External or local applications for the treatment of toothache, and minor infections of the mouth and skin. Also used as an antiseptic for dressing of minor wounds, and, in the form of lozenges, for sore throats and coughs associated with the common cold. The essential oil (1–5%) is used in mouthwashes.

Uses described in folk medicine, not supported by experimental or clinical data: Treatment of asthma, bleeding gums, dyspepsia, fevers and morning sickness

Climate and soil:

Clove grows well in rich, loamy soil of the humid tropics, with well spread out rainfall. An annual rainfall of 250-300 cm is ideal for clove cultivation. They abhor water logging condition, so clay soils in deciduous tracts of these islands are not found suitable due to water logging in the rainy season and the soils becoming too hard in summer. The slopes facing South and west are also not suitable due to severe sun in summer. **Propagation:**

The seeds should be collected from fully ripe fruits. Fruits for seed collection, popularly known as mother of clove, are allowed to ripen on trees itself and drop down naturally. Such fruits are collected from the ground and sown directly in polybags or soaked in water overnight. The pericarp is removed which gives quicker and higher germination. Only fully developed and uniform sized seeds which show signs of germination by the presence of pink radical are used for sowing. Though the ripe fruits can be stored for a few days by spreading them in a cool shaded place, it is advisable to sow the seeds immediately after harvesting. Approach grafting of clove on its own root–stock is successful.

Nursery rasing

Nursery beds of 15-20 cm height, 1 m width and convenient length are to be prepared for sowing seeds. The beds should be made of loose soil sand mixture over which a layer of sand may be spread.

Seeds can also be sown in sand beds but care should be taken to prevent erosion of the soil in the beds in rains. Seeds are sown at 2-3 cm spacing and depth of 2 cm.

The seed beds have to be protected from direct sunlight .The germination commences in about 10-15 days and may last for about 40 days. The germinated seeds are then transplanted in polybags containing a mixture of, soil, sand and well decomposed cowdung. Sometimes these seedlings are again transplanted after 1 year to a large poythene bags.

Direct Sowing in Polythene bags

The seeds can be sown directly in poly bags filled with soil and cow dung mixture. They should be kept in a cool and shady place. The germination commences in about 10-15 days and last for about 40 days. The germinated seedlings are again transplanted in another polythene bag containing a mixture of soil, sand and well-decomposed cow dung in a 2:2:1 ratio. After one year it is transplanted in a larger polythene bag containing the same potting mixture. The 18 – 24 months old seedlings are ready for transplanting in the field. The seedlings are usually shaded and irrigated daily to ensure uniform seedling stand. **Planting:**

The pits of 75 cm x 75 cm x 75 cm size are dug at a spacing of 6-7 m. If an intercrop, the spacing is to be adjusted based on the spacing of the major crop. The pits are partially filled with compost, green leaf or cattle manure and covered with soil. The seedlings are transplanted in the main field with the onset of rainy season in June-July. Clove prefers partial shade. It is best suited for mixed cropping in older coconut or arecanut gardens, intercropping of banana is very good. **Manure and fertilizers:**

Apply 50 kg farm yard manure or compost and bone meal or fish meal to a bearing tree per year during April-May. Organic manures can be applied as a single dose at the onset of the rainy season in trenches dug around the tree. The application of inorganic fertilizers @ 20 gm nitrogen (40 gm urea), 18 gm P_2O_5 (100 gm rock phosphate) and 50 gm K_2O (80g murate of potash per year per tree) is recommended. The dose can be increased to 300 gm N (600 gm urea), 250 gm P_2O_5 (1350 gm rock phosphate) and 750 gm K_2O (1,250 gm murate of potash per year) for a grown–up tree of 15 years or more. The fertilizers must be applied in two equal split doses in April-May and Oct-Nov. in shallow trenches dug around the plant normally about planted as e sowing. The1-1 ½ m away from the base. The plant basin must be always kept weed free and mulched. **Irrigation:**

In the first 3-4 years, extreme care should be taken especially during summer months. Plant based water application has to be very judiciously followed. **Plant protection:**

Diseases Seedling wilt

Seedling wilt is a serious problem in some of the areas. The leaves of affected seedlings lose their natural lustre, droop and ultimately die. The root system and collar region of the seedling show varying degree of discolouration and decay. Since the infected plants promote further spread of the disease, they are to be removed and the remaining seedlings should be treated with carbendazim+mancozeb mixture fungicide by dissolving it as 2 gm per litre of water and then drenching the root zone of the seedlings.

Leaf Rot

Leaf Rot is observed in mature trees and seedlings. The infection starts as dark diffused patches at the leaf tip or margin and later the whole leaf rots, resulting in severe defoliation. The foliage of the affected tree should be sprayed with carbendazim+mancozeb mixture or copper oxy chloride by dissolving 2-3 gm in 1 litre of water, and spraying uniformly.

Leaf spot and bud shedding

The disease is characterized by dark brown spots with a yellow halo on leaves. Such spots also appear on the buds resulting in their shedding. Prophylactic spray of Copper oxy chloride @3 gm per litre of water can prevent the onset of this disease.

Insect Pests

Stem borer

The stem borer infests the main stem of young trees at the basal region. The larvae of the pest girdles the stem and bores downward into it. The girdled portion and borehole are covered with a mat like frass material. The infected trees wilt and succumb to the pest attack. Inspect the base of the tree regularly for the symptoms of the attack. Spray the crop with Quinalphos around the borehole and inject the same into the borehole after removing the frass. Swabbing the basal region of the main stem with carbaryl and keep the basins of the tree free from weeds are prophylactic measures for reducing the pest infestation. **Scale Insects**

Many species of scale insects infests the clove seedlings in the nursery and sometimes young plants in the fields. The scale are generally seen clustered together on the tender stems and lower surface of leaves. Scale insect feed on the plant sap and cause yellow spots on leaves and wilting of shoots and the plants present a sickly appearance. Spray of imidacloprid or triazophos can prevent this infestation.

Harvest:

Clove trees flower from the fifth year of its planting under good soil and management conditions. But full bearing stage is reached only after 15 years. The flower bud initiation starts from Aug-Sept. The unopened buds are harvested in Dec-Jan, when they begin to turn pink. At this time, they are less than 2cm long. The opened flowers are not valued as a spice. Harvesting should be done using step ladders without damaging the branches, as it adversely affects the succeeding growth. The harvested flower buds are separated from the cluster by hand and spread in the drying yard for drying. The correct stage of drying is, when the stem of the bud becomes dark brown and rest of the bud lighter brown. Well dried cloves are only one-third the weight of the original. About 11,000- 15,000 dried cloves weights one kilogram. Yield varies from 200 to 500 gm per plant per year.

Area under production in India

Clove was first introduced to India around 1800 AD by the East India Company in its 'spice garden' in Courtallam, Tamil Nadu. The important clove growing districts in India now are Nilgiris, Tirunelveli, Kanyakumari, Nagercoil and Ramanathapuram districts of Tamil Nadu; Kozhikode, Kottayam, Kollam and Thiruvananthapuram Districts of Kerala and South Kanara district of Karnataka. As per the estimates, the total area of 1855 hectares under clove cultivation in India spreads over 951 hectares in Kerala, 660 hectares in Tamil Nadu, 181 hectares in Karnataka and 63 hectares in Andaman and Nicobar islands. **Value-added products:**

Oleoresin is prepared by cold or hot extraction of the crushed spice using organic solvents. Volatile oil content of oleoresin is usually 70-80%.

Varieties

The clove plantations in India are reported to be of seedling brought from Mauritius. Recent discovery of dwarf varieties by the scientists at the Indian Institute of Spices Research (IISR) in Kozhikode. While the average height of clove trees is 20 m, the one found is only 2 m tall, with a canopy width of 5 m.

The main trunk of the dwarf clove tree is just 0.6 m in height with profuse branches. Also, the branching starts just 60 cm above ground level. The average yield of each tree is about 3 kg dry cloves a year.

In commerce the varieties of cloves are known by the names of the localities of their growth, and so closely resemble one another as to be distinguished only by experts. The Penang cloves have been especially esteemed. The Bencoolen cloves from Sumatra are by many druggists deemed equal to them. The Amboyna and Molucca cloves are stated to be thicker, darker, heavier, oilier, and more highly aromatic than those cultivated elsewhere.

Clove production and trade

Yield

A well maintained full grown tree under favourable conditions may give four to eight kg dried buds. The average annual yield at the 15th year may be taken as two kg per tree or 400 kg per hectare

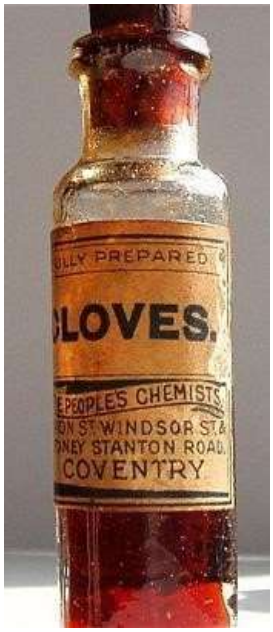
Global Production of Cloves.

The recent World average production of clove is about 80000 tonnes. About 63.0 % of global clove supply was produced in Indonesia. The second and third world clove producing countries are Madagascar (19.7 %) and Tanzania (12.6 %).

Clove producing countries in the world

No.	Country	Production	
		Tonnes	%
1	Indonesia	50,000	63.0
2	Madagascar	15,600	19.7
3	Tanzania	10,000	12.6
4	Sri Lanka	1,500	1.90
5	Comoros	1,000	1.30
6	Others	1,271	1.50
7	World	79,371	100.00

During 2008-09, the export of Clove Oil from India was 22 MT.



GINGER

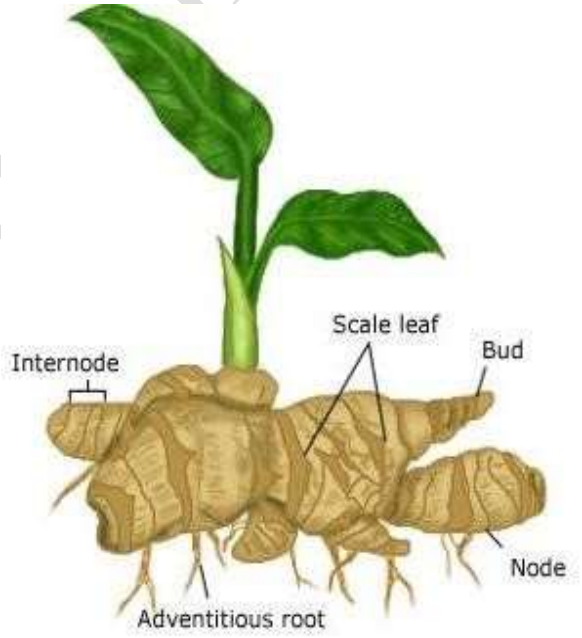
Common Name	**Ginger** Gingembre (gris et blanc), *Fr. Cod*.; *Rhizoma zingiberis*, *P. G*:; Ingwer, *G*.; Zenzero, *It*.; Jengibre (Rizoma de), *Sp*.
Botanical Name	***Zingiber officinale*** Roscoe
Family	***Zingiberaceae***

Origin and distribution

Ginger's current name comes from the Middle English *gingivere,* but ginger dates back over 3,000 years to the Sanskrit S*rngaveram* meaning "horn root" with reference to its appearance. In Greek it was *ziggiberis,* and in Latin, *Zinziberi.* There are about twenty species of the genus Zingiber, the commercial ginger being obtained from *Zingiber officinale*. The species is probably a native of tropical Asia, but is not known except in the cultivated state. It is now extensively cultivated in the tropical countries of both the Eastern and Western Hemispheres.

Morphology

The ginger plant, *Zingiber officinale* , has a biennial or perennial, creeping rhizome, and an annual stem, which rises two or three fe et in height, is solid, cylindrical, erect, and enclosed in an imbricated membranous sheathing. The leaves are lanceolate, acute, smooth, five or six inches long by about an inch in breadth, and stand alternately on the sheaths of the stem. The flower -stalk rises by the side of the stem from six inches to a foot, and, like it, is clothed with oval acuminate sheaths; but it is without leaves, and terminates in an oval, obtuse, bracteal, imbricated spike. The flowers are of a dingy yellow color, and appear tw o or three at a time between the bracteal scales. The flowers have an aromatic odor, and the stems when bruised are slightly fragrant; but it is in the rhizome that the virtues of the plant reside.



Climate and soil

Ginger grows well in warm and humid climate and is cultivated from sea level to an altitude of 1500 m above sea level. Ginger can be grown both under rain fed and irrigated conditions. For successful cultivation of the crop, a moderate rainfall at sowing time till the rhizomes sprout, fairly heavy and well distributed showers during the growing period and dry weather for about a month before harvesting are necessary. Ginger thrives best in well drained soils like sandy loam, clay loam, red loam or lateritic loam. A friable loam rich in humus is ideal. However, being an exhausting crop it is not desirable to grow ginger in the same soil year after year.

Varieties

Several cultivars of ginger are grown in different ginger growing areas in India and they are generally named after the localities where they are grown. Some of the prominent indigenous cultivars

are Maran, Kuruppampadi, Ernad, Wynad, Himachal and Nadia. Exotic cultivars such as Rio-deJaneiro have also become very popular among cultivators.

Improved varieties of ginger

Culivar	Fresh mean yield (t/ha)	Maturity (days)	Dry recovery %	Crude fibre %	Oleoresin %	Essential oil %
IISR- Varada	22.6	200	20.7	4.5	6.7	1.8
Suprabha	16.6	229	20.5	4.4	8.9	1.9
Suruchi	11.6	218	23.5	3.8	10.0	2.0
Suravi	17.5	225	23.5	4.0	10.2	2.1
Himagiri	13.5	230	20.6	6.4	4.3	1.6
IISR Mahima	23.2	200	23.0	3.2	4.4	1.7
IISR Rejatha	22.4	200	19.0	4.0	6.3	2.3

Local cultivars/land races of ginger

Culivar	Fresh mean yield (t/ha)	Maturity (days)	Dry recovery %	Crude fibre %	Oleoresin %	Essential oil %
China	9.50	200	21.0	3.4	7.0	1.9
Assam	11.78	210	18.0	5.8	7.9	2.2
Maran	25.21	200	20.0	6.1	10.0	1.9
Himachal	7.27	200	22.1	3.8	5.3	0.5
Nadia	28.55	200	22.6	3.9	5.4	1.4
Rio-de-Janerio	17.65	190	20.0	5.6	10.5	2.3

Cultivation

Season

The best time for planting ginger in the West Coast of India is during the first fortnight of May with the receipt of pre-monsoon showers. Under irrigated conditions, it can be planted well in advance during the middle of February or early March. Burning the surface soil and early planting with the receipt of summer showers results in higher yield and reduces disease incidence.

Land preparation

The land is to be ploughed 4 to 5 times or dug thoroughly with receipt of early summer showers to bring the soil to fine tilth. Beds of about 1 m width, 15 cm height and of convenient length are prepared with an inter-space of 50 cm in between beds. In the case of irrigated crop, ridges are formed 40 cm apart. In areas prone to rhizome rot disease and nematode infestations, solarization of beds for 40 days using transparent polythene sheets is recommended.

Planting

Ginger is propagated by portions of rhizomes known as seed rhizomes. Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 20-25 g each having one or two good buds. The seed rate varies from region to region and with the method of cultivation adopted. In Kerala, the seed rate varies from 1500 to 1800 kg/ha. At higher altitudes the seed rate may vary from 2000 to 2500 kg/ha. The seed rhizomes are treated with mancozeb 0.3% (3 g/L of water) for 30 minutes, shade dried for 3-4 hours and planted at a spacing of 20-25 cm along the rows and 20-25 cm between the rows. The seed rhizome bits are placed in shallow pits prepared with a hand hoe and covered with well rotten farm yard manure and a thin layer of soil and leveled.

Manuring

At the time of planting, well decomposed cattle manure or compost @ 25-30 tonnes/ha has to be applied either by broadcasting over the beds prior to planting or applied in the pits at the time of planting. Application of neem cake @ 2 tonnes/ha at the time of planting helps in reducing the incidence of rhizome rot disease/ nematode and increasing the yield. The recommended dose of fertilizer for ginger is 75 kg N, 50 kg P_2O5 and 50 kg K_2O per ha. The fertilizers are to be applied in split doses. The beds are to be earthed up, after each top dressing with the fertilizers. In zinc deficient soils basal application of zinc fertilizer up to 6 kg zinc/ha (30 kg of zinc sulphate/ha) gives good yield. **Fertilizer schedule for ginger (per ha)**

Fertilizer	Basal application	After 45 days	After 90 days
N	-	37.5 kg	37.5 kg
P_2O5	50 kg	-	-
K_2O	-		25 kg
Compost/ Cowdung	25-30 tonnes	-	-
Neem cake	2 tonnes	-	-

Mulching

Mulching the beds with green leaves/organic wastes is essential to prevent soil splashing and erosion of soil due to heavy rain. It also adds organic matter to the soil, checks weed emergence and conserves moisture during the latter part of the cropping season. The first mulching is done at the time of planting with green leaves @ 10-12 tonnes/ha. Mulching is to be repeated @ 7.5 tonnes/ha at 45 and 90 days after planting, immediately after weeding, application of fertilizers and earthing up.

Inter cultivation

Weeding is done just before fertilizer application and mulching; 2-3 weedings are required depending on the intensity of weed growth. Proper drainage channels are to be provided when there is stagnation of water. Earthing up is essential to prevent exposure of rhizomes and provide sufficient soil volume for free development of rhizomes. It is done at 45 and 90 days after planting immediately after weeding and application of fertilizers.

Crop rotation and mixed cropping

Crop rotation is generally followed in ginger. The crops most commonly rotated with ginger are tapioca, ragi, paddy, gingelly, maize and vegetables. In Karnataka, ginger is also mix cropped with ragi,

red gram and castor. Ginger is also grown as an intercrop in coconut, arecanut, coffee and orange plantations in Kerala and Karnataka. However, crop rotation using tomato, potato, chillies, brinjal and peanut should be avoided, as these plants are hosts for the wilt causing organism, *Ralstonia solanacearum*.

Plant protection (Diseases) Soft rot

Soft rot is the most destructive disease of ginger which results in total loss of affected clumps. The disease is soil-borne and is caused by *Pythium aphanidermatum*. *P. vexans* and *P. Myriotylum* are also reported to be associated with the disease. The fungus multiplies with build up of soil moisture with the onset of south west monsoon. Younger sprouts are the most susceptible to the pathogen. The infection starts at the collar region of the pseudo stem (*A false stem composed of concentric rolled or folded blades and sheaths that surround the growing point*) and progresses upwards as well as downwards. The collar region of the affected pseudo stem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot. At a later stage root infection is also noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudo stems. Treatment of seed rhizomes with mancozeb 0.3% for 30 minutes before storage and once again before planting reduces the incidence of the disease. Cultural practices such as selection of well drained soils for planting is important for managing the disease, since stagnation of water predisposes the plant to infection. Seed rhizomes are to be selected from disease free gardens, as the disease is also seed borne. Application of *Trichoderma harzianum* along with neem cake @ 1 kg/bed helps in preventing the disease. Once the disease is located in the field, removal of affected clumps and drenching the affected and surrounding beds with mancozeb 0.3% checks the spread of the disease.

Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* is also a soil and seed borne disease that occurs during south west monsoon. Water soaked spots appear at the collar region of the pseudo stem and progresses upwards and downwards. The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spread upwards. Yellowing starts from the lowermost leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms. The vascular tissues of the affected pseudo stems show dark streaks. The affected pseudo stem and rhizome when pressed gently extrudes milky ooze from the vascular strands. Ultimately rhizomes rot.

The cultural practices adopted for managing soft rot are also to be adopted for bacterial wilt. Seed rhizomes must be taken from disease free fields for planting. The seed rhizomes may be treated with Streptocycline 200 ppm for 30 minutes and shade dried before planting. Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture 1% or copper oxychloride 0.2%.

Leaf spot

Leaf spot is caused by *Phyllosticta zingiberi* and the disease is noticed on the leaves from July to October. The disease starts as a water soaked spot and later turns as a white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through rain splashes during intermittent showers. The incidence of the disease is severe in ginger grown under exposed conditions. The disease can be controlled by regular spraying of Bordeaux mixture 1% or mancozeb 0.2%.

Nematode pests

Root knot (*Meloidogyne* spp.), burrowing (*Radopholus similis*) and lesion (*Pratylenchus* spp.) nematodes are important nematode pests of ginger. Stunting, chlorosis, poor tillering and necrosis of leaves are the common aerial symptoms.

Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water soaked areas in the outer tissues. Nematode infestation aggravates rhizome rot disease. The nematodes can be controlled by treating infested rhizomes with hot water (50°C) for 10 minutes, using nematode free seed rhizomes and solarizing ginger beds for 40 days. In areas were root knot nematode population is high, the resistant variety IISRMahima may be cultivated. *Pochonia chlamydosporia*, a nematode biocontrol agent can be incorporated in ginger beds (20 g/bed) at the time of sowing. **Insect pests**

Shoot borer: The shoot borer (*Conogethes punctiferalis*) is the most serious pest of ginger. The larvae bore into pseudostems and feed on internal tissues resulting in yellowing and drying of leaves of infested pseudostems. The presence of a bore-hole on the pseudo stem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully grown larvae are light brown with sparse hairs. The pest population is higher in the field during September-October. The shoot borer can be managed by spraying Malathion (0.1%) at 21 day intervals during July to October. The spraying is to be initiated when the first symptom of pest attack is seen on the top most leaves on the pseudostem. An integrated strategy involving pruning and destroying freshly infested pseudostems during July- August (at fortnightly intervals) and spraying Malathion (0.1%) during September-October (at monthly intervals) is also effective against the pest.

Rhizome scale: The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages) and in storage. Adult (female) scales are circular (about 1 mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shriveled and desiccated affecting its germination. The pest can be managed by treating the seed material with quinalphos (0.075%) (For 20-30 minutes) before storage and also before sowing in case the infestation persists. Severely infested rhizomes are to be discarded before storage.

Minor pests: Larvae of leaf roller (*Udaspes folus*) cut and fold leaves and feed from within. The adults are medium sized butterflies with brownish black wings with white spots; the larvae are dark green. A spray with carbaryl (0.1%) or dimethoate (0.05%) may be undertaken when the infestation is severe. Root grubs occasionally feed on tender rhizomes, roots and base of pseudostems causing yellowing and wilting of shoots. The pest can be controlled by drenching the soil with chloropyriphos (0.075%).

Harvesting and curing: The crop is ready for harvest in about 8 months after planting when the leaves turn yellow, and start drying up gradually. The clumps are lifted carefully with a spade or digging fork, and the rhizomes are separated from the dried up leaves, roots and adhering soil. For preparing vegetable ginger, harvesting is done from sixth month onwards. The rhizomes are thoroughly washed in water and sun-dried for a day. For preparing dry ginger, the produce (harvested after 8 months) is soaked in water for 6-7 hours. The rhizomes are then rubbed well to clean the extraneous matter.

After cleaning, the rhizomes are removed from water and the outer skin is removed with bamboo splinters having pointed ends. Deep scraping may be avoided to prevent damage of oil cells which are just below the outer skin. The peeled rhizomes are washed and dried in sun uniformly for 1 week. The dry rhizomes are rubbed together to get rid of the last bit of skin or dirt.

The yield of dry ginger is 19-25% of fresh ginger depending on the variety and location where the crop is grown. Fresh ginger (with relatively low fibre) harvested at 170-180 days after planting can be used for preparing salted ginger. Tender rhizomes with a portion of the pseudostem may be washed thoroughly and soaked in 30% salt solution containing 1% citric acid. After 14 days it is ready for use and can be stored under refrigeration.

Storage of seed rhizomes

In order to obtain good germination, the seed rhizomes are to be stored properly in pits under shade. For seed material, bold and healthy rhizomes from disease free plants are selected immediately after harvest. For this purpose, healthy and disease free clumps are marked in the field when the crop is 6-8 months old and still green. The seed rhizomes are treated with a solution containing quinalphos 0.075% and mancozeb 0.3% for 30 minutes and dried under shade. The seed rhizomes are stored in pits of convenient size in sheds. The walls of the pits may be coated with cow dung paste. The seed rhizomes are placed in pits in layers along with well dried sand/saw dust (put one layer of seed rhizomes, then put 2 cm thick layer of sand/saw dust). Sufficient gap is to be left at the top of the pits for adequate aeration. The pits can be covered with wooden planks with one or two small openings for aeration. The seed rhizomes in the pits may be checked once in about 21 days by removing the plank and shriveled and disease affected rhizome are to be removed. The seed rhizomes can also be stored in pits dug in the ground under shade. Storage in saw dust + dried leaves of *Strychnos nuxvomica* also prevents infestation of rhizome scale.

Production in India: India is a leading producer of ginger in the world and during 2006-07 the country produced 3.70 lakh tonnes of the spice from an area of 1.06 lakh hectares. Ginger is cultivated in most of the states in India. However, states namely Kerala, Meghalaya, Arunachal Pradesh, Mizoram, Sikkim, Nagaland and Orissa together contribute 70 per cent to the country's total production. The export of Ginger from India during 2008-09 has been 5000 MT valued ` 34.83 crores as against 6700 MT valued ` 28.00 crores in 2007-08. Ginger is mainly xported in Fresh, Dry and Powder forms. Fresh ginger export, which accounts for more than 50% in volume, is from the North Eastern states and the major destination is Bangladesh. The short supply of dry ginger in the domestic market has pushed up the prices to more than 100 per kg in 2008-09 as against Rs.50 per kg in 2007-08. During 2008-09, the major buyers of Indian dry ginger are UK (480 MT), Saudi Arabia (415 MT), Spain (305 MT) and Morocco (240 MT).

Country	Production (tonnes)	Country	Production (T)	Nepal	158,905
India	420,000	Bangladesh	57,000	Nigeria	138,000
China	285,000	Japan	42,000	Philippines	28,000
Indonesia	177,000	Thailand	34,000	Sri Lanka	8,270
					World Total 1,387,445

TURMERIC

Common N.	Eng: Turmeric; San: Haridra, Varavarnini; Hin: Haldi, halda; Ben: Haldi; Mal: Manjal, Pachamanjal, Varattumanjal; Tam: Mancal; Kan: Haldi, Arasina; Tel: Pasapu
Botanical N.	***Curcuma longa* Linn. *C. domestica* Valeton.**
Family	Zingiberaceae

Action Anti-inflammatory, cholagogue, hepatoprotective, blood-purifier, antioxidant, detoxifier and regenerator of liver tissue, antiasthmatic, anti-tumour, anticutaneous, antiprotozoal, stomachic, carminative. Reduces high plasma cholesterol. Antiplatelet activity offers protection to heart and vessels. Also protects against DNA damage in lymphocytes.

The rhizomes gave curcuminoids, the mixture known as curcumin; volatile oil (3-5 %), containing about 60 % of turmerones which are sesquiterpene ketones, and bitter principles, sugars, starch, resin. Curcumin related phenolics possess antioxidant, anti-inflammatory, gastroprotective and hepatoprotective activities. The antioxidant activity of curcumin is comparable to standard antioxidants

Climate and soil

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above sea level, at a temperature range of 20-35° C with an annual rainfall of 1500 mm or more, under rainfed or irrigated conditions. **Varieties**

A number of cultivars are available in the country and are known mostly by the name of locality where they are cultivated. Some of the popular cultivars are Duggirala, Tekurpeta, Sugandham, Amalapuram, Erode local, Alleppey, Moovattupuzha, and Lakadong. **Cultivation**

Preparation of land

The land is prepared with the receipt of early monsoon showers. The soil is brought to a fine tilth by giving about four deep ploughings. Hydrated lime @ 500 kg/ha has to be applied for laterite soils (*A red soil produced by rock decay; contains insoluble deposits of ferric and aluminium oxides*) and thoroughly ploughed. Immediately with the receipt of pre-monsoon showers, beds of 1.0 m width, 15 cm height and of convenient length are prepared with spacing of 50 cm between beds. Planting is also done by forming ridges and furrows.

Planting

In Kerala and other West Coast areas where the rainfall begins early, the crop can be planted during April-May with the receipt of pre-monsoon showers.

Characteristics of improved turmeric varieties

Variety	Mean yield fresh (t/ha)	Crop duration (days)	Dry recovery (%)	Curcumin (%)	Oleoresin (%)	Essential oil (%)

Suvarna	17.4	200	20.0	4.3	13.5	7.0
Suguna	29.3	190	12.0	7.3	13.5	6.0
Sudarsana	28.8	190	12.0	5.3	15.0	7.0
IISR Prabha	37.5	195	19.5	6.5	15.0	6.5
IISR Prathibha	39.1	188	18.5	6.2	16.2	6.2
Co-1	30.0	285	19.5	3.2	6.7	3.2
BSR-1	30.7	285	20.5	4.2	4.0	3.7
Krishna	9.2	240	16.4	2.8	3.8	2.0
Sugandham	15.0	210	23.3	3.1	11.0	2.7
Roma	20.7	250	31.0	9.3	13.2	4.2
Suroma	20.0	255	26.0	9.3	13.1	4.4
Ranga	29.0	250	24.8	6.3	13.5	4.4
Rasmi	31.3	240	23.0	6.4	13.4	4.4
Rajendra Sonia	42.0	225	18.0	8.4	-	5.0
Supreme	35.4	210	19.3	6.0	16.0	4.0
IISR Kedaram	34.5	210	18.9	5.5	13.6	3.0

Seed material

Whole or split mother and finger rhizomes are used for planting and well developed healthy and disease free rhizomes are to be selected. Small pits are made with a hand hoe on the beds with a spacing of 25 cm x 30 cm. Pits are filled with well decomposed cattle manure or compost, seed rhizomes are placed over it then covered with soil. The optimum spacing in furrows and ridges is 4560 cm between the rows and 25 cm between the plants. A seed rate of 2,500 kg of rhizomes is required for planting one hectare of turmeric.

Manuring and fertilizer application

Farmyard manure (FYM) or compost @ 30-40 t/ha is applied by broadcasting and ploughed at the time of preparation of land or as basal dressing by spreading over the beds or in to the pits at the time of planting. Fertilizers @ 60 kg N, 50 kg P2O5 and 120 kg K2O per hectare are to be applied in split doses as given in Table 2. Zinc @ 5 kg/ha may also be applied at the time of planting and organic manures like oil cakes can also be applied @ 2 t/ha. In such case, the dosage of FYM can be reduced. Integrated application of coir compost (@ 2.5 t/ha) combined with FYM, biofertilizer (*Azospirillum*) and half recommended dose of NPK is also recommended.

