E-Content

on

Medicinal and Aromatic Crops
HFL 311

B.Sc. (Hons.) Horticulture

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DECLARATION

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Chapter 1

History of Cultivation of Medicinal and Aromatic Plants in India

Introduction

Plants have been one of the important sources of medicines even since the dawn of human civilization. Inspite of tremendous developments in the field of allopathy during the 20th century, plants still remain one of the major sources of drugs in modern as well as traditional system of medicine throughout the world. Approximately one-third of all pharmaceuticals are of plant origin, wherein fungi and bacteria are also included. Plants may have bioactive constituents like alkaloids, glycosides, steroids, phenols, tannin, antioxidants and other groups of compounds which may have marked pharmaceutical actions as anti-cancerous, anti-malarial, anti-helminthic or anti-dysentric, etc. Many of the essential oils, dyes, latex and even vegetable oils are also widely used as medicines. Many substances that go into making up medicines are frequently products of living cells, although seemingly 'waste' or intermediate, metabolic compounds and not an integral part of the protoplasm and may have no obvious utility to the plants.

Drugs are derived from trees, shrubs, herbs and even from primitive kinds of plants which do not fall into the above categories. They are made from fruits (Senna, *Solanum viarum*, Datura, etc.), flowers (*Butea monosperma*, *Bauhinia variegata* etc.), leaves (Senna, Datura, Periwinkle, Tylophora etc.,), stems (Liquorice, Ginger, Dioscorea, Costus, Garlic), roots (Rauvolfia, Periwinkle, Ginseng etc.), seeds (Isabgol, Abrus, Nux vomica) and even bark (Cinchona).

History

- Plants have been associated with the health of mankind from time immemorial.
- In the past, sickness was viewed as a punishment by the gods and hence, was treated with prayers and rituals that included what may have been considered 'magic potions' (Jaduyi Sharbat) prepared out of local herbs.
- Archaeological discoveries from 60000-year-old Neanderthal burial grounds in Iraq point to the use of several plants like marsh-mallow and yarrow that still figure in folk medicine.
- Mexican Indians are reported to have used peyote cactus for its hallucinogenic and also possibly its healing properties for thousands of years. This plant is now known to have antibiotic properties as well.
- Cuneiform (logo-syllabic script) writing on clay tablets by the Sumerians of the Tigris and Euphrates (present day Iraq) around 4000 BC, reported the use of opium, liquorice, thyme, mustard and the chemical element sulphur as medicine.
- The Babylonians who apparently followed the Sumerians in this field added senna, coriander, saffron, cinnamon and garlic among the other herbs in their formulations.
- The history of the use of aromatics dates back through many ages and many civilizations. It is, however, difficult to pinpoint when exactly man first used essential oils. Obviously, it must be prehistoric. The sense of smell plays a significant role for man in the identification of the right type of food. Most of the fruits, when

ripe and fit for consumption, emit a pleasant smell or aroma. The pleasant smell of flowers attracts insects and this helps in the cross-pollination, so essential oils have played a vital role, directly as well as indirectly, in the life of man since appearance on the Earth as a result of evolution.

- India has enjoyed a pre-eminent position in the manufacture of superior perfumes and aromatics since ancient times and the industry has flourished and grown considerably. The famous Chinese traveler Fa-Hien described India as the land of aromatic flowers fruits, woods, roots resins and grasses. Fragrances were very expensive and were used mostly in worship as incense.
- In ancient India, perfumers were important traders; they were called 'gandhikas', who created their own blends of perfumes and incense in the form of liquid, sticks, powders, pastilles and pastes.
- In Sanskrit literature, there is description of the toilette of a Mauryan queen, where her perfumes were freshly made by her maid. Sandalwood was grated on a wet stone, spices pounded in a pestle, then the paste blended in oil and sweet smelling flowers and leaves added to them.
- In the Ain-e-Akbari, Abul Fazal mentions Akbar's love of attar and incense, "daily