Fertilizer schedule for turmeric (per ha)

Schedule	**N**	**P_2O_5**	**K_2O**	**Compost/cowdung**
Basal application	-	50 kg	-	30-40 tonnes
After 45 days	30 kg	-		-
After 90 days	30 kg	-	60 kg	-

Mulching

The crop is to be mulched immediately after planting with green leaves @ 12-15 t/ha. Mulching may be repeated @ 7.5 t/ha at 45 and 90 days after planting after weeding, application of fertilizers and earthing up.

Weeding and irrigation

Weeding has to be done thrice at 60, 90 and 120 days after planting depending upon weed intensity. In the case of irrigated crop, depending upon the weather and soil conditions, about 15 to 23 irrigations are to be given in clayey soils and 40 irrigations in sandy loams.

Mixed cropping

Turmeric can be grown as an intercrop in coconut and arecanut plantations. It can also be raised as a mixed crop with chillies, colocasia, onion, brinjal and cereals like maize, ragi, etc. **Plant protection**

Diseases

Leaf blotch

Leaf blotch is caused by *Taphrina maculans* and appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown. The leaves also turn yellow. In severe cases the plants present a scorched appearance and the rhizome yield is reduced. The disease can be controlled by spraying mancozeb 0.2%.

Leaf spot

Leaf spot is caused by *Colletotrichum capsici* and appears as brown spots of various sizes on the upper surface of the young leaves. The spots are irregular in shape and white or grey in the centre. Later, two or more spots may coalesce and form an irregular patch covering almost the whole leaf. The affected leaves eventually dry up. The rhizomes do not develop well. The disease can be controlled by spraying zineb 0.3% or Bordeaux mixture 1%.

Rhizome rot

The disease is caused by *Pythium graminicolum* or *P. aphanidermatum*. The collar region of the pseudostem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes. Treating the seed rhizomes with mancozeb 0.3% for 30 minutes prior to storage and at the time of sowing prevents the disease. When the disease is noticed in the field, the beds should be drenched with mancozeb 0.3%.

Nematode pests

Root knot nematodes (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis*) are the two important nematodes causing damage to turmeric. Root lesion nematodes (*Pratylenchus* spp.) are of common occurrence in Andhra Pradesh. Wherever nematode problems are common, use only healthy, nematodefree planting material. Increasing the organic content of the soil also checks the multiplication of nematodes. *Pochonia chlamydosporia* can be applied to the beds at the time of sowing @ 20 g/bed (at 106 cfu/g) for management of nematode problems. **Insect pests**

Shoot borer

The shoot borer (*Conogethes punctiferalis*) is the most serious pest of turmeric. The larvae bore into pseudostems and feed on internal tissues. The presence of a bore-hole on the pseudostem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs. Spraying Malathion (0.1%) at 21 day intervals during July to October is effective in controlling the pest infestation. The spraying has to be initiated when the first symptom of pest attack is seen on the inner most leaf.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages of the crop) and in storage. Adult (female) scales are circular (about 1mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shrivelled and desiccated affecting its germination. Treat seed material with quinalphos (0.075%) (For 20-30 minutes) before storage and also before sowing in case the infestation persists. Discard and do not store severely infested rhizomes.

Harvesting

Depending upon the variety, the crop becomes ready for harvest in 7-9 months after planting during January-March. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties after 9 months. The land is ploughed and the rhizomes are gathered by hand picking or the clumps are carefully lifted with a spade. The harvested rhizomes are cleared of mud and other extraneous matter adhering to them.

Processing

Curing

Fresh turmeric is cured for obtaining dry turmeric. The fingers are separated from mother rhizomes. Mother rhizomes are usually kept as seed material. Curing involves boiling of fresh rhizomes in water and drying in the sun. In the traditional method of curing, the cleaned rhizomes are boiled in water just enough to immerse them. Boiling is stopped when froth comes out and white fumes appear giving out a typical odour. The boiling should last for 45-60 minutes when the rhizomes turn soft. The stage at which boiling is stopped largely influences the colour and aroma of the final product. Over cooking spoils the colour of the final product while under-cooking renders the dried product brittle. In the improved scientific method of curing, the cleaned fingers (approximately 50 kg) are taken in a perforated trough of 0.9 m x 0.5 m x 0.4 m size made of GI or MS sheet with extended parallel handle. The perforated trough containing the fingers is then immersed in a pan; 100 litres of water is poured into the trough so as to immerse the turmeric fingers. The whole mass is boiled till the fingers become soft. The cooked fingers are taken out of the pan by lifting the trough and draining the water into the pan. The water used for boiling turmeric rhizomes can be used for curing fresh samples. The processing of turmeric is to be done 2 or 3 days after harvesting. If there is delay in processing, the rhizomes should be stored under shade or covered with sawdust or coir dust.

Drying

The cooked fingers are dried in the sun by spreading them in 5-7 cm thick layers on bamboo mats or drying floor. A thinner layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the rhizomes should be heaped or covered with material which provides aeration. It may take 10-15 days for the rhizomes to become completely dry.

Artificial drying, using cross-flow hot air at a maximum temperature of 60oC also gives a satisfactory product. In the case of sliced turmeric, artificial drying has clear advantages in giving a brighter coloured product than sun drying which tends to undergo surface bleaching. The yield of the dry product varies from 10-30% depending upon the variety and the location where the crop is grown.

Polishing

Dried turmeric has a poor appearance and a rough dull outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing. Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. The improved method is by using a hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh.

When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against the mesh as well as by mutual rubbing against each other as they roll inside the drum. Turmeric is also polished in power operated drums. The yield of polished turmeric from the raw material varies from 15-25%.

Colouring

The colour of the processed turmeric influences the price of produce. For an attractive product, turmeric powder (mixed with little water) may be sprinkled during the last phase of polishing.

Preservation of seed rhizomes

Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of *Strychnos nuxvomica* (kanjiram). The pits are to be covered with wooden planks with one or two openings for aeration. The rhizomes are to be dipped in quinalphos (0.075%) solution for 15 minutes if scale infestations are observed and in mancozeb (0.3%) to avoid storage losses due to fungi.

Production and Trade

India is a leading producer and exporter of turmeric in the world. Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra, Assam are some of the important states cultivates turmeric, of which, Andhra Pradesh alone occupies 35.0% of area and 47.0% of production. During 2006-2007, the country produced 8, 37,200 tons of turmeric from an area of 1, 86,000 ha.

HONEY PLANT

Common Name	English: Honey plant; Bishop's weed, Bullwort, Greater ammi, Laceflower)
Botanical Name	***Ammi majus* L.** *Apium ammi* Crantz, *Selinum ammoides* E.H.L. Krause
Family	Umbelliferae

Honey Plant originated in Egypt and grew in the Nile valley especially in Behira and ayoom. It is found distributed in the basin of Mediterranean sea in Syria and Palestine. It is also found in some regions of Iran and the mountains of Kohaz. It is found wildly in Abbottabad, Mianwali, Mahran, Lahore (Pakistan) and also in Europe, West Africa and Abyssinia.

Geographical Distribution

Fields of winter crops in the Nile Delta and Valley, also in the Oases and the Mediterranean region. Middle East, Europe and North Africa. In India it is cultivated on an experimental scale in the places like U.P., Gujarat and Tamil Nadu. In India with the courtesy of UNESCO in 1955, two species i.e. *Ammi majus* and *Ammi visnaga* were introduced in the Forest Research Institute, Dehradun (Uttarakhand).

Morphological Description

Glabrous annual plant with much branched stem, erect, ridged, 30-100 cm in height. Leaves are greenish-glaucous, triangular ovate or ovate-oblong with long petioles, basal leaves grow in rosette, umbels 8-50 rays with small white flowers with indented petals, involucres (highly conspicuous bract or bract pair or ring of bracts at the base of an inflorescence) with numerous pinnatified bracts very elongated towards the tip. Fruit is 105 mm, small, oblong, prominently ribbed, ovoid achenes of 1.5-2 mm, laterally compressed, forming 2 small sized mericarps surrounded by a disk shaped stylopod and 2 divergent curved styles, persisting carpophores (the lengthened receptacle to which the carpels are attached) on inflorescence after fruit fall.

Useful parts: Fruits and flowers.

Organoleptic properties

Odour: slightly aromatic, terebinthinate; taste: aromatic, strongly pungent, and slightly bitter

Traditional Medicinal Uses

• Anti asthmatic, Anti-hypoglycemic, Antispasmodic, Carminative, Digestive problems, Diuretic, Skin diseases (vitiligo and psoriasis)

Other uses of the plant: The plant is used as a preservative and against Snakebites.

Chemical constituents

Coumarins and coumarin glycosides. The fruit yields not less than 0.5% of ammoidin (xanthotoxin), 0.3% ammidin (imperatorin), and 0.01% of majudin (bergapten). Furanocumarins have also been produced by cell suspension cultures of *Ammi majus*.

Varieties: Two varieties are found i.e. Sutton's Monica and Horticulture.

Cultivation technology:

Soil: Moist, well-drained, fertile soil is best, but will grow on a variety of soils.

Propagation: The plant can either be raised by sowing seeds or by raising in a nursery and then transplanting it. About 1.5 – 2 Kg of seeds are needed for one hectare of land. The most favorable time for sowing of seed in North India is between third weeks of October to the first week of November. The seed sown later gives lower yield. After sowing the seed is covered with thin layer of soil. The germination of seed occurs after 10 –12 days of sowing. During sowing the spacing of 45 cm X 60 cm is recommended.

Plant protection: The disease is caused by *Aspergillus orchraceus* also some damage is caused by *A. niger*, *A. flavus* and *Fusarium oxysporum*. All these fungus are found to affect the xanthotoxin content and can be controlled by spraying proper fungicides. **Harvesting and processing:** Harvesting of a crop is extended for a longer duration due to continued maturation of fruiting umbels. When primary umbel matures and is not harvested soon, leads to the shedding of seeds. The shattering of seeds in this way in India is mainly responsible for the low yield. In case after primary umbels mature harvested was carefully done at an interval of two to four days, very good yield was achieved.

Therefore it is believed that timely maturity of primary umbel and secondary umbels are the major contributors towards the yield. This harvested crop is then stored for a couple of days and then, the seeds are thrashed. The collection of seeds in its green stage yields maximum amount of xanthotoxin. Seeds should be stored in polythene bags at room temperature. Yield: The average crop (seed) yield varies from 900 –1200 Kg per hectare. The timely harvest ensures at least 25% increase in the yield.

Scope for future development:

The development should be done to improve the varieties yielding high amount of seed and also the seed producing high percentage of xanthotoxin. There is need to protect the seed from attack of fungus during storage so that the xanthotoxin amount is not reduced.

BELLADONNA

Common Name	**BELLADONNA** Commonly known as belladonna or deadly nightshade

Botanical Name	***Atropa belladonna* Linn**
Family	**Solanaceae**

Native to Europe, North Africa, and Western Asia.

Habit

Atropa belladonna is a branching herbaceous perennial, often growing as a sub shrub, from a fleshy rootstock. Plants grow to 1.5 metres tall with 18 centimeters long ovate leaves. The bellshaped flowers are purple with green tinges and faintly scented. The fruits are berries, which are green ripening to a shiny black, and approximately 1 centimeter in diameter. The berries are sweet and are consumed by animals that disperse the seeds in their droppings, even though the seeds contain toxic alkaloids.

It is European species, presently grown on a small scale in Kashmir. The plant is a small perennial herb which grows up to 1.5 m in height. It branched freely and produces a large tapering root. With 18 centimeters long ovate leaves. The bell-shaped flowers are purple with green tinges and faintly scented. The fruits are berries, which are green ripening to a shiny black, and approximately 1 centimeter in diameter. The berries are sweet and are consumed by animals that disperse the seeds in their droppings, even though the seeds contain toxic alkaloids.

The leaves and roots of belladonna constitute the commercial drug which contains atropine, hyocyamine and hyocine, used in pharmacy for their mydriatic, analgesic and antispasmodic properties; the roots are used for external application only. The leaves and roots contain not less than 0.3 and 0.4 percent of the total alkaloids calculated as hyocyamine. *A. acuminata* Royel is a closely related Indian species, found at altitudes between 1800 and 3000 meters in the western Himalayas; its leaves and roots contain similar alkaloids. A part of belladonna alkaloids and their products used in India are imported.

Soil and Climate: The crop prefers a well-drained slightly acidic, silt loam to clayey-loam soil, rich in humus. It cannot withstand water-logged conditions. It is a crop of the temperate climate, prefers a sunny location and clear whether, particularly preceding and during the harvesting of the crop; continuous dampness or high humidity favours root-rot.

Agrotechnology

The crop shows a wide variation in growth and alkaloid content in its plants population. Seeds from selected plants with high alkaloid contents should be used for raising a plantation.

Propagation through seed is the easiest and least expensive method, through vegetative methods, such as shoot, root and root-shoot cuttings are also used. The seeds are very small, weighing about 700 per g. They should be treated with ethyl alcohol for 3 minutes or with petroleum either for 6 minutes for improving germination.

The treated seeds should be washed in running water for a few hours to remove the adhering chemicals. The seeds are sown in rows in the nursery during early spring. Germination takes place 10 to 21 days and is 15 to 40 per cent. The seedling bearing 1 to 3 leaves are planted in the field during August at 45 x 60 cm. or 60 x 60 cm. spacing. Ridge planting is preferred in localities receiving heavy monsoon rains.

The land is given about 40 tonnes of farm yard manure, besides 100 kg of diammonium phosphat and 30 g of K_2O per hectare before planting and 20 kg of N is given at the time of branching and each time the crop is picked.

The plantation is given to 2 to 3 weedings and hoeings before the first leaf crop is obtained and then I or 2 hoeings are usually given before each leaf picking.

The crop is irrigated after every 10 to 15 days during summer. The first picking of leaves is obtained in October; in subsequent years, 3 to 4 leaf crops are obtained for the next three years. Harvesting is done by cutting the plants 20 to 25 cm on bright sunny days above the ground, except at the time of the autumn harvest when the plants are cut 3 cm above the ground. The stumps put forth fresh growth during the succeeding spring and bear flowers during June -August and the berries are produced in October. The alkaloids are synthesized in the root and are translocated through the stem to the leaves.

Post harvest Care

The harvested crop is dried rapidly in the sun for 2-3 days and the leaf-stalks are detached only after the produce is dried. The plants are uprooted after three or four years; the thicker are sliced into 3-4 cm long pieces and dried. The crop loses 70-80 per cent of its weight during drying. A well dried leaf crop retains its green colour. The average crop yield in the first year is 300 kg of leaves and thereafter, 750 kg of leaves per hectare annually. An additional root crop of 2-3 quintals per hectare is obtained when the plants are finally uprooted. Higher average yields of 1 - 1.2 tonnes per hectare are reported from European countries. The produce should be stored in cool dry place away from light.

Pests and Disease

Cutworms (*Agrostis flammatra*) attack the tender growing seedling during yearly summer. The application of 5 percent Aldrin dust at 20-25 g per square meter of the nursery bed before sowing protects the crop. The beds may be drenched with 1:19 wettable solutions of chlordane, 2-3 times after every 10 days during the attack of the pace.

Sometimes **damping off** of seedlings is caused by *Pythium* sp. Chloropicrin is recommended as a fumigant.

Root-rot also damages the crop; the affected plants along with the adhering soil are removed and burnt. Seeds treated with the Agrosan generally protect the seedlings from soil-borne diseases.

CINCHONA

Common Name	**CINCHONA** San: Cinchona, Kunayanah Hin: Kunain Mal: Cinchona, Quoina Tam: Cinchona
Botanical Name	***Cinchona spp.***
Family	***Rubiaceae***

Importance

Cinchona, known as **Quinine, Peruvian** or **Crown bark tree** is famous for the antimalarial drug '***quinine***' obtained from the bark of the plant. The term cinchona is believed to be derived from the countess of Chinchon who was cured of malaria by treating with the bark of the plant in 1638. Cinchona bark has been valued as a febrifuge by the Indians of south and Central America for a long time. Over 35 alkaloids have been isolated from the plant; the most important among them being quinine, quinidine, cinchonine and cinchonidine. The cultivated bark contains 7-10 % total alkaloids of which about 70% is quinine. Similarly 60 % of the total alkaloids of root bark is quinine. Quinine is isolated from the total alkaloids of the bark as quinine sulphate. Commercial preparations contain cinchonidine and dihydroquinine. They are useful for the treatment of malarial fever, pneumonia, influenza, cold, whooping coughs, septicaemia, typhoid, amoebic dysentery, pin worms, lumbago, sciatica, bronchial neuritis and internal haemorrhoids. These are also used as anaesthetic and contraceptive. Besides, this alkaloids are used in insecticide compositions for the preservation of fur, feathers, wool, felts and textiles.

Distribution

Cinchona is native to tropical South America. It is grown in Bolivia, Peru, Costa Rica, Ecuador, Columbia, Indonesia, Tanzania, Kenya, Zaire and Sri Lanka. It was introduced in 1808 in Guatemala, 1860 in India, 1918 in Uganda, 1927 in Philippines and in 1942 in Costa Rica. Roy Markham introduced the plant to India. The first plantation was raised in Nilgiris and later on in Darjeeling of West Bengal.

Botany

The quinine plant belongs to the family Rubiaceae and genus *Cinchona* which comprises over 40 species. Among these a dozen are medicinally important. The commonly cultivated species are *C. calisaya* Wedd. *C. ledgeriana* Moens, *C. officinalis* Linn. *C. succirubra* Pav. ex Kl., *C. lancifolia* and *C. pubescens.* *C. officinalis* Linn. is most common in India.

It is an evergreen tree reaching a height of 10-15 m. Leaves are opposite, elliptical, ovate-lanceolate, entire and glabrous. Flowers are reddish-brown in compound cymes, terminal and axillary; calyx tubular, 5-toothed, obconical, sub tomentose, sub-campanulate, acute, triangular, dentate, hairy; corolla tube 5 lobed, densely silky with white depressed hairs, slightly pentagonal; stamens 5; style round, stigma submersed. Fruit is capsule ovoid-oblong; seeds elliptic, winged margin octraceous, crinulate-dentate.


Agrotechnology

Soil and climate: The plant widely grows in tropical regions having an average minimum temperature of 14° C. Mountain slopes in the humid tropical areas with well distributed annual rainfall of 1500-1950 mm are ideal fertile forest soils with pH 4.5-6.5 are best suited for its growth. It does not tolerate water logging.

Propagation: Cinchona is propagated through seeds and vegetative means. Most of the commercial plantations are raised by seeds. Vegetative techniques such as grafting, budding and softwood cuttings are employed in countries like India, Sri Lanka, Java and Guatemala. *Cinchona succirubra* is commonly used as root stock in the case of grafting and budding. Hormonal treatment induces better rooting. Seedlings are first raised in nursery under shade. Raised seedbeds of convenient size are prepared, well decomposed compost or manure is applied, seeds are broadcasted uniformly at $2g/m^2$, covered with a thin layer of sand and irrigated. Seeds germinate in 10-20 days.

Transplanting: Seedlings are transplanted into polythene bags after 3 months. These can be transplanted into the field after 1 year at 1-2m spacing. Trees are thinned after third year for extracting bark, leaving 50% of the trees at the end of the fifth year.

Insect pest and Disease: The crop is damaged by a number of fungal diseases like damping of caused by *Rhizoctoria solani*, tip blight by *Phytophthora parasatica*, collar rot by *Sclerotiun rolfsii,* root rot by *Phytophthora cinnamomi*, *Armillaria mellea* and *Pythium vexans*. Field sanitation, seed treatment with organo mercurial fungicide, burning of infected plant parts and spraying 1% Bordeaux mixture are recommended for the control of the diseases.

Harvesting and yield: Harvesting can be done in one or two phases. In one case, the complete tree is uprooted, after 8-10 years when the alkaloid yield is maximum. In another case, the tree is cut about 30

cm from the ground for bark after 6-7 years so that fresh sprouts come up from the stem to yield a second crop which is harvested with the underground roots after 6-7 years. Both the stem and root are cut into convenient pieces, bark is separated, dried in shade, graded, packed and traded. Bark yield is 9000-16000 kg/ha.

PYRETHRUM

[

Common Name	**Pyrethrum**
Botanical Name	***Chrysanthemum cinerariifolium*** (TREV.) VIS.
Family	**COMPOSITAE**

Pyrethrum is a perennial herb much valued for its pyrethrin content. It is used as an insecticide and accordingly, with the increasing emphasis on organic agriculture, the demand for it is rising. Sometimes, inferior grades, and flowers of other varieties are used to adulterate powdered pyrethrum. In view of its safety in use and its efficacy, pyrethrum preparations are employed in certain crops prior to harvesting, especially in fruits and vegetables which are mostly consumed fresh without cooking**.**

Origin and distribution

Pyrethrum is a native of Yugoslavia. The plant is found distributed in America, Europe, Africa and Asia**.**

Area and production

Pyrethrum is cultivated in **KENYA, JAPAN, BRAZIL, India** and in many other countries**.** Worldwide, the crop covers an area of 26,410 ha and the production of dried flowers is 12,455 tonnes**. IN India,** commercial cultivation started in Kashmir (J&K) and in the Nilgiris (TN) during World War II.

Composition

Pyrethrum flowers contain pyrethrosin, pyrethrol. The petroleum ether extract of flowers produces sitosterol, hentriacontane, nonacosane, B-amyrenol and ceryl alcohol containing un saponifiable matter. Besides, the aerial parts of the plants produce 7-glucosides and 7-glucuronides of apigenin, luteolin and quercetin. The flowers contain 0.07% essential oil. Various types of carotenoids have been identified in pyrethrum extract and residue. The dried flowers are commonly known as pyrethrum flowers or insect flowers. Powdered pyrethrum has a pleasant and characteristic odour. It is due to pyrethrins. About 90% of the pyrethrins are found in the ovary and developing achenes, which possess more oil glands than the rest of the flower. The fertilized achenes have more oil glands than the unfertilized ones. The distribution of pyrethrins in different parts of the plants is given in Table 1.

Distribution of pyrethrins in different parts of pyrethrum

Flower parts	Composition of flowers%	Pyrethrin %	% of total pyrethrin
Achenes	34.2	22.27	92.4
Receptacle	11.3	0.26	03.5
Involucral scale	11.5	0.16	02.0
Disc florets	25.8	Trace	-
Ray florets	17.2	Trace	-
Stems	-	0.15	-

Uses

Pyrethrum is a contact poison. It consists of dried flowers containing not less than 0.7 % of pyrethrins I and II. Pyrethrum is effective against a broad range of insects like flies, cockroaches, aphids, lice and mosquitoes. As an insecticide, it is used in the form of powder, sprays, aerosol, creams and ointment.

The flowers are powdered, mixed with some inert carriers and used as an insecticide. In this form, it is useful in controlling cockroaches, crickets, silverfish, ant, lice, storage pests and pests of refuse dumps. In the liquid form, it is useful in controlling pests in factories, hospitals, food processing industries and in food grain stores. Liquid sprays are also useful as livestock sprays for control of parasitic insects.

As aerosols which consist of fine droplets of pyrethrins which remain suspended in the air for long periods of time, pyrethrum is very effective in controlling flying insects like flies, mosquitoes and also for dis-infectation of passenger aircraft. Pyrethrum coils are prepared from finely ground powder, organic filler and a binder. It is considered to be the cheapest method to control mosquitoes in the humid tropics. Pyrethrum ointments and creams are used to control parasitic insects in animals. Pyrethrum has been used for the protection of dried fish and fishmeal against flies.

Botany

Pyrethrum is a tufted perennial herb that usually grows to a height of about 60 cm. The leaves are alternate, pinnate, 10-30 cm long, capitulate, three to four cm in diameter, borne slightly on long slender peduncles. The capitulum bears several yellow disc florets on a receptacle surrounded by cream coloured ray florets. Achenes are four mm long. The disc florets are perfect and fertile. The ray florets are pistillate and fertile.

Cultivars*:* Breeding attempts are underway towards the development of suitable cultivars. However, some strains like SL 71564, SLE 2, D-3-14, F-l-16, H-2-21, Nos. 326, 329, 387, and 395 have proved promising results.

Soil and climate

The plants thrive best in well-drained loamy soils. The soil should be neutral or slightly acidic in reaction. The pH of the soil should be 6.5-7.0. Nutrient rich and waterlogged soils are not suitable. In high altitude areas, where the soil remains continuously moist, pyrethrum can be grown as a rainfed crop. In acidic soil, adjusting pH to 6.6-7.5 by liming has been reported to increase the flower yield. The crop can be cultivated between 1500-2400 m altitudes. For maximum yield, the crop requires dormancy during winter. This is not possible in the tropics at altitudes less than 1830 m. High pyrethrin content in flowers has been reported in cool mountain valleys, where the mean temperature is low. High rainfall badly affects the growth of the plant. In Kashmir, the crop is cultivated in areas receiving an annual 'rainfall of 90 to 125 cm. In south India, pyrethrum is cultivated in areas receiving 150-170 cm rainfall.

Propagation

The crop is raised by seeds. About 40 kg seeds are required to raise plants sufficient for transplanting one hectare. In Kashmir, the seedlings are sown in nurseries during August to September. In other areas, the seedlings are sown in nurseries during November or early spring, when the plants are about 10-15 cm in height. In south India, the seeds are sown in March to April, in raised nursery beds. The germination is completed in about 15 to 20 days and the seedlings become ready for transplanting in about 75 to 90 days during rainy season.

Overnight soaking of seeds in 50 ppm gibberellic acid hastens germination. Suckers with desired characteristics may also be used for planting. Following earthing up practices, sucker production can be increased, which is required for large-scale production.

LAND PREPARATION AND PLANTING

The soil is worked up to a fine tilth before planting. In Kashmir, a spacing of 45 x 27 cm^2 is practised. At Kodaikanal, the spacing is maintained at 45 x 45 cm^2. The planting is undertaken during June/July. Under Kashmir conditions, planting is done during November.

IRRIGATION

The plants respond to irrigation. With regular irrigation, the plant produces four to five times more yield. It thrives best and gives better results when the crop is irrigated at weekly intervals. Due to continuous irrigation the plants flower earlier.

MANURES AND FERTILIZERS

In Kashmir, 60 kg each of phosphorus and potassium is given to the crop. Along with these, 100 kg nitrogen is given to the crop at the crown initiation stage. A dose of 45 kg urea, 480 kg rock phosphate and 30 kg muriate of potash per hectare is considered ideal for maximum yield under acidic soil conditions. Urea may be applied in two split doses; the first half dose at the time of planting and the rest after three months of planting. In phosphate-deficient soil, inoculating the plant with mycorrhiza has given beneficial results. Inoculation with *Glomus caledonius, G. fasciculatum* and *Gigaspora margarita* results in increased plant height, plant weight, number of branches and root length.

WEEDING

Weeds greatly affect the yield of flowers. The pre-emergence spraying of Tok-E 25 at 4.0 L/ha, along with hand weeding at 45 days after chemical spray has been found to be beneficial in getting higher yields.

MANAGEMENT OF DISEASES AND PESTS

ROOT ROT (Fusarium solani)—This disease is mostly noticed during June/July. Symptoms of the disease are yellowing of leaves, stunted growth and reduced tillering of the plants. Black colouration is observed on the infected roots and shoots. Partially rotted tillers produce only small buds, which fail to open. The disease can be controlled by raising the seedlings in healthy soil and drenching the nursery bed with 0.2-03% carbendazim or thiram.

Wilt *(Phytophthora cambivora* and *Rhizoctonia solani)*—Due to the disease, yellowing and browning of leaves are noticed. It is followed by progressive drying of leaves and shoots. Wilting may cause rotting of the root or the base of the stem of young plants. Vascular tissues may be brown and discoloured. The disease can be controlled similar to root rot.

Rust *(Puccinia chrysanthemi)* — The symptoms of the disease are a blister like swelling over the surface of the leaves. The blister later on breaks open and discharges masses of brown powder. Severely infected plants become very weak and fail to bloom properly. The field should be sprayed with Dithane Z-78 @ 0.2% to control the disease.

Leaf spot *(Septoria chrysanthemella)* — The symptoms of the disease first appear on the lower leaves. Initially the leaves turn yellow; later on they become dark brown and black. In cases of severe infection, there may be premature withering of the leaves. It can be controlled by spraying of 0.2% Zineb or Dithane M-45.

Powdery mildew *(Oidium chrysanthemi)* — The disease is characterized by the appearance of white powdery masses on the aerial portion of the plant. In case of severe infections, the foliage turn brown and dried. For its control, spraying with 0.5% Karathane is useful.

PESTS

APHIDS

Myzus persicae, Macrosiphoniella sanborni, Brachicaudus helichrysi, Aphis gossypii and *Aphis fabae* are the aphids which attack the chrysanthemum. The pests damage the plants by sucking the sap from the growing portion of the stem and also from the under surface of the leaves. The affected plants lose their vigour.

The pest excretes honeydew, which provides a congenial condition for the growth of the fungus. The aphids also act as a vector for viral diseases. The spray of spores of the fungus *Verticillium lecanii* is helpful in controlling the pest. Spraying the field with 0.1% Metasystox is effective in keeping the pest under check.

THRIPS

Thrips tabaci, T. nigrophllosus and *Frankliniella tritici* commonly feed on the chrysanthemum. They suck the sap from the leaves; as a result, the leaves are mottled and distorted. The leaves turn silvery due to the separation of the upper epidermal tissue from the leaves. The foliage appears as if dried due to the scorching sun. The insect pupates in the soil and hence drenching the soil with Diazinon 0.4% is helpful in controlling the pest. Spraying of 0.15% Metasystox is also effective in controlling the pest.

HAIRY CATERPILLAR *(*Diacrisia obliqua*)*

The attack of the pest is noticed during the rains or in autumn, till the commencement of winter. The pest is gregarious in nature and feeds heavily on the leaves. It eats away the entire upper surface of the leaves, leaving a papery skeleton. The foliage later on dries up. During early stages, the insects can be collected and destroyed. Spraying Thiodon 35 EC @ 1.25 ml/1 is recommended to control the pest.

HARVESTING AND YIELD

Mature flowers have highest pyrethrin quantity. The flowers are best harvested when three fourths of the disc florets are open. Delay in picking affects pyrethrin content. It has been observed that the yield and quality of the flowers improve if picking is done at an interval of 7 to 14 days. Harvesting should be avoided during early morning or rains, as the moisture present in the flowers proves harmful while drying. After harvesting, the plants may be left as such or should be cut at 15 to 20 cm height from ground level for initiating fresh growth in the next season.

The yield of the flowers varies depending upon soil, climatic conditions and management practices. A one hectare crop produces about three to five quintals of dry ***flowers***. Under Kashmir conditions, higher yield is expected when some cultivars flower twice or thrice in the season. At Kodaikanal, more yield of pyrethrins has been recorded in the third and fourth year of the crop. Of course, a well-maintained plantation remains productive for four to five years.

Processing

The harvested flowers are dried under the sun and partly under shade by spreading in two layers. Shade drying is preferred to sun drying. Heaping of the fresh flowers should be avoided as it leads to fermentation. The fresh flowers should be spread thinly on the wire trays at a density of 3.66 Kg/m.^{2}

The flowers are dried using a mechanical drier, where the flowers are spread on trays and dried by hot air heated by passing over hot flues. The drying is completed in six to eight hours. During drying, the moisture content of the produce drops down from 75-83% to 8-10%. Drying under controlled conditions helps maintain the original content of pyrethrin, whereas exposing the material to air or sunlight reduces its activity due to oxidation. Pyrethrin loses its activity with the advancement of storage period. After 24 months storage, about 45% loss in insecticidal activity of dried flowers and somewhat less in powder form has been noted.

Constraints

Though, pyrethrum is a much-valued plant for its insecticidal attributes, the crop is not yet as popular in commercial cultivation as it ought to be. Breeding and improvement aspects of the crop are largely neglected and commercial cultivars with broad adaptability are still lacking.

Varieties with greater tolerance to poor climatic conditions and improved diseases/pest resistance are in demand. Quality parameters of the crop call for improvement. In view of the rising demand of organic produce, boosting pyrethrum cultivation and improving the crop to suit the need of farmers and the market is important.

GREEN CHIRETTA

Common Name	*GREEN CHIRETTA* San: Bhunimbah, Kiratatiktah Hin: Kalamegh, Kalpanath Ben: Kalmegh Mal: Nilaveppu, Kiriyattu Tam: Nilavempu Kan: Kreata
Botanical Name	*Andrographis paniculata*
Family	*Acanthaceae*

Importance

Kalmegh, the Great or **Green Chiretta** is a branched annual herb. 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, haemorrhoids and vitiated conditions of *pitta.* It is used to overcome *sannipata* type of fever, difficulty in breathing, hemopathy due to the morbidity of *kapha* and *pitta*, burning sensation, cough, oedema, thirst, skin diseases, fever, ulcer and worms. It is also useful in acidity and liver complaints. The important preparations using the drug are *Tiktakagheta, Gorocandi gulika, Candanasava, Panchatiktam kasaya*, etc. A preparation called "*Alui*" is prepared by mixing powdered cumin (*Cuminium cyminum*) and large cardamom (*Amomum subulatum*) in the juice of this plant and administered for the treatment of malaria. It is also a rich source of minerals.

Distribution

The plant is distributed throughout the tropics. It is found in the plains of India from U.P to Assam, M.P., A.P, Tamil Nadu and Kerala, also cultivated in gardens.

Botany

Andrographis paniculata (Burm.f.) Wall ex. Nees belongs to the family *Acanthaceae*. It is an erect branched annual herb, 0.3-0.9m in height with quadrangular branches. Leaves are simple, lanceolate, acute at both ends, glabrous, with 4-6 pairs of main nerves. Flowers are small, pale but blotched and spotted with brown and purple distant in lax spreading axillary and terminal racemes or panicles. Calyx-lobes are glandular pubescent with anthers bearded at the base. Fruits are linear capsules and acute at both ends. Seeds are numerous, yellowish brown and sub-quadrate. Another species of Andrographis is *A. echioides* (Linn.) Nees. It is found in the warmer parts of India. The plant is a febrifuge and diuretic. It contains flavone-echiodinin and its glucoside-echioidin.

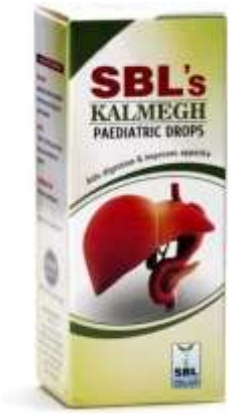
Agrotechnology

The best season of planting Andrographis is May-June. The field is to be ploughed well, mixed with compost or dried cowdung and seedbeds of length 3m, breadth 1/2m and 15cm height are to be taken at a distance of 3m. The plant is seed propagated. Seeds are to be soaked in water for 6 hours before sowing. Sowing is to be done at a spacing of 20cm. Seeds may germinate within 15-20 days. Two weedings, first at one month after planting and the second at 2 month after planting are to be carried out. Irrigation during summer months is beneficial. The plant is not attacked by any serious pests or diseases. Flowering commences from third month onwards. At this stage, plant are to be collected, tied into small bundles and sun-dried for 4-5 days. Whole plant is the economic part and the yield is about 1.25t dried plants/ha.

Properties and Activity

Leaves contain two bitter substances lactone "andrographolid" and "kalmeghin". The ash contains sodium chloride and potassium salts. Plant is very rich in chlorophyte. Kalmeghin is the active principle that contains 0.6% alkaloid of the crude plant. The plant contains diterpenoids, andrographolide, 14-deoxy-11-oxo-andrographolide, 14-deoxy-11, 12-dihydroandrographolide, 14deoxy andrographolide and neoandrographolide. The roots give flavones-apigenin-7, 4-dio-O-methyl ether, 5-hydroxy-7, 8, 2', 3'-tetramethoxyflavone, andrographin and panicolin -sitosterol. Leaves contain homoandrographolide, andrographosterol and andrographone.

The plant is vulnerary, antipyretic, antiperiodic, anti-inflammatory, expectorant, depurative, sudorific, anthelmintic, digestive, stomachic, tonic, febrifuge and cholagogue. The plant is antifungal, antityphoid, hepatoprotective, antidiabetic and cholinergic. Shoot is antibacterial and leaf is hypotensive (Garcia *et al*, 1980). This is used for the inflammation of the respiratory tract. Apigenin7, 4'-O-dimethyl ether isolated from *A. paniculata* exhibits dose dependent, antiulcer activity in shay rat, histamine induced ulcer in guinea pigs and aspirin induced ulcers in rats. A crude substance isolated from methanolic extract of leaves has shown hypotensive activity. Pre-treatment of rats with leaf (500mg/kg) or andrographolide (5mg/kg) orally prevented the carbon tetrachloride induced increase of blood serum levels of glutamate-oxaloacetate transaminase in liver and prevented hepatocellular membrane.



KAPIKACHU

Common Name	Kapikachu or Cowhage
Botanical Name	*Mucuna pruriens*
Family	Leguminosae (Fabaceae)

Mucuna pruriens Bak. Leguminosae (Fabaceae), is one of the popular medicinals of India and is constituent of more than 200 indigenous drug formulations. It is widespread over most of the subcontinent and is found in bushes and hedges and dry-deciduous, low forests throughout the plains of India. All parts of *Mucuna* posses valuable medicinal properties and there is a heavy demand of *Mucuna* in Indian drug markets. After the discovery that *Mucuna* seeds contain L-dopa, an antiparkinson's disease drug, its demand in international market has increased many fold and demand has motivated Indian farmers to start commercial cultivation.

Botany

Mucuna is an annual twinning plant. Leaves are trifoliate, gray-silky beneath; petioles are long and silky, 6.3– 11.3 cm. Leaflets are membranous, terminal leaflets are smaller, lateral very unequal sided. Dark purple flowers (6 to 30) occur in drooping racemes. Fruits are curved, 4–6 seeded. The longitudinally ribbed pod, is densely covered with persistent pale-brown or grey trichomes that cause irritating blisters. Seeds are black ovoid and 12 mm long.

Uses

Roots, according to the *Ayurveda*, are bitter, thermogenic, anthelmintic,

diuretic, emollient, stimulant, aphrodisiac, purgative, febrifuge, and tonic. It is considered useful to relieve constipation, nephropathy, strangury, dysmenorrhoea, amenorrhoea, elephantiasis, dropsy, neuropathy, consumption, ulcers, helminthiasis, fever, and delirum.

Leaves are popular potherbs and are used as a fodder crop. Leaves are useful in ulcers, inflammation, cephalagia and general debility.

The trichomes of pods contain mucunain and serotonin and as a result pod causes itching, blisters, and dermatitis. Pods are also used as vegetable. Pod hairs (trichomes) are used as anthelmintic. Hairs mixed with honey have been used as vermifuge. As ointment prepared with hairs act as a local stimulant and mild vesicant. Beside medicinal properties, *Mucuna* fixes nitrogen and is as green manure and covercrop. Seeds contain L-DoPA (4-3, 4-dihydroxy phenylalanine), glutathione, lecithin, gallic acid, glycosides, nicotine, prurenine, prurenidine, dark brown viscous oil. It is a source of minerals. According to*Ayurveda*, seeds are astringent, laxative, anthelmintic, aphrodisiac, alexipharmic and tonic.

Cultivation: *Mucuna* is a popular kharif crop in India. Seeds are sown at rate of 50 kg/ha between 15 June to 15th July with plant spacing of 60 × 60 cm of sowing may result in infestation of aphids (*Aphis craccivora*).

Although, no named cultivar of *Mucuna* is available, locally available seeds possess good viability and higher germination. Plant support increases yield 25% and reduces pest infestation. Normally flowering begins 45–50 days after sowing. Yields of 5000 kg/ha have been recorded from well managed irrigated crop having supports.

SONAMUKHI

Common Name	Indian or Tennevelly Senna or Sonamukhi
Botanical Name	*Cassia angustifolia*
Family	Cesalpinaceae

Origin and Distribution: It is indigenous to dry areas Somalila and South Arabia. Now it is cultivated in South India in Tinnevelly, Madurai and Trichonopoly districts of Tamilnadu. Recently, it has been introduced in Mysore and Banglore (Karnataka), Anand (Gujrat), Jodhpur (Rajasthan). **Plant Description:** A small perennial shrub with ascending branches. The leaves are large, compound and pinnate. Full-grown leaflets are bluish green to pale green in colour. Flowers are bright yellow in colour. Flowering in April-June.

Types: Tinnavelly senna (*C. angustifolia*) and Alexanderian seena (*C. acutifolia*)

Uses: Senna pods and leaves are valued in medicine for laxatives and its cathartic properties. Flower contains chrysophanic acid. Fruit contain oxymethyl anthraquinone to the extent of 1.33%. It is especially useful in habitual constipation. It increases the peristaltic movements of the colon. Laxative principle of seena is two glycosides viz. sennosides C and D. The pods have the same therapeutic effect as the leaves, but they cause less gripping. The senna is contradicted in spastic constipation in cases of colitis.

Soil and Climate: The plant requires bright sunshine and occasional drizzling. It is cultivated usually in dry land. It prefers a clayey light porous soil and sensitive to water logging condition.

Cultivation Techniques:

Propagation: It is cultivated usually in dry land in south India. It is sometimes grown on rice land immediately after the rice crop is harvested. Sowing of seed is either by broadcasting or by dribbling, the seed rate being about 20 kg per ha. The seeds have a tough seed coat and a certain amount of abrading of the surface is necessary to induce even and quick germination. This is secured by pounding the seeds lightly with coarse sand in a mortar. Seed sown in line is 30 cm apart.

Manures and Fertilisers- FYM @ 5-10 tonnes per ha. is applied at the time of sowing. NPK is applied @100/50/30 kg per ha. Nitrogen is top dressed after 90 days after sowing.

Irrigation: Heavy irrigation is injurious the plant. It may be given light irrigation and grown as a semi-irrigated crop. Continuous rain during growth spoils the quantity of the leaves.

Harvesting: The plants are usually allowed to grow for 3-5 months only and the first flush of flower stalks is cut off to induce lateral branching. When the leaves are fully grown and are thick and bluish in colour, they are stripped of by hand. A second stripping is made after about a month and the plant allowed to bear flowers to set seed.

CASSIA ANGUSTIFOLIA (SEENA PODS)

Drying and Storage: The leaves are spread out under shade on a hard floor in an even layer without overlapping to dry. The layer is frequently stirred to ensure even drying. After 7 days, when the leaves are sufficiently dry and become yellowish-green in colour, they are graded and packed in gunny bags. **Yield:** A dry land (unirrigated) crop of Senna yields 10 quintols per ha. Leaves and 4 quintols of pods. The yield from a wetland (irrigated) crop is 15 quintols leaf and 7 quintols of pods per ha.

Plant Protection: Catterpillar (Carbaryl, 4gm/lit), pod borer (Endosulphan 0.05%), leaf spot disease (0.15% Diethane M-450, Damping off (Thiram or Captan 2.5 g per Kg).

DATURA

Common Name	Datura San: Dhustura Hin.: Kaladhatura Ben: Dhatura Mal: Ummam Kan; Dattura Tam: Vellummattai Tel: Tellavummetta
Botanical Name	*Datura metel*
Family	Solanaceae

Importance

Downy datura or thorn apple is an erect branched under shrub who's intoxicating and narcotic properties have been made use of by man from ancient time. The plant and fruit are spasmolytic, anticancerous and anthelmintic. Leaves and seeds are inhaled in whooping cough, asthma and other respiratory diseases. Root, leaf and seed are febrifuge, antidiarrhoeal, anticatarrhal and are used in insanity, cerebral complications and skin diseases. Leaf is antitumour, antirheumatic and vermicide. Flower is antiasthamatic, anaesthetic and is employed in swellings and eruptions on face. Fruit juice is used in earache and seed decoction in ophthalmia. For the rheumatic swellings of joints, lumbago, sciatica and neuralgia, warm leaf smeared with an oil is used as a bandage or sometimes the leaf is made into a poultice and applied. The root boiled with milk is used in insanity. It is also an ingredient in the ayurvedic preparation *Kanakasva* used in bronchial troubles, and the *Unani* formulations "*Roghan dhatura*" used as a massage oil for the paralysed part. The alkaloids of pharmaceutical interest present in the plant are **hyoscyamine, hyoscine** and **meteloidine**.

Datura is the chief commercial source of hyoscine available from natural source. Hyoscine, in the form of hyoscine hydrobromide, is used as a pre-anaesthetic in surgery, child birth, ophthalmology and prevention of motion sickness. It is also employed in the relief of withdrawal symptoms in morphine and alcoholic addiction, paralysis agitans, postencephaletic parkinsonianism and to allay sexual excitement. Hyoscyamine and its salt hyoscyamine sulphate and hyoscyamine hydrobromide are used in delerium, tremour, menia and parkinsonianism.

Distribution

Datura is distributed throughout the world, particularly the warmer regions. *Daturastramonium* is indigenous to India. Out of 15 species reported from different parts of the world, only 10 are known to occur in India. They are found commonly in wastelands, gardens and roadsides. They are distributed in rich localities under semi-arid and arid regions of Punjab, Haryana, Rajastan, and Gujarat; the Central Plateau of Andhra Pradesh and Maharastra and the southern peninsular region of Tamil Nadu. *Datura innoxia* is indigenous to Mexico and is distributed in Latin American countries. A wealth of genetic stock on genotypes and varieties are maintained in several research institutes in Germany, Bulgaria, USSR and Poland.

Botany

The genus *Datura*, belonging to the family solanaceae, consists of annual and perennial herbs, shrubs and trees. Three species, viz, *Datura metel* Linn., *D. stramonium* Linn. *and D. innoxia* Mill. are medicinally important. Flowers are large, solitary, short pedicelled, purplish outside and white inside. Fruits are sub-globose capsules covered all over with numerous, fleshy prickles, irregularly breaking when mature. Seeds are numerous, smooth, yellowish brown.

Agrotechnology

Datura grows well in a wide range of climate from tropical to temperate conditions. The plant thrives best in areas of low rainfall where winter and monsoon rains are followed by long dry periods. Areas with annual rainfall below 1000mm with mean temperature of 10- 15ºC in winter and 27 - 28oC in May-June are ideal. The crop cannot stand frost, high rainfall or high temperature in the plains in May-June. It grows on majority of soils, however, alkaline or neutral clay loam soil or those tending to saline-alkaline reaction rich in organic matter are ideal for vigorous growth. The clayey, acidic, waterlogged or moisture deficient soils do not suit this crop.

Propagated by seeds but it is characterised by poor and often erratic seed germination which can be improved either by leaching out the inhibitor from the seeds or by alternate freezing and thawing of seeds. The optimum season for raising the crop is Rabi in tropical and subtropical areas while *Kharif* in temperate areas. The seeds can be broadcast - sown or seedlings can be raised in nursery and then transplanted. Seed rate is 7-8 kg/ha for broadcasting and 2-3 kg/ha. for transplanting. The field is ploughed and disced adequately to produce fine seed bed. In the case of direct seeding, seeds are drilled in rows taken 45-60 cm apart. The plants are thinned to keep a spacing of 30-45 cm at the time of first weeding. In the case of transplanting 4-6 weeks old seedlings are planted at 45-60 x 30-45 cm spacing.

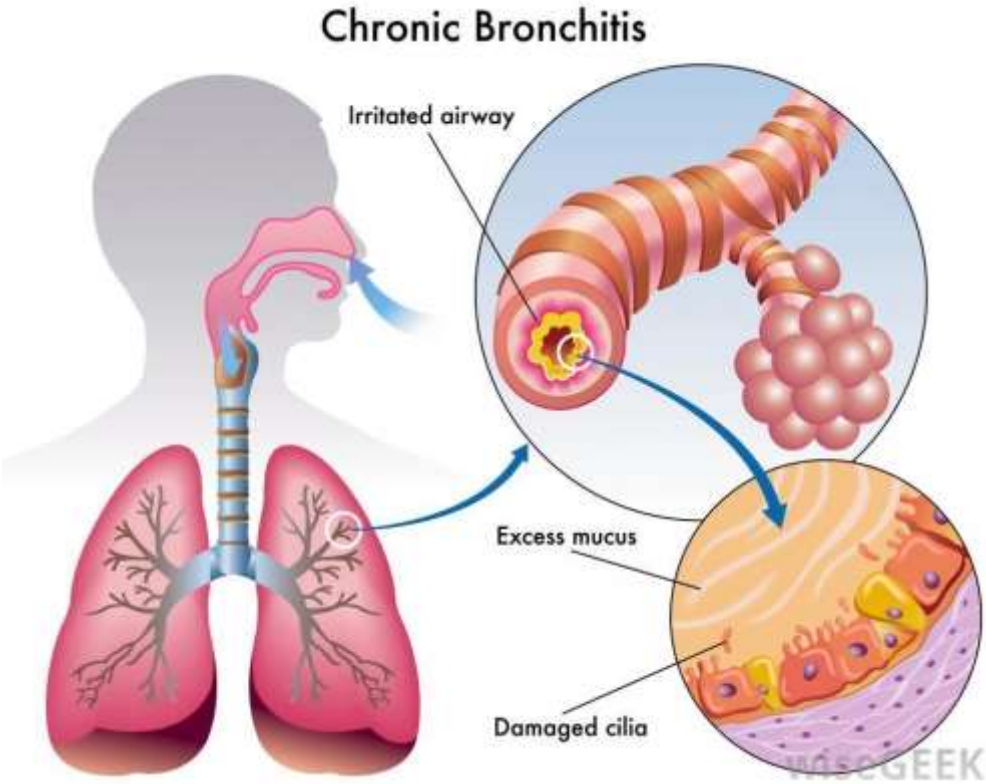
The field should be irrigated immediately after sowing or planting if soil moisture is inadequate. Thereafter 3-4 irrigations may be given if sufficient rainfall is not received. Application of organic manure at 10-15 t/ha and fertilisers at 60:40:40 kg N, P2O5 and K2O/ha is recommended for the crop for better growth and yield N may be applied in 3-4 equal split doses at planting and after each weeding which is required 2-3 times during the growing season. Application of micronutrients is reported to improve the alkaloid contents. No major insect pest is known to attack this crop. However, leaf spot, wilt and mosaic diseases cause damage to this crop. Leaf spot is caused by *Alternaria tennuissima* (Nees) Wiltshire and characterised by brown round to oval spots, becoming necrotic at later stage which leads to withering and dropping of leaves.

Wilt is caused by *Sclerotium rolfsii* Sace; it starts with dropping of leaves and finally wilting of the entire plant. Root and foot wilt, caused by *Corticium solani,* appears as damping off of seedlings and mature plants. Datura distortion mosaic is characterised by yellowing of the veins followed by inward rolling and distortion of leaves with a reduction in plant size. For reducing the impact of these diseases, field sanitation, use of resistant varieties, crop rotation for 3-4 years and fungicide application should be resorted to. For the purpose of leaf and top, harvesting is done as soon as flowering starts. Entire top

containing leaves and twigs is cut, dried in shade and stored in gunny bags. For seed and fruit, fully grown fruits, still green are picked 2-3 times before final harvest when the entire plant is cut from the base and dried in the open. The dried fruits are then thrashed with a stick to separate the seeds. The seed yield is 1-1.5 t/ha.

Properties and activity

The alkaloids hyoscyamine and hyoscine (scopolamine) and meteloidine are found in all parts of the plant. The total alkaloid content is 0.26 - 0.42 % Fruits contain daturaolone and daturadiol while roots contain additionally ditigloyloxy tropane derivatives, tigloidine, apohyoscine, norhyoscine, norhyocyamine, cusiohygrine and tropine. Other alkaloids isolated from the plant are apohyoscyamine, DL-scopolamine, normeteloidine, tigloylputrescine, scopine, nortigloidine, tropine, psuedo valeroidine, fastudine, fastunine, fastusinine, 7-hydroxy-3, 6-ditigloyloxytropane (2) datura nolone and fastusic acid. The physiological effects of hyoscyamine are qualitatively the same as those of its recemic derivative atropine. This is relatively more active in its paralysing affect on nerve endings and less active in its stimulant action on the central nervous system. The sedative and hypnotic action of hyoscyamine is weaker than that of hyoscine. Atropine has a stimulant action on the central nervous system and depresses the nerve endings to the secretary glands and plain muscles. The plant or the different alkaloids have narcotic, anthelmintic, spasmolytic anaesthetic, sedative, ophthalmic, anticancerous, antitumour, antirheumatic, **antiasthmatic,** antidiarrhoeal and anticatarrhal activities.



LIQUORICE

Common Name	Liquorice San: Yashtimadhu Hin: Jathimadh Mal: Irattimadhuram Tam:Athimadhuram Tel: Yashtimadhukam Ben: Yashtomadhu Pun:Muleti
Botanical Name	***Glycyrrhiza glabra***
Family	***Papilionaceae***

Importance

Liquorice or **Muleti** is a perennial herb or undershrub about 1m high. Its dried peeled or unpeeled underground stems and roots constitute the drug which is an important constituent of all cough and catarrh syrups, throat lozenges and pastilles. This has been used in medicine for more than 4000 years. Hippocrates (400 BC) mentioned its use as a remedy for ulcers and quenching of thirst. Dioscorides, the father of Greek medicine described this drug in detail and considered it useful for maintaining shape of arteries and in burning stomach, trouble of liver and kidney, scabies, healing of wounds and as a remedy for eye diseases. It has been used in Arab system of medicine for more than 600 years from where it has been adopted to modern medicine (Gibson, 1978).

The commercial name of the dried rhizome and root of the plant is liquorice which is used as flavouring agent and the taste coorigent in pharmaceutical and confectionery industries and its products are widely reported to be useful in ulcer therapy. Glycyrrhizin, a triterpene glucoside, is the principal constituent of *G. glabra* which is 50 times sweeter than sugar.

Distribution

Liquorice is native to Mediterranean region, South Europe and Middle East. It is widely distributed in Spain, Italy, Greece, Syria, Iraq, Afghanistan, Turkey, parts of USSR and China. However its cultivation is limited to small areas in USSR, UK, and USA. In India, it grows in Punjab and Jammu and Kashmir. Semi arid areas of Haryana, Rajasthan and Gujarath states are suitable for the cultivation of Liquorice. However, its commercial cultivation has not yet been possible and the domestic requirement is largely met through imports.

Botany

Glycyrrhiza glabra Linn. Belongs to the family Papilionaceae. The word *Glycyrrhiza* is of Greek origin meaning '*sweet*' and glabra means '*smooth*' which refers to smooth fruit of the species. This is a tall perennial, self pollinated herb or undershrub about 1m high with long cylindrical burrowing rootstock and horizontal creeping stolons which reach 1.5-1.8m in length. Leaves are alternate, pinnate with 9-17 leaflets. Leaflets are yellowish-green, 2.5-5cm long, ovate and obtuse. Flowers are pale blue arranged in a raceme and 1.25cm long. Calyx is glandular and pubescent. The pods are glabrous, red to brown having 3-4 seeds. Rhizome is soft, flexible and fibrous with light yellow colour and a characteristic sweet taste.

Agrotechnology

This plant thrives well in subtropical areas with very warm summers and cool winters with a rainfall not exceeding 500mm. Semi-arid and arid areas in subtropical zones are not suitable for the cultivation of this crop. It does not tolerate high humidity and waterlogged conditions. Well drained light loam soils which are rich in calcium and magnesium with slightly alkaline pH and free from stones are

ideal for this crop. There are a number of varieties of this crop among which *Spanish, Russian* and *Persian* liquorice are quite common. Commercial varieties are *Typica, Regel* and *Herd*.

This is propagated by seed, but usually multiplied vegetatively either through crown cuttings or stolon pieces. In the case of crown cuttings, 10-15cm long crown pieces with 2-3 buds are planted vertically at a distance of 0.6-0.7m in rows 1-1.5m apart. However, most of the liquorice is propagated through stolon pieces of the above size planted horizontally, preferably on ridges during spring at the same distance as above. Rapid clonal propagation is also possible by tissue culture technique.
Murashige and Skoog's medium supplemented with 6-benzylaminopurine and indole-3-acetic acid favoured multiple shoot production without any intervening callus phase.

In order to produce good rhizome, flowering shoots are clipped. No serious disease except leaf spot caused by *Cercospora cavarae* has been reported in this crop. Roots are ready for harvesting after 3-4 years. The root is dug when the top has dried during autumn (November- December). A trench 60cm deep is dug along the ridges and the entire root is lifted. Broken parts of the root left in the soil, sprout again and give another crop after 2-3 years. Thus liquorice once planted properly can be harvested for 10-15 years.

Postharvest technology

Harvested roots are cut into pieces of 15-20cm long and 1-2cm in diameter. They are washed and dried upto 6-8% moisture in the sun and shade alternately which reduces the weight by 50%. The average yield of dried roots varies from 1-3 tonnes per hectare depending on the variety, soil and climatic conditions.

Properties and activity

Roots gave a number of compounds the most important bieng a glucoside, glycyrrhizin which gave glycyrrhetinic acid on enzyme hydrolysis. Root also contains flavans, flavones, isoflavanoes and coumarins including a 4-methyl coumarin, liqcoumarin, glabridin, glabrene, 4'-0-methyl and 3'-methoxyglabridin, formononetin, salicylic acid, 0-acetyl salicylic acid which has been isolated first time from nature, hispaglabridins A and B and 4'0-methylglabridin.On hydrolysis it also gave two molecules of d-glucuronic acid, each linked with b1-2 linkage to 3-hydroxyl of the sapogenin (Elgamal *et al*, 1969) Glycyrrhizin is antidiuretic, antiinflammatory, expectorant, antiulcerous, antihistamine. Glycyrrhizic acid is antiviral. The roots are emetic, tonic, diuretic, demulcent, mild laxative, aphrodisiac, trichogenous, expectorant, emmenagogue, alexipharmic, alterant and intellect promoting.

ASHWGANDHA

Common Name	**Ashwgandha,** Winter cherry, Indian Ginseng
Botanical Name	*Withania somnifera*
Family	Solanaceae

Importance and chemical composition

Aswagandha (*Withania somnifera)* is commonly known as 'winter cherry' and Indian Ginseng in English. Several types of alkaloids are found in this plant, out of which, withanine and somniferine are important. In addition the leaves are important to contain five unidentified alkaloids. The total alkaloid content in the roots of Indian types has been reported to vary between 0.13 -0.31. The drug is mainly used in Ayurvedic and Unanic preparations. Withaferin A- contains antibiotic and antitumor properties. It is used for curing carbuncles in the indigenous system of medicine.

The paste prepared out of its leaves is used for curing inflammation of tubercular glands and that of its roots for curing the skin diseases, bronchitis and ulcers. It is used as aphrodisiac, remunerative tonic, Diuretic, Hypnotic, Sedative and restorative, useful in rheumatism, cough debility from old age, dropsy and general weakness. In addition to alkaloids, roots are reported to contain starch, reducing sugar, hentriacontane, glycosides, dulcital, withaniol acid and a neutral compound. The free amino acids identified in the roots include aspartic acid, glycine, tryosine, alanine, proline, tryptophan, glutamic acid and cystine.

Berries contain milk coagulating enzymes, esterases, free amino acids, fatty oil, essential oil and alkaloids. The amino acids present are proline, hydroxy-proline, valine, tryoline, aspartic acid, glycine, asper agine, cystine and glutamic acid.

Origin and distribution

Aswagandha is found wild in grazing grounds in Mandsaur and the forest lands in the Bastar district of Madhya Pradesh, all over the foothills of the Punjab and Himachal Pradesh and Western Uttar Pradesh, in the Himalayas. It is also found in the wild in the Mediterranean regions in North Africa. The crop is cultivated in an area of about 4000 ha in India, mainly in the drier parts of Manasa, Neemach and Jawad tehsils of the Mandsaur district of Madhya Pradesh, in Punjab, Sindh, Rajasthan and South India. In Karnataka, its cultivation has been reported in the Mysore districts.

5000 hectares in India

Area and production

Aswagandhais cultivated in predominantly in Madhya Pradesh. The estimated annual production is 2500 metric tones of dry roots.

Varieties

A variety named Jawahar Asgandh (WS-20) has been released from a single plant selection from the Jawaharlal Nehru Krishi vishwa Vidhyalaya, Regional Agricultural Research Station, Mandsaur. This variety has recorded the highest dry root yield, consistently over the others. A high root and alkaloid yielding variety 'Poshita' is released from CIMAP, Lucknow.

Soil and climate

Ashwagandha grows well in sandy loam soil, in slightly alkaline soil with good drainage condition. It grows better in 600-1200m altitude. The semi-tropical areas receiving low rainfall are suitable for cultivation of this crop. The crop requires dry season during its growing period. Temperature between 20°C to 35°C is most suitable for cultivation. Late winter rains are conducive for the proper development of the plant roots.

Land preparation

Ashwagandha is usually grown in fields which are not well covered by the irrigation systems. The field on which food crops cannot be grown profitably because of low rainfall can be used for ashwangandha cultivation. The soil of the field selected for ashwagandha cultivation is well pulverized by ploughing. The field should be leveled and pressed by using heavy wooden plank.

Nursery raising and planting

The crop can be sown either by broad casting or in lines. Line to line method should be preferred increased root production and also helps in performing intercultural practices in required by farmers. The seeds are usually sown about 1-3 cm deep during June- July in nursery. A light shower after sowing ensures good germination. About 5-12 kg seeds are sufficient for one hectare field.

The seedling of 25-35 days old can be transplanted in the fields marinating 30 x 30 cm.

spacing between the plants & the rows. As Ashwagnadha is a rainy season *Kharif* crop, the time of its sowing should be decided by date of arrival of monsoon in area of cultivation.

Thinning and weeding

The seeds sown by broadcasting or in the line should be thinned out by hand at 25-30 days after sowing to maintain a plant density of about 30-60 plants per square meter (about 20,000 to 25,000 plants/hectare). The plant density to be used may depend on the nature and fertility of the soil. On the marginal land the plant population should be kept high. One weeding at an early stage is sufficient to enable the Ashwagandha plants to take over the growth.

Manures and fertilizers

The ashwagandha crop does not require heavy doses of manure and fertilizers. In Madhya Pradesh, where it is grown on a commercial scale, no fertilizers are applied and the crop is cultivated on only residual fertility. Studies at the Indore Research Station have showed no effect of nitrogen and phosphorus on its root yield **Irrigation**

Light shower after transplantation ensures establishment of seedlings. There is no need of irrigation if rainfall is at regular intervals. Excessive rainfall/water is harmful to the crop. Only life saving irrigations may be applied, if required to ashwagandha. This is to be noticed that ashwagandha is a dry land crop and do not need much water.

Pest and disease management

Seed rotting, seedling blight and leaf blight are common diseases affecting ashwagandha. Their incidence can be minimized by spraying Dithane M-45 @ 3g/ l at the interval of 7-10 days.

Harvesting

The plants start flowering and bearing fruits from December onwards. The crop is ready for harvest in January- March at 150 to 180 days after sowing. The maturity of crop is judged by drying out of leaves and yellow red berries in the plant standing in the field.

Processing

The entire plant is uprooted for roots which are separated from aerial parts by cutting the stem 1-2 cm above the crown. The roots are then either cut transversely into small pieces (7 to 10 cm) or dried as it is, in the sun. About 350 kg fresh roots can be obtained from one acre of land. On drying, it comes to 180 kg. Berries should be hand plucked separately. They are dried and crushed to take out the seeds. The dried roots, entire or transversely cut into smaller pieces, have to be further cleaned, trimmed and graded. The roots are beaten with a club which removes adhering soil and breaks off the thin, brittle lateral rootlets. Lateral branches, root crown and stem remains on roots are carefully trimmed with the help of knife.

Grading: The entire produce (dried roots) is then carefully hand sorted into following 4 grades. **Grade A:** Root piece 7 cm long, diameter 1 to 1.5 cm. Roots should be brittle, solid and pure white from inside.
Grade B: Root pieces 5 cm, diameter 1 cm, roots brittle, solid and white from inside.
Grade C: Root pieces should be solid, 3 - 4 cm long, diameter less than 1 cm.

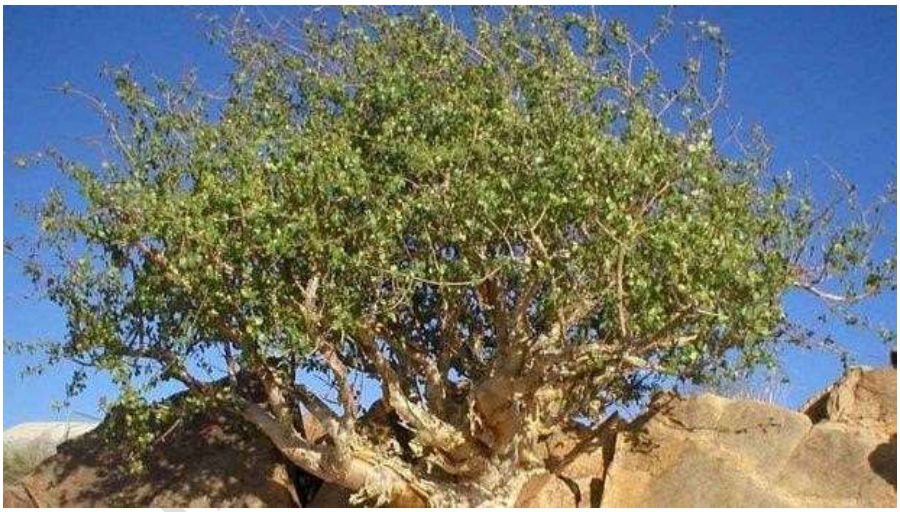
Lower grade: Small pieces of root, roots are somewhat hollow, yellowish from inside.

GUGGUL

Common Name	**Guggul,** Indian Bdellium
Botanical Name	***Commiphora mukul***
Family	Burseraceae

Importance and chemical composition

Guggul or Indian Bdellium (*Commiphora mukul* Hook.) is a small tree belonging to family Burseraceae. This plant is a source of Indian Bdellium, an oleo-gum-resin obtained by incision of the bark. The resin is largely used as incense, as a fixative in perfumery and in medicine. In indigenous medicine it is used as an astringent, antiseptic and digestant. It is highly effective in the treatment of obesity, arthritis and indolent ulcers. Inhalation of the fumes of burnt guggul is recommended in hay fever, acute and chronic cataeeh, chronic laryngitis, chronic bronchitis and phthisis. It is an ingredient of ointment of ulcers. Due to its property of lowering the cholesterol level of blood it is in good demand in modern medicine also.



Origin and distribution

The genus *Commiphora*, which has 165 species, has its origin in Africa and Asia and is widely distributed in the tropical regions of Africa, Madagascar, Asia, Australia, India, Bangladesh and Pakistan. Four spices occur in India. These are *C. agollochoa, C.STOCKSIANA*, *C. mukul* and *C.berryi*. The genuine Guggul gum is derived from *C. mukul*. In India, this species is distributed in the states of Rajasthan, Tamilnadu, Assam, Gujarat, Maharastra and Karnataka.

Area and production: No published data on area and production of this crop is available.

Varieties: Marusudha, a high yielder which has been released for cultivation from Anand, Gujarat.

Soil: It is practically a desert plant .Faster growth of the plants is observed in soils which have moisture retaining capacity. An average soil which has good drainage capacity is suitable for its cultivation.

Climate: The crop prefers a warm dry climate and hence quite suitable for dry regions. The plant is susceptible to the frost and hence such situation should be avoided for growing this crop.

Cultivation

Propagation: Guggul can be propagated by seeds and vegetatively through stem cuttings. However as the propagation through vegetative mean is easy, it is preferred over seed propagation.

Planting: The land is prepared well in advance of rainy seasons by 2.3 ploughing and laid out into plots of convenient sizes. Pits of size 0.5 x 0.5 m (0.5 m^2) are dug at the spacing of 3x3 m. They are filled

with FYM and top soil. The rooted cuttings are planted in the pits during the rainy season. As the plant grows they are trained properly by cutting the side branches.

Fertilizer application: The crop has not shown good response to fertilizers expect to low level or nitrogen fertilization. Hence urea or ammonium sulphate @ 25/50 g per bush is given twice a year before irrigation.

Irrigation: Light irrigation during summer season is required.

Intercultivation: Weeding and hoeing in the early stages of growth and stirring of soli around the bushes twice in a year is beneficial to increase the growth of plants.

Pests and diseases: Pest – The plants are attacked by leaf eating caterpillar, white fly and termite. The diseases noticed on this crop are leaf spot and bacterial leaf blight.

Harvesting: The plants attain normal height and girth after 8 to 10 years of growth when they are ready for tapping the gum.

Processing (Gum tapping)

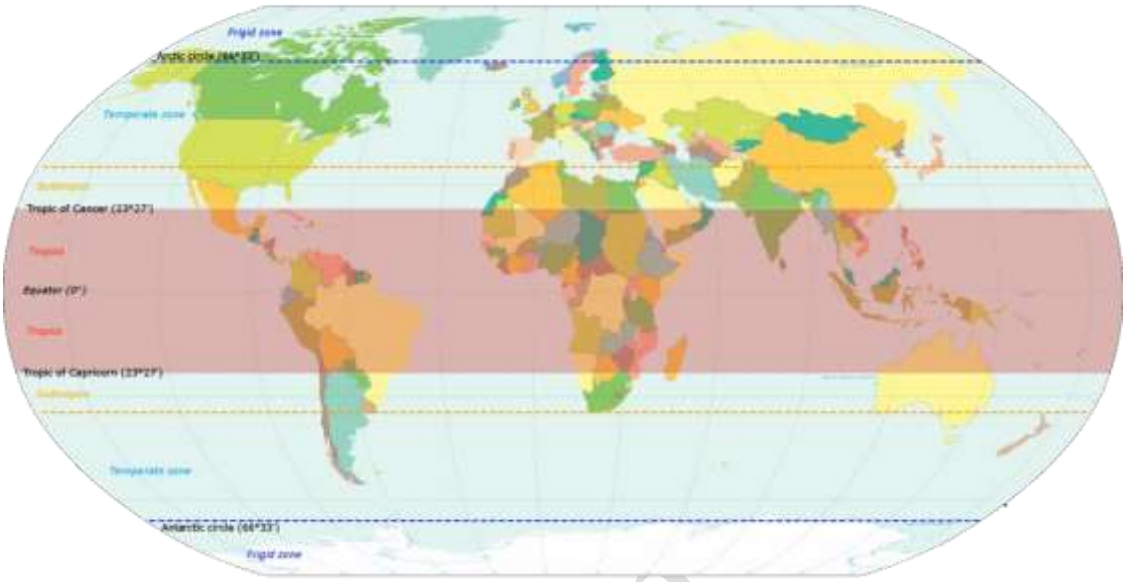
Yellow gum resin from incision

The dried gum resin

For tapping the gum which is present in the Balsam canals in the phloem a shallow incision a small quantity of Guggul gum in the bark. While making the incision a small quantity of Guggul gum mixed with water may be applied to the incised place using the prick chisel. The sharp end of the chisel is dipped in the Guggul solution and incision is made on the bark carefully. Usually the incision is made after November month but before April. The resin is collected at an interval of 10-15 days. Weather conditions influence the success of obtaining gum.

Yield

From a 10 year old plant, about 700-900 g of gum resin may be obtained. This is turn may give a yield of about 700-900 kg of gum resin per hectare.



AROMATIC CROPS

CITRONELLA GRASS

Common Name	Citronella Grass
Botanical Name	*Cymobopogon winteriaruns* Jowitt
Family	Poaceae

Origin: *C. winterianus* is native to Sri Lanka.

It is a stem less perennial grass. It is a recent introduction into India and its cultivation mainly in the lower hills of Assam, in Karnataka and southern Gujarat, covers about 2,000 hectares. A part of requirement is still met by imports. Oil is mainly used in soaps, cosmetics, deodorants and mosquitorepellent creams. It is distributed in Andhra Pradesh, Jammu & Kashmir, Maharashtra, Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal. It covers total area of 9000 ha.

Botany

The name Cymbopogon is derivative of two Greek words 'Kymbe' meaning a boat and 'pogon' meaning a board. The former refers to the boat shaped spatheole; a marked feature of inflorescence and latter to many awned inflorescence. These formed the basis of its generic name, the Cymbopogon. Cymbopogon species are perennial in nature, coarse growing tufted grasses, with a stem clasping filiform leaves. Many species possess aromatic foliage. The oil is mostly confined to the leaves, with a little in the stem and root.

C. winterianus has shallow root hence suffers under moisture stress adversely. The inflorescence is a complex panicle which culminates in a pair of racemes, one sessile and other with a common peduncle enclosed by a boat-shaped spathe or spatheole (Figs. 1 and 2). These spathes are very prominent in inflorescence.

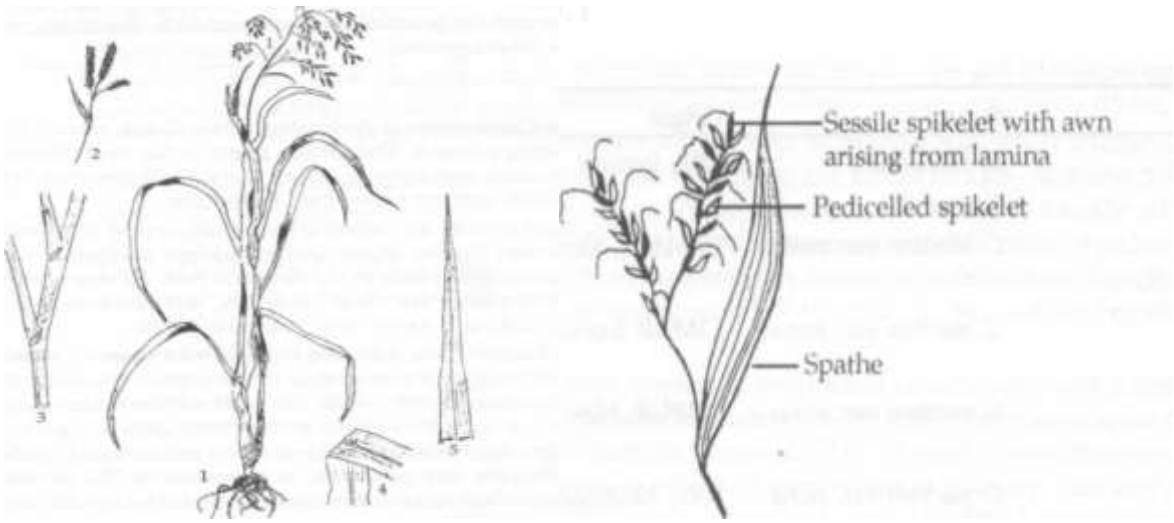


Fig. 1: Morphology. 1. Inflorescence 2. Racemes with spathe 3. Vegetative shoot 4. Mid portion of leaf and leaf lamina 5. Tips of leaf lamina **Fig. 2:** Spikelets in Cymbopogons.

The receme possess fragile rachis over which the pedicelled spikelet remains attached. The lowest pair of spikelets in sessile receme is homogeneous. The lower glume has sessile spikelet. The sessile spikelets have awn. **Cultivars**

Genetic improvement of Cymbopogons has been attempted to evolve cultivars having higher yield potential, varying chemical compositions and also to tolerate abiotic stresses. Some important cultivars developed in different parts of India are given below

Some important cultivars

Clone/Variety	Source	Origin
Manjusha, Mandakini Bio-13, Manjari	*C. winterianus*	CIMAP, Lucknow
Jorlab-C-2, RRL- Jor-3-1970	*C. winterianus*	RRL, Jorhat
RRL(b)-15	*C. winterianus*	RRL, Bhubaneshwar
CKP-25	C. *khasianus* x C. *pendulus*	RRL, Jammu
ODP-1, ODP-2 Tripta	*C. martinii* var. *motia*	Odakkali, Kerala
Trishna, PRC-1, Tripta	*C. martinii* var. *motia*	CIMAP, Lucknow
1W-31243, 1W-31245, IW-3630	*C. martinii* var. *motia*	NBPGR, New Delhi
RRL (B)-77, RRL(B)-48, 65, 69, 71	*C. martinii* var. *motia*	RRL, Bhubaneshwar

RRL Jorhat evaluated the performance of the RRL JOR-3-1970 variety of citronella in comparison with Jorhat and Bangalore strains. RRL JOR-3-1970, are best performing.

Major constituents

Citronellal (30-45%), geraniol (20-25%), citronellol (4-10%), caryophyllene (2.1%), citronellyl acetate (3.0%), elemol (6.0%), geranyl acetate (4.2%), linalyl acetate (2.0%), methyl-iso-eugenol (2.3%), nerol (7.7%)

Climate and Soil

Java citronella is grown up to 1,000 m above sea level on well-drained sandy-loam to clayeyloamy soils with pH varying from 5 to 7.5 as a rainfed crop.

Propagation and Cultivation

It is propagated by using rooted slips, and is planted during the rainy season in rows, 60 to 45 cm x 45 to 30 cm apart, depending on the rate of growth and the soil fetility. Usually, the leafy portion is removed at planting during the monsoon season and the plants begin to tiller in 30 days after planting. A healthy one-year -old clump yields 60 to 80 slips. The crop needs a large quantity of nitrogenous fertilizers , When grown on medium soils, it is given 60 kg of P, 40 kg of K and 20 kg of N per ha at planting, supplemented with 80 to 100 kg of N per hectare annually as top-dressing in 3 to 4 split doses. The crop is irrigated after every 10-15 days during the dry season and the first harvest is count 20 cm above the ground after 90 days of planting; usually 3 cuttings are obtained annually (4 under Assam conditions) for 3 to 5 year after planting. **Management of diseases and pests**

Plant	***Disease/Pests***	***Causal organism***	***Control***
C. WINTERIANUS	Leaf blight	***C. ANDROPOGONIS***	-
	Lethal yellowing	Unknown	-

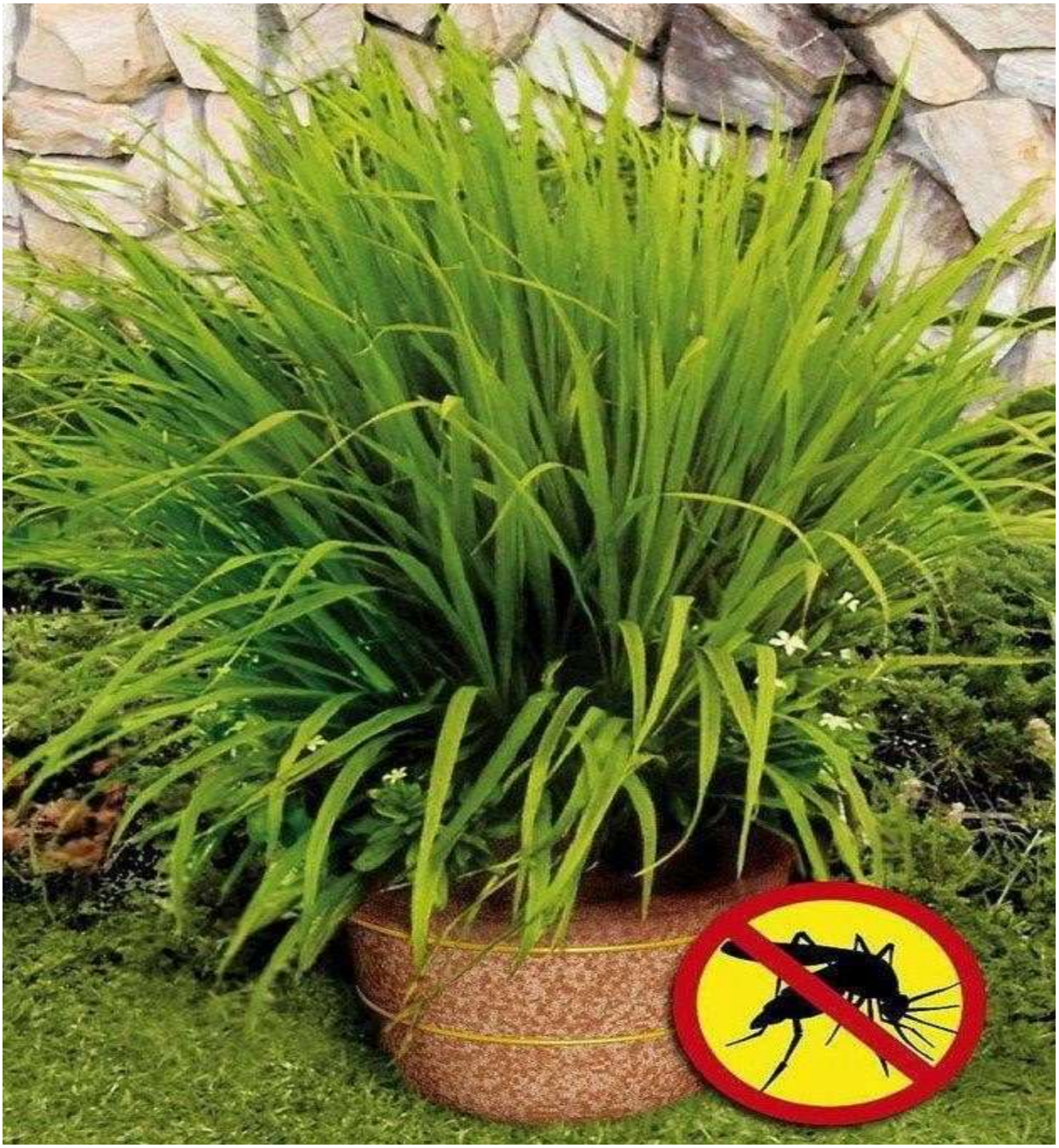
Processing

The essential oils are obtained by distillation process since these oils are steam volatile. Generally, two methods are employed for this purpose: 1. Steam distillation 2. Hydro-steam distillation.

Steam distillation is carried out in specially designed distillation equipments which consist of boiler, distillation stills, condensers and oil separators. A hydro-steam distillation is essentially a single unit wherein steam generation is cheaper and suitable to small farmers. For large-scale cultivation**,** steam distillation method is suitable. In this method, oil recovery is better and control of distillation parameters is easier which results in better recovery and quality of essential oils.

Hay storage of citronella either in the shade or open has generally increased the essential oil content of the leaves. After harvesting citronella, herbage can be stored for six days in the rainy season without loss of oil, shade drying was better than open drying; whereas, during summer, storage should be avoided. The residue remaining after distillation is called 'spent grass' and it can be used for varied purposes such as organic manure, fuel, in making paper boards, in the formulation of cattle feed etc.

The essential oil distilled, is stored properly to maintain good quality. Presence of air, moisture, sunlight, high temperatures affects the quality of the oil adversely. The oil, soon after distillation, has to be filtered; moisture is then removed by physical and chemical methods and the oil is stored in air tight containers. Aluminium containers are ideal for storing essential oils. Processes such as oxidation, resinification, polymerization, interaction of functional groups etc. cause deterioration in the quality of the oils. Therefore, after distillation, the oils have to be treated with organic acids such as tartaric acid to remove metallic impurities and then moisture has to be removed by treating with anhydrous $NaS0_4$. Such clarified oils have to be filled well into airtight containers.
Sometimes, filling air gap in containers with N_2 gas is advisable.



VETIVER OR KHUS

Common Name	**VETIVER OR KHUS**
Botanical Name	***Vetiveria zizanioides* Linn Nash**
Family	Poaceae

Habitat and Distribution:

It is found throughout the plains and lower hills of India, particularly on the riverbanks and rich marshy soils in places with an altitude of about 1200 metres. **Field Recognition Features:**

The plant is a densely tufted grass, with a tuft of many culms arising from an aromatic rhizome, that grow up to and over 2 meters tall. Roots are adventitious in nature and arise from the base of the culms to form a dense mat. Roots are filament like, stout, spongy and aromatic. Leaves are narrow, erect, and tape like smooth with a central groove, growing up to 2 feet. Inflorescence is long and branched that

grows up to 40 centimetres with numerous slender and small flowers that appear in whorls on a central axis. Flowers are greyish green or purple in colour and are the size of paddy flowers.

Climate

Vetiver prefers a mild climate but can be grown under both wet and dry or arid tropical and sub tropical conditions. An annual rainfall of 100-200 cm, temperature ranging from 21-44°C and moderately humid climate is ideal for taking up this crop. In places with scanty rainfall, it can be taken up as an irrigated crop **Soil**

Since it is hardy in nature this plant can be grown in wide variety of soils. But red lateritic soils rich in organic matter is ideal for growing this crop. It can be grown in saline and alkaline soils even at a pH of 8.5-10. Light soils should be avoided as the roots so obtained produce very low percent of oil.

Propagation

Land preparation: The land is open by giving a deep disc ploughing and left for weathering for a fortnight. This is followed by cross harrowing. Field is levelled and laid out in to small plots.

Planting: Vetiver can be propagated through tillers or slips. Tillers take long time for growing and therefore, slips are the better planting materials for propagation. The top of the slips are trimmed down before planting to avoid transpiration loss, thus giving a better chance for survival of the slips. 2-3 slips are planted during June-July after the onset of rainy season about 5-10 cm deep vertically at a distance of 45 x 30 cm. After planting, the soil around the slips is pressed firmly and levelled. Slips begin to sprout in 7 to 10 days. Around 1, 50,000-2, 25,000 slips are required for planting one hectare area.

Sowing: Seeds may also be sown in nursery during May. However seed planted crop is not preferred due to the variation in the produce.

Fertilizer: 10 tons of FYM and 25 Kg each of Nitrogen, Phosphorus and Potash can be applied for an area of one hectare.

Irrigation: Around 8-10 supplemental irrigation needs to be given during drier months of the season otherwise irrigation is not necessary when rainfall is well distributed in a year and humidity is high.

Interculture

3-4 weedings are necessary in newly established plantations until the bushes are formed well. Earthing up after 60 days enhances root development.

Plant protection

Leaf blight is commonly noticed and it's advised to spray Copper fungicides 0.3 % containing metallic Copper.

Harvest and postharvest

The plants planted in July should be harvested after 18 months for getting maximum oil yield. Harvesting is usually done during the dry season from December to February by digging out the bush along with its roots manually. Light irrigation before digging facilitates easy removal of roots. Aerial parts of the growing plant are cut off from ground level and roots are dug out in rows. A good quality root with high oil yielding potential has slightly reddish brown colour. Roots are separated from the leaves, washed and dried under shade before distillation. Drying is done in shade for 5 to 7 days till the moisture content reduces to 10 percent. **Yield:**

The yield of roots may range from 5000-7000 Kg per hectare which on distillation may yield 12-14 Kg of oil. Roots yield 1-1.5 per cent of oil on dry weight basis.

BACH

Common Name	**Bach,** Sweet flag**,** Safed bach
Botanical Name	*Acorus calamus Linn.*
Family	Araceae

Also known as sweet flag in English and *safed bach* in Hindi, bach is an annual, marshy, aromatic, rhizomatous medicinal herb. The rhizomes of bach are known to have medicinal properties and are used in the preparation of many medicines. Being adapted to marshy land, the plant is worth cultivating on such soil.

Origin and distribution

Bach is native to northeastern America and temperate Asia. In India, it is commonly found growing in marshy and moist areas of the northeastern Himalayas. In Madhya Pradesh, it is mostly grown in the Vindhya Plateau, the Narmada Son valley, Satpura and in the Chhatisgarh Bastar plateau.

Bach is usually found near the banks of rivers and streams and its cultivation is mostly undertaken in marshy areas. **Uses**

The rhizomes of bach are used for a variety of purposes. Its much branched aromatic rhizomes are used medicinally as a carminative, stimulant to the central nervous system and as a tonic. It relieves flatulence and also acts as an expectorant. It is also useful in treating diarrhoea and dysentery. Leaves and rhizomes are used for flavouring drinks and for preparing insecticides. Powdered rhizomes are used as a vermifuge. An essential oil obtained from rhizomes is used in perfumery and for flavouring liquors and other foodstuff. It is also used by distillers to improve the flavour of gin and by brewers to give taste to certain kinds of beer. Alcoholic extract of the plant has sedative and analgesic effects and causes moderate depression in blood pressure. The details of uses are furnished in table 1. **The different drugs prepared from the rhizomes**

Drug manufacturer	Name of the drug	Uses
1. H.B. pharma, Rajkot	1. Crumina syrup	All types of endogenous worms
	2. Spasmocarpin syrup	Antispasmodic given without sedation
	3. Autospray powder	For smooth and shiny skin
	4. Toothache powder	Toothache
	5. Otomar drops	Acute or chronic bacterial infection of mid and outer ear
2. Shilpachem, Indore	1. Livobel syrup	Treatment of liver diseases
	2. Livobel drops	__
	3. Cybil tablet	Tranquilizer
	4. Shilpazyme syrup	For indigestion
3. Charak pharmaceuticals, Mumbai	1. Dryconil syrup	For cold, cough and fever
	2. Galacol	For increasing milk secretion
	3. Nade tablet	Epilepsy
	4. Rimmonil tablet	Bone inflammation, joint pains, back pain, rheumatism
	5. Sapra tablet	Mental stress
	6. Tranquil	Tranquilizer
4. Atasin, Mumbai	1. Phortage	Aphrodisiac
	2. Suctin	Acidity, gastro, cardiac syndrome, flatulence,dyspepsia, gastritis and peptic ulcers
	3. Celidin	Tranquilizer in almost all psychosomatic disorders

Botany

It is an aromatic herbaceous plant measuring to 80100 cm in height with distinct leaves arising from the rhizomes. The rhizome is a modified stem and is brownish in colour. The rhizomes on cutting give off a mild pleasant fragrance. Leaves are linear to lanceolate with an acute tip and a prominent mid-vein. The leaves are also fragrant. Inflorescence is a spadix measuring four to eight cm in length. Flowers are greenish yellow and fruits are round and red.

Soil

It is usually cultivated in areas having sandy loam to clayey soil with an assured irrigation facility. Cultivation of bach is not possible in areas without such irrigation facilities. It can be successfully grown along irrigation and drainage channels, canals and river banks, where there is continuous seepage of water. It can also be grown in kitchen gardens, in places where there is constant water supply.

Climate

It grows well under shady conditions and can be easily cultivated in areas having a temperature range of 10-38° C and an annual rainfall of 700 mm -2500 mm.

Propagation

The rhizomes are used as the propagating materials. These are cut into small pieces and planted. The following methods of propagation can be adopted for the cultivation of this herb:

The cut pieces have one or two nodes and are ideal planting material. The lower portion of the leaves is attached to the rhizomes and can also be used as planting material, which is prepared by planting them in nursery beds or in polyethylene bags.

Nursery raising is done under shady conditions. The rhizomes are planted in a mixture of FYM and sand and are constantly moistened. The sprouted rhizomes are then cut into pieces, each piece having a sprout and then planted in the main field. The polyethylene bag method is also practised to prepare the planting material. This provides ease in handling and transportation of the planting material. To raise them, the rhizomes can be cut and planted in small polyethylene bags of 20 cm x 20 cm size and 100 gauge thickness. Polyethylene tubes can also be used for this purpose. The polyethylene bags or tubes are filled with a potting mixture consisting of 1/3 soil + 1/3 well rotten FYM and 1/ 3 sand. This is kept in partial shade and irrigated. After the development of the root and shoot, it is planted in the main field.

Land preparation

The field should be ploughed three to four times thoroughly. Before transplanting, the land is soaked well with water, just as in paddy. It would be more effective, if the field is made somewhat swampy. **Planting**

The sprouted cut pieces are planted in the field at a distance of 25 cm x 25 cm and at a depth of three to four cm. It is usually planted in the months of July to August. Planting density is maintained at about 1, 60,000 plants/hectare. **Irrigation**

Sufficient watering should be done immediately after planting, as irrigation is the most important requirement for growing bach. Irrigation is not required during the rainy season. During other seasons, it should be grown at an interval of two to three days. It can be profitably cultivated on river banks and in other marshy areas where cultivation of other crops is difficult.

Manures and fertilizers

Organic manure should be used to avoid deterioration in quality and fragrance of the rhizomes, but in order to get higher yields, inorganic fertilizers can be used.

Well-rotten FYM is applied @ 15-20 tonnes/ha. If inorganic fertilizers are used, this amount can be reduced to 10 tonnes/ha. The inorganic fertilizers are applied @ Nitrogen 60 kg/ha, Phosphorus 40 kg/ha, and Potash 60 kg/ha. Nitrogen is given in two split doses, half during planting and the remaining half at 60 days after planting.

Weeding and hoeing

Weeding and light hoeing are necessary for getting a good crop yield and also for conserving soil moisture. Usually four to five hand weedings are required.

Crop rotation

Vegetable like cowpea and green manure crops like sunhemp can be grown after bach. It is an ideal crop sequence. **Plant protection**

No case of disease or insect infestation has so far been reported in bach but it is advised to treat the rhizomes before planting in a solution of 1 g Bavistin + 2 g Dithane M-45/litres of water for 20-30 minutes as a precautionary measure.

Harvesting

The crop matures in six to eight months. The rhizomes are dug up in the months of December/January when the leaves turn yellow and dry. The plants are then uprooted. If undertaken on a large scale, the plants can be uprooted by light ploughing also. The leaves are then removed from the rhizomes. **Yield**

An eight months old crop yield about 18-20 q/ha dried rhizome. In addition to this, the upper portion of the rhizome can be used as planting material which forms an additional source of income.

Drying:

The rhizomes are cleaned and all the dust adherents are removed. They should not be washed in water as washing is reported to affect the oil percentage. The rhizomes are cut into small pieces and dried under shade so that the oil percentage is not affected.

LAVENDER

Common Name	**Lavender**
Botanical Name	*Lavandula angustifolia, L. Angustifolia, L. latifolia. L. latifolia (syn. L. spicata).*
Family	*Lamiaceae*

The lavender genus *Lavandula* (family *Lamiaceae* syn. *Labiatæ)* has over twenty species that are mostly of Mediterranean origin. There are three main species within the genus producing lavender, lavandin and spike lavender that are essential oils for the fragrance and perfume industry. "True lavender" oil is derived from *Lavandula angustifolia (syn. L. officinalis)*, lavandin oil is considered a hybrid of *L. Angustifolia, L. latifolia.* and finally spike lavender oil is derived from *L. latifolia (syn. L. spicata)*. Lavender is the most highly prized of these three oils.

World distribution & production areas

Lavender is a native of the western Mediterranean and the eastern coast of Spain, France, Switzerland, North Italy, Corsica and North Africa. Lavender and lavandin oil have long been the major essential oils produced on the southern slopes of the French Alps. The world production of high quality lavender oil is about 200 tonnes per year. Australia's largest farm producing lavender oil is the Bridestowe Estate near Nabowla in the north east of Tasmania which was established by the Denny family in 1921. The estate currently produces a high quality lavender oil following many years of line selection from *L. angustifolia.* Oil produced by this plantation is highly regarded by the industry. Oil yields at the Bridestowe Estate have been reported to be normally 50kg/ha but may be up to 70kg/ha. Recent, annual production at this estate has been approximately two tonnes per year.

Lavandin is native to Spain, France, Italy, and the Balkan Peninsula. Over recent years Bulgaria has become a major producer. Even more recently the changes in the economies of countries like Bulgaria and the former USSR make the price of lavender and lavandin oils fluctuate markedly. The ratio of lavender to lavandin production worldwide is about 1:5 and the prices for lavandin are lower. Lavandin plants produce more oil and are hardier than lavender plants. The world production of lavandin oil is about 1000 tonnes per year. Lavandin oils have been progressively replacing lavender oils for all but the most expensive products. Though lavender oils bring higher prices, the higher yield of lavandin make it worthy of consideration. While there is no shortage of all three of these oils, a stable supply of high quality lavender oil similar to that produced in France and Tasmania is likely to always have a market. Spike lavender has its main production area in Spain but grows wild over a large part of the Mediterranean area, preferring warmer and lower regions than lavender and lavandin. World wide production of spike lavender oil is 150-200 tonne per year. The prices obtained for lavender oils vary widely based on quality and batch size. A broad guide to bulk prices of the three major groups is:- "True Lavender" about $A60/kg, "Lavandin" about $A15/kg and "Spike Lavender" about $A60/kg (as at Sept.95). Remember that these prices are for large volumes moved through the established traders. Niche marketing of high quality products in smaller volumes will result in higher prices being realised. The developing aromatherapy market is an area that lends itself to such market targeting.

Uses

The oils from lavender, lavandin and spike lavender have long been used separately and in combination with other essential oils in the fragrance and perfumery industry. Minor uses, in terms of quantity, include aromatherapy which relies on the sedative effects of lavender oil vapours. The most likely component to be active in this regard is linalool.

Production of lavender

The following notes relate to production of lavender oil under Australian conditions. There is very little data available on the production of lavandin and spike lavender in Australia.

Cultural requirements

Lavender requires free-drainage and less irrigation than most essential oil crops. The plants have a deep rooting system and are tolerant to both moderate frosts and drought. Severe frosts will affect the plants. Soils of neutral (7) pH are preferred but successful crops have been produced over the range 5.8 to 8.3 pH. Nutrition of lavender crops will normally involve some additional phosphorus (P) (about 33kg/ha actual P in Tasmania) and potassium (K), however the actual amounts will vary with soil types. Nitrogen (N) will need to be supplied in up to four split dressings throughout the growing season and could total 80-100kg/ha of actual N each year. Care should be taken to produce the appropriate balance of flowers and leaves. Experience on a given soil type and geographic region will be required to get the best production of oil.

Propagation

Propagation is normally accomplished by taking cuttings from known genetic sources in winter. Fields are planted in rows 1-1.2m apart with intra-row spacing of 0.4m at an approximate density of approximately 20,000 plants/ha. The first year of the plantation should be for establishment. Harvest in the second year will depend on the rootstock vigour of a particular stand. The life span of lavender plants is 10-15 years after which replacement plantings may be required. Attention to obtaining the correct genotype is essential as recognised markets are only open to oil that closely resembles the international standards. Sources of the preferred genotype are currently not easily available.

Pest and diseases

There are several disease and pest problems that occur in overseas plantations. Australian plantings have been relatively free from pests. An exception found in the Tasmania lavender oil producing area is the light brown apple moth *Epiphyas postvittana*, a pest of significant proportion (in apple growing areas), which may require some control measures if found on lavender. Root diseases, *Fusarium sp.* And *Armillaria sp.* have been a problem but selections of resistant plant types can reduce this problem. The soil nematode, *Meloidogyne hapla*, has been reported as a potential threat to lavender production in India but has not yet been a problem in Australia.

Weed control

Lavender does not offer good competition for weeds, therefore attention to weed control is very important. Apart from nutrient and water competition between lavender and weeds, there is considerable risk of contamination from the weed species in the distilled oil product if weeds are allowed to grow in the rows.

Harvest

A dedicated harvester that lifts and clips only the flowering stems has been developed in Tasmania and would be needed to efficiently harvest the crop. Over two tonnes of flower heads per hour is achieved using the Tasmanian harvester. Yields of 0.8% oil from fresh flowers have been reported. Typical lavender oil yields of 50kg/ha can be expected from mature plantings.

The highest lavender oil yield obtained in Tasmania is reported to be over 70kg/ha. Harvest commences from mid-December to early-January depending on seasons in Tasmania. **Extraction**

Steam distillation

The oil is released from the oil glands in the flower heads using steam distillation. Speedy extraction of the oil has some quality benefits. Normal steam distillation equipment as used in the peppermint and eucalyptus oil industries can be used for lavender oil extraction. Trial distillations of lavender oil have been performed successfully at the Ovens Research Station from locally produced lavender crops. Laboratory-scale distillation units that process 3kg of flowers at a time are well suited to varietal selection work. These units can be bought or assembled from readily available parts for a few hundred dollars. Equipment for commercial distillation operations would start at a 0.5 tonne distillation plant which could be constructed for approximately $10,000 and a fully commercial distillation unit that would hold up to 8 tonne of flowers could cost $300,000.

Solvent extraction

A smaller quantity of lavender and lavandin concretes is produced in Southern France by solvent extractions. Concretes are extracted from fresh plant material using solvents such as toluene, hexane and petroleum ether. The solvents are evaporated off leaving residues called concretes. Concretes find uses in the perfumery industry (particularly soaps). As in the distilled product the yield of lavender is less than lavandin using solvent extraction. A further refinement is to mix concretes with ethanol. The mixture is then cooled and filtered, then the ethanol is evaporated to produce a wax-free residue called an absolute. There is frequently a 50% yield loss from concrete to absolute. Absolutes are more widely used in fine perfumery.

Availability and selection of variety

For the production of high quality lavender oils the use of the correct genotype or variety of lavender cannot be too highly stressed. This must be considered as a primary research step in any potential enterprise. To obtain the correct supply of lavender, the plant variety and strains from a range of sources must be selected and planted in the field. This selection process may take several years. It is essential that harvest and oil distillations, over more than one year, be undertaken. Assessment of oil quality by the use of gas chromatography and organoleptic testing will also be needed.

SCENTED GERANIUM

Common Name	Scented geranium
Botanical Name	*Pelargonium graveolens L.Herit*
Family	Geraniaceae

Importance and chemical composition

` Scented geranium (*Pelargonium graveolens L.Herit*.) is one of the important aromatic crops, yielding an essential oil which is highly priced for its very profound and strong rose-like odour. The plant is also known as rose Scented geranium. The chief constituent of the oil are geraniol and citronellol. The pure scented geranium oil is almost a perfume by itself and blends well with all other perfumes. It is widely used in scenting soaps and for the isolation of rhodinal which forms part of most high-grade perfumes. India is importing more than 20 t of this oil from other countries to meet the local demands of the Indian perfumery industries, in addition to an indigenous production of only about 20 t of oil annually.

Origin and distribution

Scented geranium is a native of the Cape Province in South Africa. It is commercially cultivated in France, Belgium, Spain, Morocco, Madagascar, Egypt, Reunion Island, Congo, China, India and the former USSR countries. The world production of Scented geranium oil is estimated at 250-300 t, whereas the demand is more than 500 t annually. The first planting of high-yielding *P. graveolens*, introduced from Reunion Island was grown at Yercaud by a French planter, Ernest Sens in the early twentieth century. From that time onwards it has been cultivated as a commercial crop, but only in high altitude areas with a milder climate. However, the crop also comes up well in the South Indian plains. Presently, it is being commercially cultivated mainly in the Nilgiris and Kodaikanal
Hills of Tamil Nadu and in and around Bangalore in Karnataka, also in Uttarkhand in an area of about 2 000 ha.

Area and production

Geranium is cultivated in a meager extent in India; especially in Tamil Nadu in Kodaikanal hills.No precise data is available on production.

Description of the plant

The commercial oil of Scented geranium is obtained from *P. graveolens*, L. Herit.(2n=88) of the family Geraniaceae. There are about 600 species of the genus Pelargonium, many of which possess an agreeable odour. Other species like *P. radula*, *P. fragrance* are of lesser importance and have not attained any commercial significance. Scented geranium is a bushy, aromatic plant. The stem is cylindrical, woody at the base, pubescent, green when young and turning brown with age. The leaves are highly aromatic in nature.

Types/varieties

1. Algerian or Tunisian

This type of Scented geranium is slender with flowers of a dark pink colour. It is being grown in the Nilgiris and is unsuitable for wet conditions. This variety yields 5060% more oil with a more delicate odour than that of the Reunion type.

2. Reunion or Bourbon

Grown in the Nilgiris and Anamalai hills, the plant is sturdier with light-pink flowers and more suitable for wet conditions. The oil content is higher during the summer months from April to June. The terminal portion with 6 to 12 leaves contains more oil than the middle and basal portions. **KKL-1:** In the evaluation trial of the Algerian and Reunion types, PG-7 and PG-20, respectively at the Horticultural Research Station, Kodaikanal, the clone PG-7 recorded 0.3% essential oil has been released under the name 'KKL-1'.

Sel-8: The Indian Institute of Horticultural Research (IIHR), Bangalore, has found 'Sel-8' a Reunion type, as the highest yielder under Bangalore conditions and has recommended it for cultivation. 'Hemanti' 'Bipuli' and 'Kunti' are the other varieties released by the CIMAP, Lucknow, for cultivation in the plains of North India. Kelkar and Ooty, are the other varieties available in this crop.

Cultivation

Soil

Scented geranium is shallow-rooted crop and, as such, it requires well drained porous soil. The crop is found to perform well in red lateritic soils with a pH of 5.5-8.0, though a calcium rich porous soil is the best.

Climate

Scented geranium can be grown in temperate, subtropical and tropical climates at various altitudes from 1 000 to 2 200 m. It thrives best in subtropical climates with a temperature ranging from 5°C to 23°C. However, temperatures below 3°C will kill the plant. Warm winters coupled with mild summer temperatures and, well-distributed annual rainfall ranging from 100-150 cm is ideal. However, heavy rainfall results in water-logging, causes root-rot and stunted growth. It has been observed that it grows equally well at much lower altitudes and tolerates higher temperatures up to 43° C in the plains when grown under irrigated conditions.

Propagation

Scented geranium is easily propagated by cuttings, since there is no seed setting in Scented geranium, vegetative propagation is must. Terminal cuttings about 20 cm long and consisting of about 8 nodes are the best suited material for propagation, as they give 80% rooting even without any treatment. However, the middle portion and basal cuttings are reported to give poor rooting, which can be improved by treating them for 6 minutes with growth regulators like IBA or IAA at 200 ppm. Thus, a rooting of 80% and 65% respectively can be obtained.

The cuttings are planted in raised beds of 3 m long and 1 m wide. The soil should be well mixed with powdered FYM. The cuttings are planted closely at a spacing of 8-10 cm. Before planting, the cut ends are dipped in 0.1% Benlate solution. Before root initiation, temporary shade is provided and the beds are watered regularly. The nursery is sprayed with a 0.2% urea solution at biweekly intervals and the cuttings are ready for transplanting. They can also be rooted in polythene bags, which help to avoid damage to the root-system while planting in the main field. This practice ensures a high percentage of success in the field.

Recently, its propagation through leaf petioles has also been reported to give a good rooting percentage (75%), which will help to multiply this plant in larger numbers than the traditional method of propagation using 20 cm-long cuttings. The CIMAP, Lucknow, has developed a protocol for large–scale production of scented geranium calliclones and plants have been obtained under field conditions with improved oil-yield and quality.

Planting

About 30,000 cuttings are required for planting a hectare area. Before planting, the land should be properly prepared by ploughing (disc) and brought to a fine tilth. Ridges and furrows are made, the application of fertilizer and irrigation should be done a day prior to planting. The cuttings are carefully dug out from the nursery and planted at a spacing of 60 cm x 60 cm.

Irrigation

Plants are irrigated immediately after planting. Irrigation is continued on alternate days for about 10-15 days and then reduced to twice a week. The schedule is modified during the winter and summer months at intervals of 7 to 10 days, depending on the situation. Though scented geranium tolerates short periods of drought, water-logging of the crop must be completely avoided.

Weeding

The crop growth is slow initially; weeds should, therefore, be removed periodically. Trials conducted at CIMAP, Lucknow, revealed that mulching helps in reducing weed infestation, the number of irrigations and produced less weed biomass.

Intercropping

Intercropping of cowpea or black gram is beneficial during the log phase and they do not affect the Scented geranium crop. **Manures and fertilizers**

Prior to transplanting the cuttings, 10 t of FYM, 35 kg N, 35 kg P_2O_5 and 35 kg K_2O/ha are incorporated into the soil. A second dose of nitrogen at 35 kg/ha is applied about 2 months after the first application, Further, nitrogen is given in two equal split doses for each harvest-the first dose being just after the crop is harvested and the second two months later. Altogether, 210 kg/ha/yr of N is applied to the crop in six equal doses to cover three harvests. Similarly, an application of copper (20 kg/ha) and molybdenum (30 kg/ha/year) in four split doses after each harvest has been found to increase the yield by 37%.

Pests and diseases

Wilt

The crop is affected by wilt disease, caused by the *Fusarium* species, and *Botrydeplo diatheobromae*, which are soil borne fungi.

Control measures

Dip the cuttings in 0.03% Benlate solution at the time of planting in the nursery.Prior to transplanting the rooted cuttings must be again dipped in 0.03% Benlate solution and then planted. The crop is sprayed with 0.03% Benlate solution about 2 weeks before it is harvested. Also after the harvest it is repeated, so that the cut-ends are drenched with the fungicide. It has been observed at the CIMAP, Lucknow, that the cultivation of Scented geranium in association with marigold (*Togetes minuta*) improves the survival of Scented geranium plants over the monsoon time in the North Indian plains.

Roots-knot nematodes (*Meloidogyneincognita* and *M. hapla*): Affect the Scented geranium plant. Application of Aldicarb @ 20 kg/ha to the soil reduces the incidence of root-knot. **Harvesting and processing**

Scented geranium is harvested 4 months after transplanting, when the leaves begin to turn light -green and exhibit a change from a lemon - like odour to that of rose. However, this requires careful observation and experience. The crop should be harvested using a sharp sickle and sent for distillation im mediately. The use of sharp sickle is important as it minimizes the jerks, pulls and damage to the crop while harvesting.

After every harvest, hoeing, fertilizer application and irrigation are done according to the schedule. The plant then puts forth fresh shoots, grows faster, and reaches the next harvesting stage in 4 months. Thus, a total of 3 harvests can be obtained for 3-6 years.

Cultivation under polyhouse conditions is reported to reduce the harvest time by 21 days.

The essential oil is distributed over the green parts of the plant, particularly in the leaves. The oil content is higher during the summer months, from April to June. The terminal portion with 6-12 leaves contains more oil than the middle and basal portions.

Yield

The quality and yield of oil will be better if the crop is harvested at the appropriate time of maturity. For a higher yield, a good plant population in the field is necessary. A minimum of 25,000 plants should be maintained in a hectare in a year which, in turn, may yield 15 kg of oil on steamdistillation. The recovery of the oil ranges from 0.08 to 0.15%, depending upon the season of harvest and type of material. Cultivation under polyhouse cover is reported to increase herb and oil yields up to 53% over the conventional planting of the scented geranium crop.

PATCHOULI

Common Name	**Patchouli**
Botanical Name	***Pogostemon cablin* Benth.**
Family	Lamiaceae

Patchouli, an aromatic herb is distributed in the Indo- Malaysian and Sino-Japanese regions. The shade dry leaf upon steam distillation yields the Patchouli oil of commerce, which is used in perfumery, cosmetics, processed food and is imported into India every year in large quantities. The essential oil is one of the best fixatives for heavy perfumes, which imparts strength, strong character, alluring notes and lasting qualities. Natural fragrances like sandalwood, rose, jasmine, vetiver, agarwood and patchouli are complex mixtures of organic molecules, which cannot be reproduced in the laboratory. Thus, patchouli enjoys an additional importance as aromatic oil. In fact, it is a perfume by itself and is highly

valued in perfumes, soaps, cosmetics and flavour industries. Patchouli alcohol ($C_{15}H_{26}$) will have long-lasting fragrant aroma when blended with other aroma chemicals.

Patchouli is native to The Philippines and grows wild and also cultivated in Malaysia, Indonesia, Singapore, China and India. Leaves constitute the economic part, which contain the oil glands. The plant, an erect, well-branched, pubescent, small aromatic bushy herb attains a height of about 0.5 – 1.2 m. that yields fragrant leaves containing very sweet smelling oil.

Commercial Importance

Patchouli oil is an essential ingredient and used as a 'base' material in perfumery industry. There is no synthe tic substitute for patchouli oil, which increases its value and demand in the perfumery market. Consumption of Patchouli oil in the world is about 2000 tonnes per annum. In India due to increase in chewing tobacco and pan masala industries, consumption has gone up to about 300 tonnes per annum while the production is below 50 MT. Hence, the country mostly depends on import mainly from Indonesia.

Economic crop cycle

Patchouli is a perennial species and as a crop can be maintained for more than one year but yield declines after about 3-4 cuttings. Therefore, it is advisable to take patchouli as an annual crop for average condition particularly for plains. However, the crop can be attained for 18 to 24 months period economically in well-drained soil with proper care. The first 3 to 4 cuttings give better leaf material; the quality declines with subsequent cuttings. Therefore, for quality products it is better to consider patchouli as an annual crop.

Variety selection: Indonesian type. A promising selection and well adapted in Assam conditions.

Soil and Climate

The land selected for patchouli should be well-drained, loamy fertile soils, rich in organic matter. The land should not be subjected to water stagnation even for a shorter period. Heavy clay and sandy soils with poor water holding capacity are not suitable for its commercial ultivation. Acidic soil with pH value from 5.5- 6.2 is reported to be the ideal. It is advisable to avoid nematode infested areas. Patchouli prefers warm and humid climate. The crop can be grown successfully on a fairly heavy and evenly distributed rainfall ranging from 1500 –3000 mm per annum. A temperature of 24 – 28° C and an average RH of 75 % are taken to be ideal. It grows successfully upto an altitude of 500 m above the mean sea level.

Propagation

Patchouli is propagated through stem cuttings. Terminal stem cuttings are taken from healthy mother plants growing either in open area or under light shade (less than 30 %). Cuttings obtained from crops growing in shaded area the internodes become longer with soft stem of which the survival percentage is low. Cuttings with shorter internodes are preferable.

Nursery rising

Cuttings are rooted in nursery equipped with provision of shade and water supply before planting in main field. Rooting is done either in poly bags or directly in beds under shade. Best time for rooting is during April-September. But with precautions cuttings may be rooted any time of the year. Cuttings are best rooted in poly bags, which gives highest survival percentage when transplanted in the main field. When rooted directly in raised beds cuttings are planted at a spacing of 10 x 10 cm. Cuttings become ready for transplanting in about 30 – 45 days during April – Sept and 45 – 60 days during October to March. Cuttings are prepared in the morning or afternoon period. Apical and branch twig of 10-15 cm long with 4-5 nodes is cut away from healthy mother plants. At least two pairs fully developed lower leaves of the cuttings are stripped off before planting in rooting medium. For early rooting cut ends are dipped in IBA hormone solution of 1000 ppm strength (1 g per litre water gives 1000 ppm. This is prepared by dissolving the hormone powder in little alcohol and then made up to volume by cold water) for 5-7 seconds and spread 10 minutes in shade for drying. Hormone powder in ready to use form like Rootex or Seradex etc available in the market in 3 grades of which the 'No.2' or 'B' grade may be used directly. Hormone treatment seems to be helpful when seedlings are prepared during winter as hormone enhances root initiation.

Rooting media

Best medium is riverbed sand or silt. An ideal rooting medium can be prepared by mixing 50 part sand + 50 part soil. Quickest rooting is obtained in riverbed sand.

Hardening of seedlings

Hardening of the seedlings is necessary before planting. This is achieved by gradual reduction in water supply and removing shade from about 7-10 days ahead of planting. Before planting the poly bags are to be watered adequately. This helps rainfed crop in early establishment. Only the selected healthy seedlings of 30-45 days old should be planted.

Time of planting

March – May followed by September - October considered ideal. Avoid planting during winter (Dec-Jan) and high rainfall period (July-August). Planting in wet soil during July-August shows poor growth due to temporary anaerobic condition developed within the root zone. Planting of mother plants for propagation should preferably be done during Sept.-Nov.

In Assam excess moisture in the root zone during *kharif* leads to severe root rot during JulyAugust particularly in plains. As a result it becomes difficult to maintain optimum plant population. Under this situation planting in Sept – October and harvesting thrice and terminating the crop in the later part of July or during August gives good harvest.

Spacing: 45 x 45 cm in raised beds in plains and 60 x 45 cm in sloppy lands.

Planting

Poly bag seedlings can be transplanted throughout the day. But if the cuttings are rooted directly in seedbed and planted in the main field then planting should be restricted in afternoon only. However, if the day is cloudy it can be done any time of the day.

Method of planting

(1) Double row planting at 45 x 45 cm spacing in raised beds keeping a gap of 60 cm in between two beds. This should be on ridge (containing two rows) and furrow style when the soil is clay loam to clayey in texture.

(2) 4 rows at 45 x 45 cm spacing on raised beds. The height of the beds should be depending on soil texture. In case of light texture it is low height and in case of heavy soil height should be more so that the root system does not remain in saturated zone during rainy days. A gap of 65-70 cm may be kept to serve as drainage and to facilitate cultural practices, harvesting etc.

Detopping / Tipping

Tips should be removed after 20-30 days of planting to encourage early branching. This can also be done at the time of planting. When the age of seedlings exceeded by 45 days in the nursery, then the top is removed in the nursery itself. Cutting back the main stem leaving 3-4 nodes above ground surface at 45-60 days of planting is done enabling branching from lower sides of the crown. This will give a bushy architect of the plant.

Mulching

After 2nd hand weeding and top dressing apply mulch in adequate quantity at 45- 60 days of planting when planting is done during Sept-October. Mulching with organic waste (like patchouli spent after distillation) or any other organic matter gives best results. In case of March-June planting, post monsoon (October) mulching is beneficial for rainfed crop. In termite infested field anti-termite drenching is necessary.

Manures

15-20 ton FYM or compost or well decomposed cowdung per hectare should be applied at final land preparation. If organic manure is not available in bulk green manuring crop should be raised and incorporated in soil. During monsoon period greenmanuring crops like *Sesbania rostrata* or *Sesbania aculeata or pulses like Cowpea* may be grown in between rows and at 50-60 days of growth may be uprooted and cut into pieces and applied as mulch.

Fertilizers

A fertilizer dose of 100 kg N, 50 kg P2O5 and 60 kg K2O per hectare is recommended. Basal application of 330 kg Single super phosphate (SSP) and 50 kg Muriate of potash (MOP) is done at least 2 days ahead of planting. Total quantity of 220 kg urea /hectare/ year in 4 equal splits should be applied. An extra dose of 30 kg K2O as top dressing along with 4th urea application may be done. It is better to avoid application of urea as basal initially. Because it will encourage weed growth and part of it will go

waste as the newly planted seedlings remain unable to absorb the available N. The annual dose of NPK for subsequent years should be applied during March when there is irrigation and in May/ June without irrigation.

Top dressing

Out of total urea of 220 kg/hectare/year should be applied in 4 equal splits as given below. Additional 30 kg Muriate of potash should be applied after 90 days growth to increase the resistivity against adversity.

N application schedule (Topdressing) /ha

Assuming the planting date-15th February, 100 kg N in the form of urea in four equal splits

No. of application	Days after planting	Time of application	N (kg)	Urea (kg)	K2O (kg)	No. Of harvests
Ist	45	March 30	25	55	-	----
2nd	90-100	May 15	25	55	30	1st harvest
3rd	135-145	June 30	25	55	-	2nd harvest
4th	170 -180	July 30	25	55	-	3rd & 4th harvest

NB: Depending on crop duration another one or two top dress should be applied. During application urea should be mixed with 2-3 volume of sand / dry cowdung. **Foliar feeding**

Application of 0.5 - 1.0% urea as foliar spray at 20 days and 10 days before harvesting found to increase herb and oil yield. This is in addition to the above fertilizer schedule. **Cultural practices**

Compaction of surface soil particularly around root zone is avoided. This is achieved by racking with dry land weeder twice or thrice followed by one hand weeding. Forking and raking besides weeding is found to be beneficial in developing a strong root system. Incorporation of urea with soil is done by racking and hand weeding. **Irrigation**

Sprinkler irrigation is advocated. Immediately after planting light watering daily upto 3-4 days and thereafter irrigation at 10-15 days interval should be applied. Saturation of poly bags before planting in field eliminates watering for 2-3 days. Surface drainage is more important than irrigation in high rainfall plains.

Age of harvesting

New shoots from lower branches start developing only when the branches are pruned back above active buds at early stages of growth. With age the lower buds become dormant and as the branch grows tall creating shade, the lower leaves are defoliated. Plant growth is continuous; all parts of the plant cannot attain harvestable age at the same stage. Therefore, those branches attain the age of 70-90 days should be selected and cut back leaving 2-3 active buds or new shoots for regeneration. Delayed cutting beyond 100 days, defoliation from lower part started. A typical patchouli odour emanates while harvesting the plant.

Harvesting

Patchouli should be harvested following selection method. In this method a partial harvest is taken at 60-65 days after planting. At 90-100 days after planting the first regular harvesting is done by cutting selected matured branches only. Branches so selected should be about 70 – 90 days old and showing signs of maturity as 1-2 lower leaves turning yellowish. These branches bear 6-7 pairs of leaves. In 1st harvest the main branch should be cut back above 3-4 nodes from base depending chances of regrowth. Growing buds in the lower side get suppressed and degenerated in absence of light and apical dominance

if harvesting is delayed. If top portion is cut back just above the buds, the growing buds develop quickly into new branches. Harvesting of mature branches is otherwise encouraging the new shoots from lower sides of each branch. In selected harvesting (pruning) the plant is not getting enough stress and normal metabolic functions continue through out the growing period. Harvesting and other intercultural operations should be done from the side drains only without disturbing or compacting the root zones. This is necessary for quick regeneration by maintaining soil aeration. The selection of the branch for harvesting can be so planned that a few branches attain this stage at an interval of 35-45 days.

Harvesting time

Harvesting in the morning cool hour gives desired result. Harvesting can be done in the afternoon hour also but in no case during midday scorching sunny hour and rainy time. If the day is cloudy and not raining harvesting can be done throughout the day. After harvesting and till the herb is brought to the drying shed the fresh herbs should be kept spreading in thin layer and not in heaps to avoid loss of oil by heat generation due to continuing respiration. They should be kept spreading till they are physiologically active.

Drying of leaves

After harvesting, the fresh herbs should be spread over on bamboo mats or on *tarpaulin*for drying under shade for 7-10 days. The thickness of the herb should not be more than 2 inches. Turning atleast once in a day is necessary to avoid fermentation and for uniform drying. A drying structure of 30 x 15 ft with 4 tiers racks is sufficient to cope up one-hectare area. The drying house may be constructed by bamboo with thatched roof or tarpaulin roof or may be a semi permanent structure with tiers. The fresh and dry ratio of herb is 5.5: 1 at around 12 % moisture. **Low cost drying shed**

Storing of dried leaves

The dry leaves should be packed tightly in gunny bags and stored at least for 3 months without touching ground. **Distillation**

Shade dried and cured leaves are subjected to steam distillation for obtaining the oil of patchouli. The distillation unit consists of a boiler, distillation still, condenser and receiver. The distillation still is made up of preferably food grade stainless steel (304 or 316). The vessel has a perforated metal sheet or net above the bottom to support the herb, which is loaded into the still for distillation. Steam is injected through perforated coils that uniformly pass through the material. This steam while passes through takes out the oils by rupturing the oil glands that moves to condenser along with water vapour. The condenser, which cools the hot vapours received from the still, consists of mainly tubes made up of stainless steel and mounted inside a jacket. The condenser id provided with inlet and outlet for the circulation of cooling water. The hot vapours consisting of steam and essential oil vapours are cooled in the condenser tubes and the condensate then flows out into the receiver.

The oil being lighter than water and insoluble flows on the top in the receiver and only the water gets drained out. The oil is drawn off separately at the end of distillation.

The process of distillation consists of loading the dried leaves into the still, closing the lid securely, letting in steam generated in the boiler from the bottom of the still, condensing the vapours in the condenser and collecting the oil in the receiver It has been noted that interchange of light and low pressures, i.e., 1.4 to 3.5-kg/sq cm produces better yield as more cell walls rupture in this process. The duration of distillation varies from 12- 16 hours. Prolonged distillation gives higher yield and better quality of oil.

Oil recovery and oil yield: On an average a recovery of 3.0 to 3.5 % is obtained which varies largely on drying procedure, leave: stem ratio and curing. A yield of 135 to 180 kg from 45 to 60 q dry leaves is obtained.

Drying and storage of oil

Immediately after the distillation, all free water is removed completely and the remaining traces can be removed treating with anhydrous sodium sulphate @ 20-30 g per litre and stirring the contents vigorously. Left for 4-5 hours after which the water free transparent oil is obtained by filtering. The oil is now fit for storing. The purified oil is stored in clean aluminum containers.

Yield

5-6 cuttings (14-16 months) yield 375-450 q fresh herbs, which on drying gives 67-88 q dry herb/ha/year. When the crop is grown as seasonal crop 3 - 4 cuttings yield 247 - 275 q fresh herb or about 45-50 q dry herb/ha within a span of 8-9 months may be obtained. Under optimum management it can generate more than Rs. 60,000/ha in one cut.

Plant protection measures

Diseases: During July-August in some areas leaf and stem gall disease caused by a fungus *Synchytrium pogostemonis f.sp. patchouli* appears in a considerable extent. Soil application with PCNB (Penta chloronitre benzene) or Brassicol @ 5 kg/ha or 1 % Bordeaux mixture (100 g copper sulphate + 100 g lime in 10 litre water) should be done 10-15 days ahead of planting. On appearance of symptoms 2-3 foliar sprays should be given at a 7-10 days interval with copper oxychloride like Blitox 0.25 % or Bordeaux mixture @ 0.5 or Bavistin (0.25-0.30%) as control measure. This should be done after removing of affected branches. As a precautionary measure especially during monsoon one spray of Bavistin (1g/litre of water) should be given after each harvest. In heavy soils of plain land impeded drainage causes root rot and wilting followed by death of plants. In plain planting in raised beds or in ridges minimizes incidence. Proper drainage should be ensured. *Trichoderma viride* a beneficial soil fungus when used as soil drenching helps in minimizing root rot. Application of "Redomil" (a systemic fungicide) with irrigation water or drenching the root zone found to be effective.

Leaf Roller (*Pachyzacia stultalis)*: Larvae of patchouli leaf roller characteristically roll a few leaves and feed inside causing browning and drying of infested parts. Infestation is high when the crop is raised under plantation having more than 30 % shade and causes considerable damage to the crop. Sometimes the entire leaves are infested particularly during October to December. Collection and destruction of rolled leaves followed by spraying of 2-3 rounds of methyl parathion @ 1 ml or fenvalerrate 0.5 ml/lit water will control the pest.

Myriad bug (*Pachipeltis spp*): This bug makes small holes all over the leaf surface. The insect can be controlled by spraying Dimethoate 30 EC (Rogor, Tara 909 etc) or Monocrotophos (like Nuvacron) at 1 ml/litre of water or Malathion 30 EC once or twice.

Mite: Ethion or Kelthane (Acaricide) may be sprayed once or twice to control mites **Nematode:** On appearance of nematode symptoms apply Furadan granule @ 2.5 g/plant following ring method. Furadan should be mixed in the soil before filling in poly bags @ 1 kg per 100 kg soil medium. Use of adequate decomposed cowdung and organic matter keeps down the population of the pest. Avoid nematode infested areas for patchouli cultivation. Marigold can be planted in field and also in field boundaries as trap crop greatly reduces the infestation.

Crop rotation

In heavy infested area, crop rotation with short duration legumes after patchouli will keep down the nematode incidence and other soil borne fungal diseases to a great extent.

Economics of cultivation

(A) Seedling cost

Planting material alone accounts for more than 50 % of the total cost of cultivation. Therefore, a grower should raise his mother plants atleast 6 months ahead of planting and go for multiplication. A poly bag raised rooted cutting costs Rs. 0.65 – 1.00. The cost of 40,000 Seedlings required /ha is about Rs. 40,000. Therefore, one should raise a mother stock in about 1/20th of the target area and after 4 months to start taking cuttings. Starting from 4 months to 6/7 months the multiplication rate would be 20-25 times or even more.

MINT OR MENTHA

Common Name	**Mint or mentha**
Botanical Name	***Mentha* spp.,** *Mentha arvensis, Mentha piperita*
Family	**Lamiaceae**

Mint is important oil bearing aromatic herb. It is also the world's third most valuable flavouring agent, obtained from the distillation of the aerial biomass of some of the important cultivated species throughout the world. The oil and aroma chemicals in pure form command a massive demand. These derivatives of mint have their uses in food allied industries. In recent years, the use of mint oil has widened and a number of product ranges have been developed using mint oil. To meet the extensive demand, there is a need to promote mint cultivation in the country.

Origin and distribution

Mint is native to China. It was brought to Japan from China, from where it spread further after World War II. Chambers and Hummer (1992) reported 18 recognized taxa with nine mainly in European, one endemic each in North America, North Africa and Japan. In India, six wild species are reported in the hilly parts of the North Western Himalayas. Japanese mint was introduced to India in 1952, when the Regional Research Laboratory (RRL), Jammu obtained a few stallion of the crop from Japan. The material was planted under temperate conditions in Kashmir and various parameters of the crop were studied. The Drug Research Institute (DRI), Jammu, initiated the first ever commercial farm at Chakrohi, Jammu under the technical guidance and support of the Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow. This was the foundation for the cultivation of Japanese mint, which now plays a great role in chemical industries.

Area and production

Japanese mint is grown in Brazil, Japan, Formosa, China, India, South East Asia, Australia, France, Angola and Argentina. In world production of mint, China, Brazil, India, Paraguay and Taiwan, contribute the major segment. However, Korea, Thailand and Japan are other important mint growing countries. The U.S.A., mainly the states of Oregon, Indiana, Idaho, Ohio and South Michigan, is the largest producer and contributes 90 % of the world's production of peppermint (*Mentha piperita*) oil. The annual production was reported to be 2000 tonnes. U.S.A. grew *Mentha piperita* on 1, 00,800 acres, spearmint on 26,400 acres producing oil of market value of $ 86.4 and $ 25.5 millions, respectively. Other peppermint oil producing countries are France, former USSR, South Africa, Italy, Yugoslavia, Hungary, U.K., Thailand, Vietnam, Bulgaria and India. *Mentha citrata* has less acreage and is confined to China, Taiwan and India. According to an estimate, its production in China is about 500 tonnes annually.

Currently, India is the largest producer of mentha oil (16000 tonnes of *M. arvensis*, 400 tonnes of *M. piperita* and 5 tonnes of *M. citrata*). In India, *Mentha arvensis* is cultivated in the Western Himalayas, Kumaon, Garhwal, Kashmir and Punjab, *M. Piperita* in the states of Maharashtra, Jammu and Kashmir and Punjab and *M. spicata* in Punjab, UP and Maharashtra.

Composition and uses

Japanese mint (*M. arvensis*), commonly known as menthol mint, contains a very high per cent of menthol (75 to 81 %). It is used in cold remedies; cough drops, dentifrices, mouthwashes, cosmetics, and scenting cigarettes, flavouring tobacco and chewing tobacco. It has antiseptic and stimulant properties. A moderate quantity goes into the preparation of perfumed cosmetics and into the flavouring of foodstuff. Menthol mint oil has antimicrobial properties and enhances the shelf life of edible products and syrups.

Peppermint oil contains a comparatively lesser amount of menthol (50 to 60 %) and a delicate flavour. It is an excellent carminative, antiseptic and preservative and has gastro-stimulant properties. It is mainly used in flavouring applications, particularly in a wide range of pharmaceutical preparations such as toothpaste, dental creams, mouthwashes, cough syrups, alcoholic drinks, chewing gums and confectionery. Some quantity is also used in perfumery.

Mentha spicata is rich in carvone, a digestive and gastro-stimulant compound. This oil has been reported to contain as many as 109 components of which some are yet to be identified. The bulk of its oil is used in flavouring toothpaste, chewing gum and confectionery. Bergamot mint oil is a source of linalool and linalyl acetate and is mainly used in perfumery and cosmetic industry.

Botany

Mint is an ever-growing perennial herbaceous plant. It is a prostrate growing herb attaining upto one m height in rich soil. The leaves, bearing oil glands, are simple, opposite or whorled, broadly ovate and narrow at both ends. The stems are quadrangular and violet tinged. The plant produces long and narrow axillary flowering spikes. The inflorescence is verticillaster (a condensed form of a cymose inflorescence with a cluster of sessile or almost sessile flowers in the axil of a leaf forming a false whorl at the node), the flowers are lilac coloured, zygomorphic, hermaphrodite, pentamerous, calyx jointed, five in number, corolla five in number, ovary bicarpellary. The fruit is a group of four nutlets, each with one seed. Mint is a cross-pollinated crop and due to hybridity, it hardly sets seed. The seeds are non-endospermic.

Species and cultivars

Species

Naturally polymorphic, small genus of the family Labiateae (Lamiaceae) consists of 40 recognizable taxa. Several new taxa have been evolved through frequent out-crossing in nature and get established due to clonal survival.

Japanese mint—Japanese mint is the main source of mint oil and methanol. It has been cultivated in Japan for its essential oil since antiquity.

Peppermint—*Mentha piperita* is a native of the temperate climate of Europe, Asia, North America and Australia. It is considered to be a hybrid between *M. spicata* and *M. aquatica*. Since *M. spicata* itself is a hybrid of *M. longifolia* and *M. rotundifolia*, *M. piperita* is considered to be triploid hybrid.

Spearmint—*Mentha spicata* L. variety crispata Schrad with 48 natural chromosomes is double diploid (amphidiploid or allotetraploid) in origin and has 24 bivalent pairs which disjoin to produce complete seed and pollen fertility, as well as monogenic or duplicate gene segregation.

Scotch mint—M. *cardiaca* is a hybrid of *Mentha arvensis* and *M. spicata*.

The *M. cardiaca* cultivar with a carvone chemotype is believed to be a *M. arvensis* x *M. spicata* F1 hybrid. The two rather closely related spearmint viz. *M. spicata* and *M. cardiaca* produce the same ten essential oil constituents in somewhat different quantitative amounts.

Bergamot mint—*Mentha citrata* Ehrh is considered to be a variety of the species, *M. aquatica*.

Cultivars

Species and cultivars of various mints grown in India

Species/variety	Herb yield q/ha	Oil content (%)	Oil yield Kg/ha	Major constituent (%)	Remarks
Mentha arvensis				Menthol	
MAS-1	762	0.8-1.0	290-293	81.0	Dwarf, early maturing, best price in the market, not good for ratooning because of low congealing point.
HY-77(Kalka)	120.O	0.60	72.0	81.5	Tall, vigorous, compact growing culture, highly resistant to leaf spot and rust diseases.
EC-41911	300	-	123.2	70.0	Compact, bushy growth with thick leathery leaves, late maturity.
Siwalik	137.2	0.72	98.78	75.0	Tall, erect and late maturing.
Gomti	209.2	0.42	87.86	75.0	Late maturity.
Himalaya	144.0	0.90	129.60	80.0	Resistant to leaf spot and rust diseases.
Kosi	210.4	0.80	168.32	81-83	Robust growth habit. High leaf density, moderate broad and light green leaf, synchronous growth.
Mentha spicata				carvone	
MSS-1	535 (3 cuts)		253	60	Three cuts can be obtained.
MSS-5	224	0.55	125	70	
Neera	159	0.45	65	-	
Arka	159	0.55	139	-	
Punjab spearmint-1	209	—	119.29	68	Erect, growing purple green hairy stem.
Neer- Kalka	314	0.9	271	64-76	Produces suckers like Japanese mind and oil like spearmint
Mentha citrata				Linalool	
Kiran	262	0.60	13.2 kg	48%	Tall, robust and thick leaves

Mentha piperita					
Kukrail			225		
Mentha cardiaca				carvone	
MCAS-2				65.7	

Soil and climate

The soil should be organically rich and loose. It should have the capacity to hold water with pH in the range of 6.5 to 8. Drainage is an essential feature for better productivity. It is grown over a wide range of soil textures, varying from sandy loam to clay loam.

Mint is widely distributed and can be cultivated in temperate to subtropical and sub-tropical Tarai conditions on a commercial basis. In most parts of the world, it is cultivated in the northern latitude, which provides ample sunshine during its major growth. Locations with minimum temperature of 5° C and maximum temperature of 41° C, with annual rainfall of 500-1500 mm distributed throughout its growth period, are suitable. North Indian subtropical conditions of around 1000 metre above mean sea level (msl) with light showers around planting as winter rains and ample sunshine at maturity, suits the production of mint oil

Propagation

Stolon (sucker-underground stem, white to light cream in colour, smooth, fragile and juicy) in menthol mint, scotch mint and recently developed var. Neer-Kalka, herbaceous tops in spearmint and scotch mint and runners in bergamot and pippermint are the propagating materials for commercial production. Menthol mint var. Damroo can be propagated through seed also. In specific cases of menthol mint cultivation, where, fields are not available at the time of normal planting, suckers can be chopped in small pieces (2-3 cm) and seedlings are raised in nursery beds till the mint field is ready. After the second harvest from suckers (stolon), production in menthol mint is done by replanting of desired 'plants in small, well-prepared nursery beds, rich in organic carbon and potash. To overcome winter stress, the plant undergoes heavy production of suckers. In India, for runners of *M. citrata*, *M. piperata* and splits in spearmint, a small area can be replanted after the harvest. In temperate regions, the crop is continued on a perennial basis.

Land preparation and planting

Through repeated ploughing and harrowing, the land should be prepared well. Beds of convenient size may be prepared after mixing FYM. In Indian conditions, wherein the crop is harvested on an annual basis, mechanical planting is not feasible because of small holdings.

Land is prepared well for planting any of the species of mentha through repeated harrowing and ploughing. Fields should be free from weeds and stubble. In the case of menthol and scotch mint, maximum herb and oil yield can be obtained by planting during 15th January to the first week of February, in Tarai condition of Uttaranchal, whereas similar results are obtained in peppermint, bergamot mint and spearmint, by planting during end of December to January. Sometimes (on the hills), March planting is also recommended in Imphal, Manipur and Himachal Pradesh. In specific cases, menthol mint planting can also be done after harvesting wheat, but seedlings are to be raised in nursery beds in advance. However, in such cases, reduction in herb and oil yield is experienced.

Three to four quintals of suckers or 4.5 quintals of runner shoot tips are planted continuously in 7-10 cm deep in furrows 45 to 75 cm apart. Quantity of the planting material varies as per thickness of runners/suckers and spacing opted, which is variety/species specific. Suckers are covered with soil whereas tips runners/herbaceous material is kept above ground. Immediate light irrigation is recommended.

Irrigation

In subtropical conditions, the main growing period of mint species is summer i.e. March to June/July, whereas, in temperate regions, major growth takes place in the cool summer. Since mint's biomass- economic yield- is the herbaceous portion of the crop, it requires more frequent irrigation in the plains. Number of irrigations increased with the increasing growth of the plant, number of branches and more leaves. In dry season, any restriction during growth period is detrimental to biomass yield. Before first harvest, six to nine irrigations are required. In a more simple way, mint in the plains is to be irrigated after every 10-15 days till the onset of the monsoon.

About 12 irrigations after every 10 days during first harvest for maximum herb and oil yield are required, whereas, second harvest could be taken without any irrigation and the entire water requirement could be met from rainfall. Emphasis should also be given to avoid water logging which may prove detrimental to the crop especially in the second harvest. In the temperate zone, the water requirements of the crop are almost a third of the requirement in subtropical climate. Two to three irrigations are sufficient to have the best herb and oil yield.

Manures and fertilizers

Constituting the herbaceous part as a yield, mint responds favourably to organic and inorganic fertilizers. If available, 2.0-3.0 tonnes/ha FYM applied at the time of land preparation, gives a good start to the crop. Deficiency of nitrogen, which is most severe during the rainy season, causes a reduction in oil yield upto 73% than in summer and winter (47 and 20% respectively). Increase in herb and oil yield and decrease in oil content due to higher nitrogen have been well worked in almost all the species. NPK requirement varies as per the location and species/varieties of the mints (Table 2 and 3). Nitrogen application in split doses and foliar application is always beneficial for the crops. Likewise, the response of phosphorous was also established in almost all the species/ varieties of mints, by several research workers and a dose of 35 to 60 kg/ha was found suitable depending on the location and species. Response of K was almost negligible with few exceptions.

Recommended doses of N, P and K for different agroclimatic conditions

Species	**Recommended dose (kg/ha)** N:P:K	Place of work
Japanese mint (*Mentha arvensis*)	100-200 : 35-60 : 40	Pantnagar
	200 : 0:0	Dehradun
	160-200 : 0 : 0	Lucknow
	150-225 : 0 : 0	Ludhiana
Peppermint (*Mentha piperita*)	80 : 0 : 0	Imphal
	90 : 0 : 0	Jorhat
	80-200 : 0 : 40	Pantnagar
	120-125 : 0 : 0	Jammu
	160 : 0 : 0	Lucknow
	200 : 0:0	Dehradun
Spearmint (*Mentha spicata*)	120-200 : 0 : 40	Pantnagar

	200 : 100 : 50	West Bengal
	225 : 0:0	Himachal Pradesh
	200 : 0:0	Dehradun
Bergamot mint (*Mentha citrata*)	100-250 : 60 : 0	Pantnagar
	120-300 : 0 : 0	Himachal Pradesh
	125 : 0:0	Ludhiana
	200 : 100 : 50	West Bengal
	200 : 0:0	Dehradun
	60 : 60 : 10	Kodaikanal

Response functions of N to mints

Mint species	Optimum dose kg/ha)	Oil yield at optimum	Response at optimum	Response/ Kg N
Japanese mint (*Mentha arvensis*)	160	190	94.5	0.57
Peppermint(*Mentha piperita*)	153	103	55.1	0.36
Spearmint(*Mentha spicata*)	225	204	101.2	0.45
Bergamot mint (*Mentha citrata*)	145	50	25.9	0.18

WEEDING

Mint crop is to be kept weed-free which accounts for at least 30% of the total expenditure on cultivation. Minimum two to three weeding/hoeing are essential for a good harvest. The loss in oil yield up to 60-80% due to weeds in mint crop has been reported by several workers. Critical period of weed interference is 30 days to 75 days in the first harvest and 15 to 45 days in the second harvest. Any infestation in this period causes significant reduction in plant height, herb yield and oil yield.

Organic mulch and crop rotation can minimize weed infestation. Sheep grazing is also useful in controlling weed growth. Inter-culture operation (weeding + hoeing and application of organic mulch (6 t/ha) at 25 days after sprouting suppressed the growth of weeds during the critical period of competition and gave higher fresh herb yield (28.5 t/ha) and oil yield (128.7 kg/ha) in a single cut system.

Management of diseases and pests

A large number of pests and diseases cause varying amount of damage to the crop. Severity of damage depends on agro-situations favouring the causal organisms. Sagar (1989) reported that *Mentha arvensis* is atleast affected by 54 insects, pests and mites in India and 40 of them are recorded in Punjab. Pests and their management are described in brief in Table 4.

Harvesting and yield

The stage of harvesting plays a very important role in influencing the production and quality of the oil. In general, harvesting is preferred on bright sunny days. Generally, there are two harvests, the first before the onset of the monsoon (May and June) and the second by the end of the monsoon (September). Some experiments conducted to determine the proper stage of harvesting conclude that normally mint should not be harvested before 100 days of planting. Initially, the appearance of the blossom used to be the criterion but, since the crop does not flower in all agro-situations, it should be harvested when at least vegetative growth is checked, when bronze colouration of the lower leaves appear or with the appearance of very small leaves on the top etc.

Sometimes, the days of planting are also taken as the criterion, e.g. in Tarai, Uttaranchal, harvesting of *M. arvensis* is recommended after 120 days of planting as the first harvest and 65 to 70 days after the first harvest is the second harvest (oil yield 228 Kg/ha).

Mentha spicata may be harvested first after 105 days of planting and for the second time after 65 days of the first harvest for high oil productivity (210 kg/ha). *Mentha piperita* harvested 120 days after planting and 105 after the first harvest, produced 115.5 quintal herb and 68.5 kg oil/ha whereas, early harvesting (105 days) of the first crop delayed the second harvesting (120 days) and this resulted in a significant decrease in oil yield.

Quality of oil of *M. citrata* is affected drastically, if not harvested at the proper stage or on sunny days. It is advised to harvest it from the middle of May to the middle of June in the plains. In hilly areas, three cuts—June, August and December in Palampur and two cuts in June and October in Solan are obtained.

Since the harvesting stage is very specific to varieties/species, the best possible time of harvest for highest fresh herb yield, maximum oil content and desired chemical constituents should be worked out for each variety in each growing weather conditions/ management. The fresh herb yield and oil content depends on species/variety planted and cultural practices viz., planting time, fertilizer application, irrigation, soil type, number of harvests, agro-situations etc. **Processing**

The oil of mentha is usually obtained by distillation.

Distillation—The oil content, its yield and constituents depend mainly upon the time taken between harvesting and distillations, efficiency of distillation unit, particularly condensation of oil and water vapour, rate of flow of condensate, temperature of water flowing in condenser etc. Design of efficient distillation unit is well described and sketched. It has been reported that best results in the oil

quantity to the tune of an additional 16.3% can be obtained, by distilling the herb after one day of harvesting in all mint species, except *M. citrata*, which should be distilled fresh, to avoid loss of oil and deterioration in desirable chemical constituents. Hazra et al. (1990) suggested shade drying of herb upto two days till, oil content increases in contrast to sun drying. It was reported further that semi-dried herb consumes 23 to 24% less steam during distillation.

Wilted/fresh mint herbs are distilled in convenient sized units designed for either field hydrodistillation or steam distillation to be operated by steam boiler. Steam is gradually passed into the still and cold water is run subsequently in the condenser. The pressure of the steam generated is around 100-120 lb at generation point and 30-40 lb psi at the steam inlet of the still. Within the still, the steam pressure falls almost to the atmospheric pressure. The super heated steam takes 1.5 to 2.0 hrs to completely exhaust the herb of its oil depending upon the temperature and moisture of the herb inside. After releasing the steam in the tank, the material gets heated in about fifteen minutes and water along with oil mixture starts flowing into the receiver. Steam pressure is regulated or reduced to maintain the temperature of the condensate at 41-46°C for easy separation of oil from water. Almost 80 per cent of the oil is recovered in the first 45 minutes to one hr. The remaining oil is received during the other half of the period. Oil received in later stages has better menthol. In the field distillation unit, hydro distillation is completed in about three hours. In both the cases, mentha spent can be utilized as fuel.

Some common pest and diseases in mint

Pest/disease	Condition/duration of spread	Symptom/damage	Control
Hairy caterpillar (*Diacrisia obliqua* Walk)	April/May and August, attacks from surrounding crops	Caterpillar eats the under surface of the leaves, epidermis is intact and moves to the other leaf, lays eggs in clusters on the lower side.	2.0% folidol dust or spray of 1/2 litre malathion in 700 litre water/ha.
Mint leaf roller (*Syngamia abruptalis* Walk	August/September, Caterpillar feeds on 2-3 leaves of the same plant before it attains maturity	The larva stick on the underside of the leaves, folds it from midrib and feeds inside the parenchymatous tissue leaving the lower epidermal portion intact, later on, these leaves fall off.	Two-three spraying of thiodon @ 0.02%.
Armyworm Pyralid (*Laphygma exigua* Hub.)	Feb, March and April	The larvae of the pest bore into the plant and eat the leaf bud completely.	No severe damage
Cutworms (*Agrotis flammatra*)	Feb/March	It cuts the plants at the collar and cause loss of stand.	Soil treatment with Endusulfan dust @ 20 kg/ha before planting.
Termite (*Odontotermes Obesus*)	Arid land, summer months	Attacks underground parts, enters stem, tunnelling upwards forming hollow inside, affected plants become yellow, wilt and die.	Soil treatment with Hafftak @ 45-55 Kg/ha, Flood irrigation helps in prevention.
Stolon rot. (*Macrophomina Phaseolii*, *Rhizoctonia bataticola*, *Thielavia basicola*)	May, it may prolong to next crop if infected stolon or field is used	Soil borne, causes stolon rotting checks growth, wilt and reduction in sucker production.	Disease free stolon for planting, follow crop rotation, stolon treatment by 0.25% captan or 0.1% benlet
Leaf blight (*Alternaria* spp)	Summer	Oval spots appear on the upper surface of the leaves with concentric zones surrounded by pale yellow margin, leaf shedding in advance stage.	Spray of copper fungicide and change the field next year.
Wilt (*Verticillium allboartrum*)	Soil borne	Enters in the root system, interferes with uptake of nutrients and water, dwarfing, etiolation, curling of leaf, wilting and ultimately death.	Soil treatment with prepantan containing menthyl iso-cynate.

Rust (*Puccinia menthaai*)	Cool and damp weather favours its infestation and spread, soil borne	Initially swelling and twisting of the upper part of the stem and leaf stalk occurs. It produces golden brown uridospores. It penetrates through teliospores produced during autumn.	Spraying idnitroamine at 2 kg a.i. in 800 litres of water 2-3 times/ha.
Powdery mildew (*Erysiphe cichoracearum*)	April/May in localized areas of poor light and aeration.	Powdery white patches on the upper and lower surfaces of the leaves and stem. These patches are mycelia and spore of the fungus which causes defoliation and reduction in oil yield.	Fortnightly spray of sulphur formulations or organic fungicide like calixin.

MUSHKDANA

Common Name	Ambrette, Mushkdana
Botanical Name	*Abelmoschus moschatus* Medic
Family	Malvaceae

Importance and chemical composition

Ambrette (*Abelmoschusmoschatus* Medic) known as 'Mushkdana' belongs to the family Malvaceae. The seeds of this plant are the source of the essential oil which is extensively used in perfumery, flavouring and cosmetic industries. The essential oil is present in the seed-coat. It is a mixture of farnesol and ambrettolide, present in the seed to the extent of 0.12 and 0.03%, respectively. The compounds responsible for its musk-like odour are acetic acid and ambrettolic acid and its lactone – ambrettolid. The seeds also contain a fixed fat and traces of a resinous substance which is noted for its rich, sweet, floral, musky, distinctly wine or brandy-like smell with an incredible tenacity of odour rarely found in any other perfume material. The seeds are used to impart a musky odour to sachets and hair-powder and in the manufacture of indigenous flavoured tobacco (Zarda). They are powdered with clove and other scented materials for use in body perfumes. It is also used as a substitute for kasturi or musk, an animal product. The essential oil present in the seeds blend exactly with rose, sandalwood oil, and aliphatic aldehydes. Ambrette restored in the form of extracts is used in perfume, creams, lipsticks, brilliantines, hair oil and in cosmetic products.

The seeds also possess medicinal properties and are employed in the treatment of diseases due to 'kapha', 'vata' and in stomach and urinary troubles, gonorrhoea, nervous debility, hysteria and skin diseases. They are a stimulant, antiseptic, stomachic, cooling, tonic, carminative and aphrodisiac. The plant yields good quality fiber. The leaves are used for cleaning sugar. The tender leaves and shoots are reported to be used in soups and the green pods are sometimes used as vegetables. The seeds are also reported to possess insecticidal properties.

Origin and distribution

It is a native of India. It is distributed in Southeast Asia, Northern Australia, Brazil, South China, Columbia, Ecuador Peninsular IndoChina, Indonesia, Madagascar, Southwest Pacific Islands, Papua and New Guinea, and Seychelles.

Area and production: There is no data on area and production of ambrette in India.

Plant description

It is an erect, hirsute, branching shrub, 0.5 to 1 m in height, with leaves of varying shape, usually palmate, with 5 to 7 lobes. The flowers are large, 7.5 to 10 cm in diameter and yellow coloured with a purple centre. The fruit is a capsule or pod, oblong, lanceolate, 5 to 7.5 cm long, containing a large number of seeds which are scented. **Cultivation**

Soil

Ambrette is a hardy plant and comes up well on a wide range of soils, particularly in sandy loam soils with a pH of 7.0. It also gives a good yield in soils with a pH of 6.0 to 8.6. However, it prefers loose, fertile and well-drained soils.

Climate

The crop is cultivated widely in India up to an elevation of 1000 m under different climatic conditions. It is reported to occur throughout the hotter parts of India. In Karnataka, it can be grown twice a year, once during June-July and again in OctoberNovember, as an irrigated crop. Whereas, in the Terai area of Kumaon (Uttarakhand) and in Punjab, the crop is grown during the rainy season.

Propogation: Ambrette is propagated by seeds.

Land preparation and sowing

Before sowing the seeds, the land should be ploughed deep and worked thoroughly to bring it to a fine tilth. The seeds can be sown twice during the year, during the months of June-July and again in September-October. The seeds take about 8-10 days for germination. While sowing, 2-4 seeds may be sown on each hill by dibbling to a depth of 1 cm. Pre-soaking the seeds for 24 hr in water improves the germination. About 6 kg of seeds are sufficient for sowing a one hectare area. A spacing of 60 cm between rows and 30 cm between plants is recommended. The seedlings are thinned 20 days after sowing.

Manures and fertilizers

Well-decomposed FYM is applied to the soil @ 15 t/ha. Since ambrette is a heavy feeder, it also requires chemical fertilizers in large quantities. Fertilizer trials have shown that an application of N at 120 kg, P_2O_5 at 35 kg and K_2O at 40 kg/ha have resulted in the best yields under Bangalore conditions. Of these, a full dose of P and K and 40 kg N are applied as a basal dose, while the remaining 80 kg N is applied in two equal split doses of 40 kg each at 60 days and 120 days after sowing. The fertilizer mixture is applied about 10 cm away from the plants and mixed well into the soil.

Interculture

In the early stages, weeding and hoeing are done twice a month. As the plant grows and spreads its branches, the weeds are naturally suppressed.

Pests and diseases

Pests

There are several diseases and pests which infect this crop and result in low yields. The spotted boll worm *Eariasinsulana* and *E. fabia* are the most severe pests of the plant. These insects attack the plants during the flowering as well as at the fruiting stages. The growing shoots are affected by this pest. The infested shoots above the point of infestation become brown, droop and die. The attack of the pest extends from seedling to harvesting stage. During the fruiting stage, the fruits are attacked; the female worm lays eggs in the fruits. On hatching, the larvae feed on the seeds. Spraying the plant with a 0.15 to 0.2% solution of Thiodon 35 E.C. at an interval of 10-15 days from the time the crop is of one month old till harvest reduces the incidence of the pest.

The plants are sometimes seriously infested with red mites (*Tetranychustelarius*). The mites cover the undersurface of the leaves and suck their juice. In the later stages, the mites make a whitish net and kill the leaves. Spraying the infested plants with 0.1% wettablesulphur solution controls the pest.

Red cotton bugs (*Dysdercuscingulatus*), cotton aphids (*Aphis gossypii*), and green peach aphids (*Myzuspersicae*), have also been observed on the plants, but these have not caused much damage to the crop.

Diseases

The young plants sometime exhibit a mosaic-like appearance on the leaves which is caused by the Hibiscus mosaic virus. Such plants have to be removed immediately.

Collitotrichumhibisci is reported to cause anthracnose. For controlling this disease, the seeds should be treated with Agrosan GN or Cerason before and the crop may be sprayed with Bordeaux mixture. Leaf-spot disease is caused by *Alternariahibiscicum*, and *Phytophthora* spp. causes leaf blight. *Fusarium* wilt caused by *Fusariumvasinfection* has also been reported. On the drying stems and branches, a sooty black fungus (*Pseudotorulaverrucospora*) has been observed. **Harvesting and yield**

The crop starts flowering after about 2½ months of sowing. The flowers set fruits in nearly 3-4 days. The fruit requires about 2 months from set to maturity. The harvesting stage of the pods is identified when they turn blackish and white strips appear at the angles at the ridges of the fruit. Harvesting is a difficult process if the flowering season is long. The fruit should be harvested carefully as it possesses stiff hairs which cause itching. Harvesting must be undertaken regularly at intervals of 7-10 days, depending upon the availability of mature, ripe fruits. It is a 170-180 days' duration crop and in all 20-25 pluckings have to be carried out.

The pods have to be shade-dried after harvest. The seeds are separated from the pods by beating the pods with sticks or by splitting the dry pods by hand. The seeds have to be cleaned, shadedried and

stored. A normal crop may give a yield of 9-10 q/ha of seeds. The essential oil is extracted using steam distillation methods. However to extract the fatty substances, solvent extraction method is followed.

OCIMUM

Common Name	Ocimum, Sacred basil, Holy basil
Botanical Name	*Ocimum sanctum* Linn
Family	Lamiaceae

Importance and chemical composition

The 'Sacred basil' or 'Holy basil', *Ocimum sanctum* Linn. Belonging to the family Lamiaceae, is commonly cultivated in gardens. The species is worshipped by the Hindus of India and traditionally grown in courtyards and temples. The leaves of this species, on steam-distillation, yield a bright yellow, volatile oil possessing a pleasant odour characteristic of the plant, with an appreciable note of camphor and cloves.

The plant contains mainly phenols, aldehydes, tannin, saponin and fats. The essential oil components are eugenol (about 71%, eugenol methyl ether (20%), nerol caryophyllene, selinene, α-pinene, β-pinene,camphorcineole, linalool and carvacrol (3%).A terpeneurobsolic acid possessing anticancer properties has also been isolated. The seeds of this plant give a greenish-yellow fixed oil and also contain antistaphlocoagulase which can be extracted with water and alcohol.

The plant is also used as a pot herb. Its leaves are used as a condiment in salads, and other dishes. The leaves, seed and root are medicinally useful. The leaves also contain ascorbic acid (83 mg 100 g) and carotene (2.5 mg/100 g). The juice of the leaves possesses disphoretic, antiperiodic, stimulating, expectorant and antipyretic properties. It is used in catarrh and bronchitis, applied to the skin in ringworm and other cutaneous diseases and as drops to relieve earache. An

infusion of the leaves is used as a stomachic in gastric disorders of children. If taken internally, it strengthens the liver and heart and is a good appetizer. It cures amenorrhoea and promotes the secretion of milk in lactating women. The leaves, if chewed, give relief from toothache. The leaf-juice is applied to reduce inflammations. A decoction of the root is given as a disphoretic in malarial fevers. The powdered root, if taken twice daily for seven days cures spermatorrhoea.

The seeds are mucilaginous and demulcent and are given in disorders of the genito-urinary system. The seeds rubbed in water are given for irritation coughs, gonorrhea, labour pains and dysentery. The seeds rubbed with cow's milk are given for vomiting and diarrhea. The juice of the fresh leaves, flower-tops and the slender roots are considered to be good antidotes for snakebite and scorpion sting. Tribals (Santals) use the plant in cholera, cough, postnatal complaints, hemorrhagic septicemia and dog bite. The volatile oil is reported to possess antibacterial and insecticidal properties. It inhibits the *in vitro* growth of *Mycobacterium tuberculosis* and *Micrococcus pyrognes* var. *aureus*. It has marked insecticidal activity against mosquitoes.

Origin and distribution: *O. sanctum* has wide distributions, covering the entire Indian subcontinent, ascending up to 1,800 m in the Himalayas and as far as the Andaman and Nicobar Islands. This plant-occupies a wide range of habitats.

Area and production: There is no published data on commercial production of *O. sanctum* in India. In Tamil Nadu, the crop is cultivated in about 200 hectares with an estimated production of 15 ton essential oil every year.

Description of the plant

It is an erect, herebaceous, much-branched softly hairy, biennial or triennial plant, 30-75 cm tall. The leaves are elliptic-oblong, acute or obtuse, entire or serrate, pubescent on both sides, minutely gland dotted: the flowers are purplish or crimson, in racemes, closewhorled: the nutlets are subglobose or broadly ellipsoid, slightly compressed, nearly smooth,pale-brown or reddish with small, black markings.

Types and varieties

In India, two types of *O. sanctum* are under cultivation; the green type (Sri Tulsi) is the most common, the second type (Krishna Tulsi) bears purple leaves and is preferred in the trade for its higher potency of the drug. Many new varieties have been released from RRLs and CIMAP, Lucknow. Among them CIM-Angana, CIM-Soumya are important.

Cultivation

Soil

It thrives well on a variety of soils. Rich loam to poor laterite, saline and alkaline to moderately acidic soils are all well suited for its cultivation. Well-drained soils aid in better vegetative growth. Water-logged conditions can cause root-rot and result in stunted growth.

Climate

The plant can be grown under partially shaded conditions but it yields less oil. It flourishes well under fairly high rainfall and humid conditions. Long days and high temperatures have been found favourable for the plant growth and oil production.

Tropical and subtropical climate (at altitudes up to 900 m) are suited for its cultivation. The plant is moderately tolerant to drought and frost.

The nursery can be raised in the third week of February and transplanting is generally started in the middle of April. This can be undertaken in the month of March, if the seedlings are raised in beds.

Land preparation

The land is brought to a fine tilth and laid out into plots of convenient sizes for irrigation. It is preferable to add 15t/ha of FYM during the preparation of the land.

Propagation: The plant is propagated by seeds. The seeds are likely to deteriorate in future generations on account of the highly cross-pollinated nature of the crop. Hence, for fresh plantings, the growers have to take fresh seeds from the pedigree stock.

Nursery raising

Raised seed-beds of 15' x 4'x 9" size should be thoroughly prepared and well manured by the addition of FYM. About 200-300 g seeds are enough to raise seedlings for planting one hectare of land. The seeds should be sown 2 cm deep in the nurserybeds. After sowing the seeds in the nursery, a mixture of FYM and soil is thinly spread over the seeds and irrigated with a sprinkler-hose. The seeds germinate in 8-12 days and the seedlings are ready for transplanting in about 6 weeks time, at the 4-5 leaf stage. A spray of 2% urea solution on the nursery plants 15 to 20 days before transplanting helps in raising very healthy plants for transplanting.

Transplanting

It is recommended to plant the seedlings at a distance of 40 x 40 cm, 40 x 50 cm and 50 x 30 cm to get high herbage and oil-yield per hectare at Lucknow, New Delhi and Indore, respectively. The plots are irrigated immediately after transplanting.

Fertilizer application

The application of 120 kg/ha, 105 kg/ha of P_2O_5 and K_2O is recommended for saline and alkaline soils at Lucknow. The optimum fertilizer dose recommended for this crop is 120 kg N and 60 kg P_2O_5/ha. Half the dose of N and the entire dose of P_2O_5 are given as a basal dose. Whereas, the remaining N is applied in two split doses, after the first and second cuttings. The application of the micronutrients Co and Mn at 50 and 100 ppm concentrations, respectively, is reported to increase the oil-yield significantly.

Irrigation

Irrigation depends upon the moisture content of the soil. In summer, 3 irrigations per month are necessary whereas, during the remaining period, it should be done as and when required, except in the rainy season when no irrigation is necessary. Altogether, about 12-15 irrigations years are sufficient.

Weeding

The first weeding is done one month after planting, and the second 4 weeks after the first. After this, no further weeding is required as the plants become bushy, thereby naturally suppressing the weeds.

Interculture

One hoeing, two months after planting, is sufficient. The crop may also be earthed-up at this stage.

Diseases and pests

Pests

Among the insects, the larvae of leaf-rollers sticking to the under surface of the leaves fold them backwards lengthwise, thus webbing them. Malathion (0.2%) may be sprayed to control this insect.

Diseases

The plant is susceptible to powdery mildew caused by *Oidium spp*., seedling blight caused by *Rhizoctonia solani* and roor-rot caused by *Rhizoctonia bataticola*. Powdery mildew can be controlled

by spraying wettable sulphur (4 g/I of water), and the latter two diseases are managed by improved phyto-sanitary measures and by drenching the nursery-beds with a solution of mercurial fungicide.

Harvesting and yield

The crop is harvested when it is in full bloom. The first harvest is obtained 90-95 days after planting. Afterwards, it may be harvested at every 65-75 days, intervals. Harvesting should be done on bright, sunny days in order to obtain good quality oilyield. It is not desirable to harvest the crop if it has rained the previous day.

The crop should be cut 15-20 cm above ground-level. The harvested produce may be allowed to wilt in the field itself for 4-5 hours, to reduce the moisture content and the bulkiness. About 5 t/ha of fresh herbage can be obtained twice or thrice a year.

Distillation of oil: The harvested produce is usually distilled in its fresh form. However, the oil quality and yield do not diminish up to 6-8 hours after harvest, by any further delay may cause considerable loss in yield and quality of oil. Steam-distillation is found to be superior to water distillation. The whole herb contains 0.1 to 0.23% essential oil. The yield of oil varies with the type, season and place of origin. The oil-yield will be approximately 10-23 kg/ha.

ROSE

Common Name	**Rose**
Botanical Name	*Rosa spp., Rosa damascena* Mill.
Family	Rosaceae

Importance and chemical composition

Damask rose or Bulgarian rose (*Rosa damascena* Mill.) is a commercial source of rose oil, rose water, rose absolute, rose attar, gulkand, gulroghan, pankhuri, otto of rose, etc. The total world production of rose oil is estimated to be about 19 t, against the annual requirement which exceeds 25 t. Rose oil contains citronellol (0.4%), nonadecane (12.3%), geraniol (14.49%), Henicosane (6.69%), β-phenyl ethylalcohol (4.06%), 9eiscosane,hexanol, heptanol, α-pinene, β-pinene,myrcene,cis-rose oxide,trans-rose oxide, terpinen-4.01, α-terpineol, β-phenylethyl acetate,citral, eugenol, geranyl acetate, methyl eugenol, β-caryo - phyllene, - α cadinene, docosane, heptadecane, farnesol, tridecane, hepta-cosone, tetradecanol, tricosane, pentacosane and octadecane.

Rose oil is one of the most valuable perfumery materials from ancient times. All high-grade perfumes contain at least some quantities of rose oil. The best quality rose oil imparts characteristic flowery top-notes to perfumes; the absolute adds lasting tonalities and increases the fixation of odours. The different products of rose are used in cosmetics, beverages, cold drinks, foodstuffs, tobacco flavoring like snuff and chewing tobacco, fruit flavours, soft drinks, alcoholic liquors and medicines. It

is reported that 3 drops of rose oil three times a day is useful for the treatment of gallstones. The rose flowers possess a laxative property due to the presence of a flavanol glycoside.

Origin and distribution

Basically, the rose is a temperate plant. The plant is indigenous to Europe and the Middle Eastern countries especially, Iran, Afghanistan and Turkey. It is believed that the Damask rose originated in Damascus and was introduced into the European countries. The damask rose is cultivated in Bulgaria, Turkey, France, Italy, Morocco, Russia and India. Bulgaria, Turkey and Morocco are the largest producers of rose oil in the world.

Area and production

In India, scented rose cultivation is mainly confined to the states of Uttar Pradesh, Rajasthan, Jammu and Kashmir and Himachal Pradesh, in an area of 3000 ha. Out of this, Uttar- Pradesh, with 2500 ha under rose cultivation, is the leading rose growing state in the country. India is producing about 80 to 100 kg rose oil annually. At present, Rajasthan produces only rose water; although a very high quality rose oil can be produced from the Haldighati plantation.

Description of the plant

R. damacena is a perennial shrub with a long lifespan of 20 to 30 years under cultivation. It grows to a height of 2.5-3m. The stems possess numerous, moderately hooked, falcate prickles of unequal size, intermixed with glandular bristles. The leaf is stipulate, compound and imparipinnate, with 5-7 leaflets: the stipules are adnate. The leaflets are moderately large, ovate to oblong and serrate. The flowers are borne in groups of 5 to 7 in axillary terminal corymbs.

The flowers are sweet-scented, pink, red or sometimes white-striped. The pedicel possesses densely packed acicular and hispid glands. The sepals are leafy, pinnate, reflexed, and persist after flowering. The petals are over seventy, light-pink fading to white. The fruit is pseudobacate, made up of several hard achenes enclosed within a succulent calyx tube. The fruits (hips) are ovoid, brightred, pulpy and rich in Vitamin C. The damask rose has many commercial varieties known in cultivation. *R.damascena var. trigintipetala* is called Kanzanlik rose and is grown in Bulgaria. This is similar to *R. damascena* which is grown in Aligarh district. Another strain of *R. damascenavar. bifera* is grown in the Kannuaj district of Uttar Pradesh. In the Aligarh district of Uttar Pradesh two other types are grown, one of which flowers twice a year and is called 'Dofasali', the other flower only once, as usual.

Varieties

Out of 567 local germplasm, in the evaluation trials at Aligarh, a superior clone RSL-31 was evolved as the best genotype, containing more geraniol and rhodinol + geranyl acetate in the oil as compared to the Bulgarian rose oil which is considered to be the best in the world. This has been named as 'Noorjahan' by the CIMAP, Lucknow. This variety yields 100% rhodinol + gernaiol acetate, against 45.7% and 35% of the local check RSL-19 and Bulgarian rose, respectively.

Besides, the scientists at the Institute of Himalayan Bioresource Technology (IHBT), Palampur, have developed tow new varieties 'Jwala' and 'Himroz' for high flower and oil yield.

'Jwala' is suitable for cultivation in subtropical northern plains, low hills and mild temperate regions up to 1200 m altitude. It flowers in March-April and then in September and is tolerant to hailstorms, rains and high velocity winds. Jwala bears short clusters of flowers in compact bunches: the weight of a single flower varied between 2.2 to 5.0 g.

'Himroz' is ideal for cultivation in mild temperate to cold temperate regions (1200-2500 m). It is winter tolerant and grows in cold areas without any visual sign of winter injury. It flowers for 22-25

days during the early summer and the weight of a single flower varies from 1.8 to 4.00 g.

Cultivation

Soil

Scented roses can be grown on a wide range of soils; however they prefer natural, welldrained, sandy loam soil. A pH range between 5.6 to 7.0 is considered favourable for rose cultivation.

Climate

Roses thrive well in temperate climate and, for this reason, the Kashmir Valley has been identified as being the most ideal for its cultivation. It can also be cultivated in the subtropical region of North India, where winters are pronounced. It is a photophyllous plant and is sensitive to frost and shade. Low atmospheric humidity during the flowering reduces the essential oil content in the flowers and high temperature leads to abscission of the flower-buds before blooming. Temperature ranging from 0 degree to 5° C for a period of about 15 days prior to the start of blooming enhances the quantity as well as the quality of the flowers. Therefore, regions with high atmospheric humidity (more than 60%) and moderate temperature (15-20° C) at the time of flowering are considered most favourable for a good flower yield. A bright morning condition at the time of flowering is desirable as it prolongs the flowering duration and improves the quality of the oil.

Preparation of land

Open lands, free from perennial greases, with gradual slopes, facing south are the most suitable for rose plantations. The land is ploughed deep (30cm) in order to minimize the weeds and finally leveled by planking. Pits of 0.45 cm in good soils and 60 cm in poor soils are dug at a spacing of 1.5m x 1.5 m in temperate conditions, while the plants in the subtropical regions are spaced at 1 m x 1 m. They are filled with about 3 to 4 kg FYM, 20-25 g N, P and K mixture (18:32:16) 20 g Aldrin powder and soil mixture per pit, before planting.

Propagation

Scented roses are vegetatively propagated by cuttings. They can also be propagated through the division of old plants, lateral sprouts, with roots and seeds.

Preparation of nursery

A mixture of FYM (4:1) is added to the nursery-beds and mixed well into the soil. After leveling the field, P_2O_5 and K_2O @ 20:40 kg/ha are also added as inorganic fertilizers.

The propagation material (cuttings) are taken from healthy, flowering bushed during November-December, usually 25 to 30 cm-long stem-cuttings with one year growth, preferably the anterior portion with four to five nodes of 1 to 2 cm diameter, are taken. The basal end of the cuttings is treated with Indole Butyric Acid (IBA

@ 200-250 ppm) solution for four hours before planting, which helps in inducing roots. The beds are frequently irrigated. The cuttings begin to sprout after a month's time (30 to 35 days) and the beds are kept free from weeds. When the cuttings have attained a height of 10 to 15 cm, a dose of 20 kg N/ha in the form of nitrogenous inorganic fertilizer are applied 4 to 5 cm away from the plants and mixed well into the soil. Monthly spraying of Benlate (0.1%) or Bavistin is done to keep away diseases.

Rooted cuttings are transplanted into the field after one year from mid-November to midJanuary. The rooting percentage of the cuttings from the year-old shoot ranges from 50 to 60% whereas from the other shoots, it is 25 to 30%.

Transplanting

Rooted cuttings are uprooted from the nursery and subjected to a treatment of 0.01% Bavistin for five minutes before planting them in the pits. The soil around the plants is compacted and irrigated immediately. Transplanting of rooted cuttings in subtropical regions is also done in the same way during July-August.

Manures and fertilizer

FYM @ 18-20 t/ha mixed with 100-125 kg N, P and K (18:32:16) mixed with fertilizers should be applied at the time of transplanting the rooted cuttings. Since rose plants remain economically viable for 15-20 years, the soil around the plant must be sufficiently supplied with nutrients. Therefore, the need to apply fertilizer every year is evident. A total of 160 kg/ha N, 80 kg/ha each of P_2O_5 and K_2O, should be applied each year in the form of inorganic fertilizers to get a good yield of flowers.

Irrigation

The crop requires frequent irrigation during the summer months. In all, about 10 to 12 irrigations are required in one year, Irrigation after pruning is necessary in order to protect the sprouting buds from withering away due to loss of water or damage by low temperature or frost. The field may be provided with proper drainage to drain out the excess rain water.

Inter cultivation

After every pruning, weeding and hoeing should be done every year in January and February and the soil around the root-zone of each bush should be turned and pulverized well after each hoeing. At least three weedings and hoeing are essential during January and February. The weedicides, Simazine and Atrazine are used to control annual weeds.

Intercropping: Pulses and vegetables may be grown as intercrops in rose plantations during the first two years.

Pruning and training

Rose plants require a dormant or resting period before flowering. Hence, pruning is an essential operation for obtaining a good flower yield. Its intensity and shape vary with the age of the plant. The first pruning is done after plant attains two years of age of the plant. The first pruning is done after the plant attains two years of age. At 1050 m height from the ground-level, shoots and branches are removed with the help of secateurs, leaving 8 to 10 primary branches in the shape of an umbrella.

Whatever shoots appear during the growth phase are also removed, as they do not bear flowers. The time for pruning is during the first week of November to early December in temperate climates. In subtropical climates, heavy pruning at 3045 cm of the plant-height is done during December-January and the soil around the base of the rose plants is dug up to bare the primary roots which facilitates the chilling of roots and, in February, the soil is again heaped at the base of the plant. The plants take about 70 to 90 days to flower after pruning. The other purpose of pruning is to train plants in the desired form, to keep the desired size, to remove injured and diseased parts, to remove the terminal buds and change the growth habit, to encourage bushy roses, to provide more horizontal expansion and finally to produce more flower-buds.

Pests and diseases

Pests: Rose plantations are attacked by a number of pests, among which the following are the important ones.

Aphids *(Macrosiphum rosae)*: Aphids attack the plants during the flowering period. They can be controlled effectively by prophylactic sprays at 15 days' interval with Methyl Demeton or Metasystox (0.1%) or Dimethoate (0.25%) or Phosphomedon (0.1%).

Caterpillars: The caterpillars of *Operophtera frumata*, *Malacosoma Neustria*, *Orgyia antique* and *Archips podana* attack the foliage during the summer and the reainy seasons. The caterpillars can be controlled by spraying Endosulphon (0.2%) or Quinalphos (0.15%) or Fenthion (0.12%).

Red Spider Mites *(Tetranychus spp.)*: Heavy infestation results in the leaves becoming bronzed and falling prematurely. Wettable sulphur (0.4%) can be sprayed to control the mites.

Rose Thrips *(Thrips fuscipennts)*: Thrips attack is common during the flowering period. Heavy infestation causes a significant loss to the flower-yield. Sprays of Malathion (0.2%) or Sumithion (0.1%) at an interval of 10 days control the attack of thrips.

Diseases

Black Spot *(Diplocarpon rosae)*: The fungus causes black spots on the leaves, due to which the leaves will abscise. Fungicidal sprays with Captan (0.2%) or Mancozeb (0.3%) have been recommended for the control of rust.

Powdery Mildew *(Sphaerotheca pannosa)*: Small, white, powdery pustules of fungus appear on the leaves, stems and occasionally on the flowers. Dinocap (0.1 to 0.15%) or wettable sulphur (0.4%) should be sprayed at 15 days interval for the control of this disease.

Downy Mildew *(Peronospora sparsa)*: Small reddish-purple areas appear on the youngest leaves resulting in leaf distortion. Repeated sprays of Mancozeb (0.2%) or Captafal (0.3%) or Copper Oxychloride (0.3%) should be employed for effective control.

Viral Diseases: Rose mosaic is the most common virus disease. Control measure should be followed to kill the various virus vectors.

Rose Rust *(Phragmidium subcorticium)*: The disease attacks the leaves, flowers and shoots and causes leaf-fall and abscission of buds. The most important control is to bury the fallen leaves under heaps of soil around the rose bush. The winter rust spores perish due to the development of antagonistic micro-organisms. The disease is chemically controlled by the spraying of Bavistin @ 0.1% twice during the flowering period (March and May)..

Flowering

In northern India, the main season of flowering is 30-40 days during March-April. It reaches a peak in the middle of March and then starts declining. However, sporadic flowering does occur during September and October. **Harvesting and yield**

The flowers are harvested by hand in the early mornings, preferably before sunrise, when they start opening. The collected flowers should be distilled immediately as they lose their whole aroma within 25 hours of their opening. **Distillation of flowers**

A distillation apparatus made of stainless steel is the best for the production of quality rose oil. A weighed amount of fresh flowers along with six times its weight of cold water is fed into the churning tank, using a mechanical stirrer, till uniform slurry of rose flowers is formed. This slurry is distilled for about four hours for the recovery of first rose water. The rose water is then prepared in the cohabitation tower for the recovery of water and oil through a packed column. The second rose water is also distilled in the same process. In subtropical climates, an oil content ranging from 0.02 to 0.03 % on fresh-weight basis of flowers is obtained. The yield of flowers and oil is also more in temperate climates than in subtropical climates.

The average yield of fresh flowers in moderately fertile soil under the temperate climate of Kashmir is 4.0-5.0 t/ha, which corresponds to 1.31-1.6 kg/ha/annum of oil. Whereas, in the subtropics, the flower-yield reaches to about 1.2-2.0 t which corresponds to 0.3-0.4 kg/ha/annum of oil.

Rejuvenation

Yearly observations have shown that rose plantations do not have a uniform rate of production. In the first 5 to 6 years the flower yield rises, but after the sixth year the flower production declines. After 8-10 years, the roses become unprofitable, necessitating rejuvenation.

Autumn is the most favourable time for rejuvenation. The bushes are cut down to the base and on both sides of the rows, trenches 18-20 cm deep are opened and the soil is spread in the inter-row

space. In these rows, 20-30 t of FYM along with 60 kg/ha each of P_2O_5 and KO_2 are placed and covered with soil.

In the spring, new shoots develop and out of them only six to eight vigorous branches are allowed to grow. After 2 years, the yields of rose flowers reach the previous level and the life of plantation is increased by a further 8-10 years.

FRENCH JASMINE

Common Name	**French Jasmine**
Botanical Name	*Jasminum grandiflorum*
Family	Oleaceae

Importance and chemical composition

French Jasmine (*Jasminum grandiflorum*) (Family: Oleaceae) has a unique place in perfumery because of its high value of oil traded as 'concrete'. Its flowers produce a gently pleasing delicate aroma. The concrete or absolute extracted through solvent extraction is used in manufacturing of high value perfumes and their umpteen fragrance formulations. In India, its cultivations have spread in southern states after development of a culture, 'Pitchi'. It blooms for 6-7 months (mid-May to earlyDecember) in Tamil Nadu and Karnataka. India is now second largest producer of jasmine 'concrete' after Egypt, exporting most of its produce to Europe.

Description of the plant

French jasmine is a climbing shrub, but is trained into bushes under cultivation. It has compound opposite leaves, made up of 7-11 leaflets. It produces bisexual flowers in first year of planting. Because of its heterogamous nature of flowers there is no setting of seed. Therefore, it is raised through stem-cuttings. The flower buds do not emit any fragrance. But on opening in early morning, the petals emit fragrance. They continue to give out sweet, pleasing aroma for about 16hr after plucking. The oil evaporates fast in sunlight.

Area and production

Tamil Nadu leads in production of *J. grandiflorum* with an estimated area of 2000 hectares.

Varieties

CO-1: Clonal selection from germplasm. Suitable for both loose flower production and oil extraction. Pink streaks are found on external surface of petal. The average yield of flowers is 10 t/ha. with a concrete recovery of 0.29 per cent.

CO-2: Induced mutant from CO-1 Pitchi. It has bolder pink buds with long corolla tube with yield of 11t/ha.

Arka Surabhi – A selection from the germplasm obtained from Lucknow is released from IIHR, Bengalore. It is pink pin type with flower yield of about 10 tons/ha and a concrete yield of 0.35%. **Soil and climate**

Jasmine can be grown in a variety of climate and soils. Generally, it prefers mild tropical climate for proper growth and flowering. Mild winter, warm summer, moderate rainfall and sunny days are ideal climatic requirement. Loamy garden soils are best-suited for cultivation of all species and varieties. With liberal application of manure and assured water supply, jasmines can also be grown suitably in sandy soils. In clayey soil, flower production is hampered to a great extent. It is highly susceptible to water logging.

Propagation

Easy means of propagation is by stem cuttings. High percentage of rooting and increased number of long roots is obtained when cuttings are taken during AprilSeptember. The 15cm long shoot tip cuttings having 4 leaves are treated with 4000ppm IBA and planted in vermiculite or sand under mist give best performance in rooting and survival of rooted cuttings. A large number of *Jasminum* species, can be propagated from stem cuttings under mist in a sand medium with the treatment of 4, 000ppm IBA.

Planting: The land preparation is done by deep ploughing (2 times). The plants are raised through rooting of 20 cm long stem-cuttings, prepared from near mature wood and planted in pits during rainy season, Pits of 30 cmx30 cm size are dug at 1.8 x 1.5m or 2 x 2 m spacing, and connected by a irrigation channel. It is filled with a mixture of top soil and dry leaf powder mixed with farmyard manure to which 15g Aldrex is added to protect the plants from termite attack.

Pruning: The vines are pruned from late-December till mid-January at 90cm length, maintaining 911 shoots to obtain maximum flower yield. After pruning, soil around bushes should be dug out to facilitate aeration and induce growth. Sometimes, when vegetative growth is large, a light pruning in July may be done to induce lateral branching and flowering. The plantation needs fortnightly irrigation during dry season.

Manures and fertilizers: The application of 100, 150 and 100g of N, P and K per bush annually produces maximum flower yield. The plantation should be kept weed-free. Spraying of Gramoxone at monthly interval controls weeds. Usually, January-April is ideal season for intercropping to obtain additional income.

Irrigation: Moderate watering is good for jasmine. It is more essential in flowering season. During blossoming, the water should be applied twice a week if there is no rain and once a week during rest of the months. Soon after the cessation of flowering, watering is to be completely stopped until pruning and fertilizer application. With the advancement of cold weather, the plants begin to shed leaves. After pruning and manuring, watering is resumed. With the close of each flowering phase, watering is completely stopped for weeks together till the appearance of fresh flowering buds.

Harvesting and oil extraction

The flower crop (mature buds and open flowers in early stage) is picked in early morning (5-8 AM). The open flower crops are processed for extraction of oil immediately. It continues to produce blooms from May to early-December. The yield in first year is low (500 kg) but it increase to 5 tonnes in second year and 10 tonnes/ha in third year onwards. Although decline may commence after 10 years, relatively satisfactory economic yield continues to be received up to 15 years in a wellmanaged plantation. Usually, food-grade hexane or petroleum ether is employed as a medium of solvent extraction and oil along with waxes is extracted and separated out at low temperature and dried in vacuum. On an average, 340-400 kg of flowers are needed to produce 1 kg of concrete; the commercial yield of concrete being 10 kg/ha over the years.

For production of its 'absolute' (mainly used to measure purity of the produce), the 'concrete' 'is dissolved in absolute' alcohol and waxes are removed through filtration. The 'absolute' or 'otto' is a semi-viscous, dark coloured material, emitting fragrance of fresh jasmine flowers.

LEMON GRASS

Common Name	Lemon Grass or palmarosa
Botanical Name	*Cymbopogon flexuosus*
Family	Poacea

Importance and chemical composition

Lemon grass (*Cymbopogon flexuosus*), belonging to family Poacea, is the source of lemon grass oil obtained from the leaves and shoots of the plant. Lemon grass oil is mainly used in the manufacture of perfumes for soaps, hair oils, scents and medicines. It also has antibacterial properties. Ionone prepared from the citral present in lemon grass oil was one of the most important raw materials for the

preparation of Vitamin A. In addition to its use in perfumery, Ionone is used in certain kinds of confectionary and liquors. The oil can be used to improve the flavour of some fish and can be used to flavour wines and sauces. It can be used for headache, tooth aches, baths, and as a diuretic agent for fever.

Origin and distribution

The species is considered to have originated in India. It grows wild in many tropical and subtropical parts of Asia, Africa and America. The plant is grown for its oil in the West Indian Islands and also in Central America, South America, Thailand, Bangladesh, the Comoros Islands, Madagascar and China. Although the oil has been known since very early times in India, the systematic cultivation and distillation of the grass were started in Kerala only about 90 years ago. At present, it is grown commercially in the Nothern district of Travancore and Cochin (Kerala), Assam, Maharashtra and parts of Uttar Pradesh.

Area and production

Traditionally, India has been the largest supplier of lemon grass oil to the world market but has ceased to be so any longer. The crop is under cultivation in India in an area of about 2000ha.The production of oil which was 1800t in 1961 -62 has declined to about 400t at present. The Indian monopoly in the lemon grass trade in the world market has been broken due to the entry of Guatemala and a few other Latin American states including Brazil and Mexico, Puerto Rico, Dominica, and China.

Description of the plant

Lemon grassgrows to a height of about 3m. The leaves of the plant are linear, lanceolate, 125cm long and 1.7 cm broad. The plant is spreading, 100 -135 cm tall, slightly hairy.

Types and varieties

C. flexuosus

(C. citratus

There are two main types of lemon grass namely, the East Indian or true lemon grass (*C. flexuosus*) and the West Indian lemon grass (*C. citratus*). The oil obtained by the distillation of the grass of *C. flexuosus* called the East Indian oil, is the genuine oil of commercial importance. It is produced in Kerala and is popularly called the Cochin oil, since it is shipped mainly from the port of Cochin. A small quantity of oil is also obtained from *C. pendulus*, popularly known as North Indian lemon grass or Jammu lemon grass, since it is grown mainly in Jammu and other North Indian States.

Sugandhi (OD-19): It was released from the Aromatic and Medicinal Plant Research Station (AMPRS) Odakkali, Kerala. This variety is red in colour and is adapted to a wide range of soil and climatic

conditions. The plant grows from 1- 1.75 m height and with profuse tillering yields 80-199 kg/ha of oil with 80-88% citral under rain-fed conditions.

Pragathi: It is a clonal selection from OD-19, evolved at CIMAP, Lucknow. The variety is tall with a dark purple leaf-sheath and is adapted to the North Indian plains and Terai belts of subtropical and tropical climates. The average oil content is 0.63% with 86% being the citral content.

Praman: Evolved through clonal selection from *C.pendulus* at the CIMAP, Lucknow, it is a tetraploid plant with a profuse tillering habit. The leaves are erect and medium in size. The variety is reported to yield 227kg/ha/annum of oil with 82% citral content.

RRL- 16: It is evolved from *C. pendulus* and released for cultivation from the RRL, Jammu as Jammu lemon grass. The average yield of the herb is 15-20t/ha/annum, giving 100-110 kg of oil. The oil content varies from 0.6 -0.8% with 80% citral content.

CKP- 25: It is interspecific hybrid between *C. khasianus* and *C. pendulus*, developed by the RRL, Jammu. The strain gives herb yield of 80-85 t and 350-400 kg/ha/annum of oil. The citral content in the oil ranges from 80-85%

In addition to the above, OD-408 from the AMPRS, Odakkali, RRL-39 from RRL, Jammu and Kaveri and Krishna from the CIMAP, Regional Station, Bangalore, have been recently released as high yielding varieties for cultivation. The other varieties under cultivation are SD-68 and GRL-1. **Cultivation**

Soil

It flourishes on a wide variety of soils ranging from rich loam to poor laterite. In sandy loam and red soils, it requires good manuring.

Calcareous and water logged soils should be avoided as they are unsuitable for its cultivation.

Climate

It requires a warm, humid climate with plenty of sunshine and a rainfall ranging from about 200-250cm, well distributed over the year. In areas where the rainfall is poor, it can be grown with supplemental irrigations. It grows well at altitudes between 1000 1200 m.

Propagation

Lemon grass is generally propagated through seeds, vegetative propagation and rooted slips. It is reported that both the seedlings and rooted slips performed equally well, with respect to growth and yield. But due to high cost of transplanting, direct seeding is widely practiced, especially over the plains and the terraced lands in Kerala. For raising the crop by direct seeding a seed rate of 20 to 25 kg/ha is recommended. While sowing, the seeds must be thoroughly mixed with dry river sand in a ratio of 1:3, to ensure the uniform distribution of seeds during storage.

Nursery raising

For raising the seedlings required for planting 1ha of land, a 1000m area is required. The area is well prepared and raised beds of 1 to 1.5m width and convenient length are made. The recommended seed rate is 3 to 4 kg/ha. The seeds are uniformly broadcasted on the beds and are covered with a thin layer of soil, followed by watering at regular intervals.

The seeds collected during the month of January – February are usually sown in the nursery during April – May.

Transplanting

The land is prepared by repeated ploughing and harrowing, and beds of 1 to 1.5 m width and convenient length are made with a spacing of 30 to 50 cm between beds. The beds are made along the contour of the land slopes. Three to four leaved, 50 to 70 days old seedlings are planted during the monsoon season (May- June) in Kerala. A spacing of 30cm x 30cm with a plant density of 1,11,000/ha

is recommended. A wider spacing of 60cm x 45cm for seedlings and 90 cm x 60 cm for slips has been recommended for fertile, irrigated land under North Indian conditions.

Manures and fertilizers

Lemon grass is an exhaustive crop and it requires 275 kg N, 25 kg P_2O_5 and 175 kg K_2O/ha/annum. In order to promote growth and to obtain a higher oil yield the crop is applied with 2t/ha of compost made from spent grass and 2t/ha of wood ash at the time of bed formation. In addition, it has to be supplied with chemical fertilizers. Under Odakkali conditions, it was found that an application of 100kg N in 3 to 4 split doses was found to be optimum, though a response up to 200kg was recorded. The response to P and K was found to be erratic. The application of 50kg ha each P_2O_5 and K_2O as a basal dose gave encouraging results in West Bengal. It is recommended to apply 60:45:35 kg/ha N, P_2O_5 and K_2O as a basal dose and 60kg N in 3 to 4 splits/annum as top dressing during the growing season as an optimum dose. Lemon grass is also reported to respond well to the application of copper, iron, calcium and sulphur.

It is reported from the CIMAP, Lucknow, that a lower dose of boron (2.5ppm) in combination with chloride salts can be beneficial for the crop.

Interculture

The earthing up of the plant after about 4 months of planting and again after every harvest is beneficial, as the root region of lemon grass has a tendency to grow above the soil. The field is kept stubble free. Generally 2-3 weedings are necessary during the year. Among the herbicides Diuran @ 1.5 kg a.i./ha and Oxyfluorfen @ 1.5 kg a.i./ha are effective for weed control. Intercultivation can be done by a tractor drawn cultivator or a handheld hoe in row planted crops. Under rainfed conditions, burning the dry grass and stubble of the standing crop prior to the onset of monsoon is practiced in Kerala to prevent white ant attack and also to rejuvenate the old clump.

Irrigation

After planting if there are no rains, the crop should be irrigated every alternate day for about a month. It is recommended that 4 to 6 irrigations are given during the period February to June under North Indian conditions for an optimum yield.

Pests and diseases

Pest infestation is very low for this crop. Several diseases are reported on lemon grass, but none are serious enough to cause major reduction in oil yield. The leaf diseases can be controlled by prophylactic sprays of Dithane M-45 and Dithane Z-78 @ 3 g/l thrice at intervals of 15 days.

Harvesting and yield

The crop is perennial in nature and gives good yields for 5 years. Harvesting is done by cutting the grass 10cm above the ground level. During the first year of planting 3 cuttings are obtained and subsequently, 5-6 cuttings per year are taken subject to weather conditions. The harvesting season begins in May and continues till the end of January. The first harvest is done about 90 days after planting. The interval from sowing to harvest exerts a considerable influence on the yield and the quality of oil. Both immature and over mature grass gives a lower quantity of oil. For the local type of lemon grass, the optimum interval is 40-50 days.

The optimum period of harvesting, when grown on hill tops and low lying areas are 60 and 55 days, respectively. Herbage yield 15t/harvest and oil recovery about 0.3 – 0.5% from fresh grass can be expected. The oil is obtained by steam distillation. Oil yield of about 350- 400 kg/ha from the second year onwards is considered satisfactory.

Factors influencing the oil –yield

The factors influencing the oil production during distillation are:

i) Storage of the plant material ii) Treatment of the material, and iii) The method of distillation.

The cut grass is kept in a dry atmosphere with limited air circulation. The grass when stored in the shade can increase the oil recovery up to 96 hours and storage for a further period will only decrease the oil yields. The essential oils are enclosed in the oil glands, oil sacks and glandular hairs of the plant. Therefore before distillation, the plant material must be cut into small pieces to enable them to directly expose as many oil glands as is practically possible. Once the plant material has been reduced in size it must be distilled immediately. Otherwise, the essential oil being volatile will be lost by evaporation. Dipping the chopped lemon grass in sodium chloride solution for 24 hr at 1-2 % concentration before distillation has been found to increase the citral content.

ENDANGERED MAPS AND THEIR CONSERVATION SOME TERMS

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

ENDANGERED (EN)

A taxon is endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the following criteria

Medicinal plants have always been considered a healthy source of life for the people. Therapeutical properties of medicinal plants are very useful in healing various diseases.

There are more than 8000 medicinal plants listed in different classical and modern texts on medicinal plants. Around 960 medicinal plants are in active use in all India trade and around 2000 species are documented in Indian Systems of Medicine like Ayurveda, Unani and Siddha. Similarly, around 4000 species are used by rural communities in local health practices. The All India Ethno-biology Survey estimated that over 7,500 plant species are used by 4,635 ethnic communities for human and veterinary health care across the country. In 1993, the Government estimated that between 60-80% of India's population rely on medicinal plants for health care. Medicinal plants are particularly important to the rural poor, who are able to harvest these from the wild to meet their primary health care needs. The Botanical Survey states some of the common medicinal herbs as Brahmi, Babul gum, Bail, Satawar, Neem, Tesu/Gul Palash, Dalchini, Bhringraj, Amla, Jatropha, Nagkesar, Jaiphal, Ratanjot,
Isabgo, Reetha, Kuth (Bitter), Chiraita, Jamun, Arjun, Behera, Harad (Choti), Harad (Pili) etc

Nodal Agency on Medicinal Plants

The National Medicinal Plants Board is the designated nodal agency on all issues related to medicinal plants. It works under the Department of AYUSH, the Ministry of Health and Family welfare. Besides number of organizations and departments, Viz., ICMR, CIMAP, DBT, DST, NBPGR, and Ministry of Commerce are also engaged in handling the subject of medicinal plants but each one has a specific mandate. While it is research for the first three organisations, it is ex-situ conservation for NBPGR, and marketing for the Ministry of Commerce. Similarly, research on cultivation of medicinal plants, especially pertaining to standardization of agro-technology & breeding techniques is managed by the Ministry of Agriculture.

Genetic Conservation of Medicinal Plants

The Department of Biotechnology has already set up three national gene banks on medicinal and aromatic plants at the Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow, Uttar

Pradesh, National Bureau of Plant Genetic Resources (NBPGR), New Delhi and Tropical Botanic Garden & Research Institute (TBGRI), Thiruvananthapuram, Kerala.

They are engaged in collection, conservation and characterization of the precious wealth of medicinal and aromatic herbs which are rare/threatened/endangered or are being used in traditional system, or those which are commercially exploited. The Regional Research Laboratory (RRL), Jammu, Jammu & Kashmir, is the forth gene bank which covers the North-Western Himalayan region. A germ-plasma repository for medicinal plants used in Ayurveda has also been established at Arya Vaidya Sala, Kottakkal, and Kerala. More than 9,000 accessions of important medicinal and aromatic plant species are being maintained as live material in field gene banks, in the form of seed, in vitro material and DNA. For long-term conservation, the accessions are stored under cryogenic conditions.

Thrust on National Afforestation Programme

The Ministry of Environment and Forests has taken various measures for conservation and proliferation of rare medicinal herbs. United Nations Development Programme (UNDP) Project entitled 'National Programme on Promoting Conservation of Medicinal Plants & Traditional Knowledge for Enhancing Health & Livelihood Security' is in operation. It is being implemented in nine States-Karnataka, Kerala, Tamil Nadu, Maharashtra, Andhra Pradesh, Rajasthan, Orissa, West Bengal and Madhya Pradesh. The project is being coordinated by Foundation for Revitalizing of Local Health Traditions (FRLHT), Banglore. These states are of two categories – one, with five States (Andhra Pradesh, Karnataka, Kerala, Maharashtra & Tamil Nadu) wherein medicinal plants conservation activities have been initiated and the second, with remaining four States in which the conservation activities are to be initiated under this project for the first time.

The main aims are to establish a system for Rapid threat assessment and trade regulation; establish a Network of Medicinal Plants Conservation Areas (MPCAs); establish a state level medicinal plants seed center; establish Home Herbal Gardens (HHGs) and prepare Community Knowledge Registers (CKKs); capacity building on community owned medicinal plants enterprises programmes; communication and advocacy programmes for outreach and a multi-lingual website programme on Home Doctor.

Another UNDP-GEP project, "Mainstreaming Conservation and Sustainable use of Medicinal Plant Diversity" covers three Indian States – Arunachal Pradesh, Chhattisgarh and Uttarakhand. The National Medicinal Plant Board, Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), State Medicinal Plant Boards and FRLHT, Banglore are executing partners in this project. The main objective of the project is to mainstream the conservation and sustainable use of medicinal plants with particular reference to globally significant medicinal plants.
A Centre of Excellence on 'Medicinal Plants & Traditional Knowledge' at FRLHT, Banglore also supports this activity which is recognized.

Implementation of the National Afforestation Programme (NAP) Scheme include models such as 'Mixed Plantation of Trees having Minor Forest Produce and Medicinal Value' and Regeneration of Perennial Herbs and Shrubs of Medicinal Value' that relate to promotion of medicinal plants through afforestation and regeneration. The States have been advised to give requisite thrust on plantation of medicinal plants and bamboos on degraded forest lands and contiguous areas in addition to other species of local ecological and economic importance in the afforestation activities. This is intended to contribute towards poverty alleviation and also to ensure livelihood security of forest fringe dwellers besides ameliorating soil conditions and improving/increasing forest cover. The States have been also advised

to consider setting aside 10% of the project area for plantation of bamboos and medicinal plants under the NAP.

Conserving and protecting medicinal plants is being carried out through enforcement of the Indian Forests Act, 1927; Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980; Environment (Protection) Act, 1986; Biological Diversity Act, 2002 and the rules under these Acts.

Biological Diversity Act, 2002

The Government has enacted the Biological Diversity Act in 2002 and notified the Biological Diversity Rules in 2004, with the aim of conserving and sustainably using biological diversity, and regulating the biological resources (including the medicinal plants) and associated traditional knowledge of country with the purpose of securing equitable sharing of benefits arising out of these resources and associated knowledge.

Harvest of Medicinal Plants

Over Ninety-five percent of India's medicinal plants are harvested from the wild. Over 200 medicinal plant species in southern and northern India are classified as rare, endangered or threatened. The true number of threatened species are, including globally significant species, is likely to be far higher, but the status of many species is insufficiently unknown.

Banned for Export

About 29 species of medicinal plants have so far been identified and notified by Director General of Foreign Trade, Ministry of Commerce, New Delhi. Export of these 29 plants, plant portions and their derivatives and extracts as such obtained from the wild except the formulations made there from is prohibited as these species required protection against over-exploitation.

Export allowed only through the ports of Mumbai, Calcutta, Cochin, Delhi, Chennai, Tuticorin and Amritsar.

LIST OF MEDICINAL PLANTS PROHIBITED

Beddomes" cycad (*Cycas beddomei*) 2. Blue Vanda (*Vanda coerulea*) 3. *Saussurea costus* 4. Ladies slipper orchids (Paphiopedilium species) 5. Pitcher plant (*Nepenthes khasiana*) 6. Red Vanda (*Renathera imschootiana*) 7. *Rauvolfia serpentina* (Sarpagandha) 8. Ceropegia species 9. *Frerea indica* (Shindal Mankundi) 10. *Podophyllum hexandrum* (emodi) (Indian Podophyllum) 11. Cyatheaceae species (Tree Ferns) 12. Cycadaceae species 13. *Dioscorea deltoidea*	15. Orchidaceae species (Orchids) 16. *Pterocarpus santalinus* (Red Sanders) 17. *Taxus wallichiana* (Common Yew or Birmi leaves) 18. *Aquilaria malaccensis* (Agarwood) 19. Aconitum species 20. Coptis teeta 21. *Coscinium fenestratum* (Calumba wood) 22. *Dactylorhiza hatagirea* 23. *Gentiana kurroo* (Kuru, Kutki) 24. Gnetum species 25. Kamphergia galenga 26. *Panax pseudoginseng* 27. *Picrorhiza kurrooa* 28. *Swertia chirata* (Charayatah)
14. Euphorbia species (Euphorbias)	

Conservation of Medicinal Plants: Strategies & Priorities

The world conservation strategy (IUCN, UNEP & WWF, 1980) defines conservations as "the management of human use of the biodiversity so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations". The above definition invokes two complementary components "conservation" and "sustainability". The primary goals of biodiversity conservation as envisaged in the World Conservation Strategy can be summarised as follows:

1. Maintenance of essential ecological processes and life support systems on which human survival and economic activities depend,
2. Preservation of species and genetic diversity and
3. Sustainable use of species and ecosystems which support millions of rural communities as well as major industries.

Medicinal plants are potential renewable natural resources. Therefore, the conservation and sustainable utilisation of medicinal plants must necessarily involve a long term, integrated, scientifically oriented action programme. This should involve the pertinent aspects of protection, preservation, maintenance, exploitation, conservation and sustainable utilization. A holistic and systematic approach envisaging interaction between social, economic and ecological systems will be a more desirable one. The most widely accepted scientific technologies of biodiversity conservation are the in-situ and ex-situ methods.

In-Situ Conservation

In has been well established that the best and cost-effective way of protecting the existing biological and genetic diversity is the 'in-situ' or on the site conservation wherein a wild species or stock of a biological community is protected and preserved in its natural habitat. The prospect of such a 'ecocentric', rather than a species centred approach is that it should prevent species from becoming endangered by human activities and reduce the need for human intervention to prevent premature extinctions. Establishment of biosphere reserves, national parks, wild life sanctuaries, sacred groves and other protected areas forms examples of 'in-situ' methods of conservation. The idea of establishing protected area network has taken a central place in all policy decision process related to biodiversity conservation at national, international and global level. In India 4.5% of its total geographical area constitute protected area network, comprising 8 designated biospheres, 87, national parks, 447 wild life sanctuaries. This network encompasses various biogeographic zones and biomes rich in biotic diversity, including medicinal and aromatic plants. In addition to these there area number of sacred groves in different parts of the country particularly in South, West and Eastern parts which are also active centres on in-situ conservation of medicinal plants. Such conservation area network can attribute significantly towards the conservation and sustainable management of biological resources of our country. However, experiences have amply demonstrated that in a densely populated developing country like India, where a sizeable population are living in close proximity to forests, declaring protected areas will not entirely be sufficient to ensure conservation on the fast eroding biological diversity. The success of any conservation programme vests solely on the efficient management of protected areas. The involvement of local communities in conservation activities has now been increasingly realised. A people nature-oriented approach thus become highly imperative. This will help to generate a sense of responsibility among the local people about the values of biodiversity and the need to use it sustainably for their own prosperity and the maintenance of ecosystem resilience.

In-situ conservation of medicinal plants in India can be accomplished through the active support and participation of people who dwell in or near and around the protected forest areas. Involving the local mass in all phases of conservation programmes, such as planning, policy decision process, implementation etc. will be a significant component in achieving efficient management and utilization of medicinal plant resources. A few such in-situ conservation areas have been marked anci declared as medicinal plant in-situ conservation areas on the forests of three Southern States of Kerala, Tamilnadu and Karnataka by the joint efforts of the forest departments of these States and FRLHT, Bangalore.

Ex-Situ Conservation

Conservation of medicinal plants can be accomplished by the ex-situ i.e. outside natural habitat by cultivating and maintaining plants in botanic gardens parks, other suitable sites, and through long term preservation of plant propagules in gene banks (seed bank, pollen bank DNA libraries, etc.) and in plant tissue culture repositories and by cryopreservation). Botanical gardens can play a key role in ex-situ conservation of plants, especially those facing imminent threat of extinction. Several gardens in the world are specialised in cultivation and study of medicinal plants, while some contain a special medicinal plant garden or harbour special collection of medicinal plants. India has a network of about 140 botanical gardens which include 33 botanical gardens attached to 33 universities botany departments. But hardly 30 botanical gardens have any active programme on conservation. Tropical Botanical Gardens & Research Institute (TGBRI), located in a degraded forest region of Western Ghat Mountains in Kerala has an excellent example in ex-situ conservation of plant diversity in India. The field gene bank programme launched by TBGRI from 1992-1999 is now well acclaimed as a very

effective method of conservation of medicinal and aromatic plant genetic resources. This field gene bank of medicinal and aromatic plants at TBGRI, Thiruvananthapuram is essentially a blend of the exsitu and in-situ situations. Field gene bank of medicinal plants: The concept of establishing field gene banks of plants provide ample options for long term preservation of the genetic variability (interspecific) of species. Field gene banks are better established in a degraded forests where efforts could be made to reforest/restock the missing species complexes, trees, shrubs, herbs, climber etc. It is indeed a recreation of a forest or rather simulation of a typical forest. Before attempting to establish such a field gene bank it is essential to have a clear understanding of the natural ecosystem such as the spatial distribution, pattern of association i.e., structure and functional dynamics of the species in question. After undertaking an indepth study on the natural distribution pattern of the medicinal plants and the associated floristic elements - including their micro-ecological niche, a well planned action programme of recreating the same in a degraded forest area or place close to the species found in nature can be attempted. TBGRI has accomplished this task of simulating the nature while establishing the field gene bank of medicinal and aromatic plants under the G-15-GBMAP sponsored by DBT, Government of India, TBGRI experience now provide ample opportunity to repeat the same elsewhere in the country.

Identification of the keystone species and umbrella species are very important in this methods. After planting the keystone and umbrella species, other species complex which include the medicinal aromatic plants in question have to be introduced. The sampling and selection of samples for introduction have to be highly knowledge and science intensive. To capture the maximum possible genetic diversity of the target species it is extremely important to collect all valuable information such as morphological variants, chemical variants or genetic variants or chemical screening of the population of the targeted species by using the latest methods and tools. The field gene bank of TBGRI has covered 30,000 accessions of 250 medicinal and

Aromatic plant species which include 100 endemic, rare and endangered medicinal and aromatic plants of the tropical region of India. A broad spectrum of the genetic diversity of these species were captured and introduced in this gene bank which covered morphotypes, cytotypes and chemotype and the number of samples from each species varied from 50-1000 plants.

Genetic Conservation of Medicinal Plants

The Department of Biotechnology has already set up three national gene banks on medicinal and aromatic plants at the Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow, Uttar Pradesh, National Bureau of Plant Genetic Resources (NBPGR), New Delhi and Tropical Botanic Garden & Research Institute (TBGRI), Thiruvananthapuram, Kerala. They are engaged in collection, conservation and characterization of the precious wealth of medicinal and aromatic herbs which are rare/threatened/endangered or are being used in traditional system, or those which are commercially exploited. The Regional Research Laboratory (RRL), Jammu, Jammu & Kashmir, is the forth gene bank which covers the North-Western Himalayan region. A germ-plasma repository for medicinal plants used in Ayurveda has also been established at Arya Vaidya Sala, Kottakkal, and Kerala. More than 9,000 accessions of important medicinal and aromatic plant species are being maintained as live material in field gene banks, in the form of seed, in vitro material and DNA. For long-term conservation, the accessions are stored under cryogenic conditions.

The key activity of medicinal plants conservation area model will include the following:-

1. Selection of sites that cover the range of forest types, altitudes, areas of known species richness and medicinal plants presence. Sites having red listed species population should also be considered. Attempt should be made to capture the wild populations of entire medicinal plants of the country.

2. Forest areas (within protected areas) with high biodiversity or sites traditionally valued for medicinal plants diversity or sites with the presence of known red-listed medicinal species, are specially identified.
3. Detailed botanical study of each site should be completed aiming documentation of all plant taxa occuring in MPCA with herbarium records, systematic estimation of plant population and regeneration, distribution patterns, association, micro habitat and cultural information related to the plants collected.
4. Each site should be about 500 ha in area for which "Management Plan should" be formulated.
5. Taking efficient measures to protect sites from fire and other biotic pressure.
6. Locating breeding populations of red listed species and economically viable species and at a subsequent stage developed a suitable species recovery programme for critically endangered species and enrichment planting programme for economically valuable species.
7. Building and strengthening community institutions for long term management of the sites.
8. Training of wildlife staff and others for in-situ conservation of medicinal plants.

Endangered medicinal and armtic plants in some states and regions

ASU: Ayurveda, Siddha & Unani
AYUSH: Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homeopathy
BfN: Bundesamt fur Naturschutz
BSI: Botanical Survey of India
CBD: Convention on Biological Diversity
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora DFO: Divisional Forest Officer
FRI: Forest Research Institute (Dehradun)
GACP: Good Agriculture and Collection Practices
ISSC-MAP: International Standards for Sustainable Wild Collection of Medicinal and Aromatic Plants
IUCN: International Union for Conservation of Nature
MoEF: Ministry of Environment and Forests
NMPB: National Medicinal Plants Board
RET: Rare, Endangered and Threatened (Species)
SOP: Standard Operating Procedures
TRAFFIC: Trade Record Analysis of Fauna and Flora in Commerce
WHO: World Health Organization
WWF: World Wild Fund for Nature

Important conservation concern species	
In South India	
Chonemorpha Fragrans	*Humboldtia vahliana*
Gymnema khandaiense	*Garcinia rubroechinata*
Gymnema montanum	*Garcinia travancorica*
Panax pseudoginseng	*Iris bakeri*
Swertia lawii	*Cinnamomum wight*
Salacia oblonga	*Strychnos aenea*
Salacia reticulata	*Madhuca longifolia*

Cypripedium calceolus	*Dipterocarpus indicus*
Hydnocarpus alpina	*Baliospermum montanum*
South & South East Gujarat	
Saraca asoca	*Tinospora cordifolia*
Terminalia chebula	*Gloriosa superba*
T. bellerica	
In Meghalaya	
Daphniphyllum himalense Muell. - Arg.	*Dendrobium nobile* Lindl.
Elaegnus conferta Roxb.	*Gloriosa superba* L.
Hedychium coronarium Koening	*Ilex khasiana* Purk.
Nepenthes khasiana Hk.f.	*Rauvolfia serpentina* Benth. ex Kurz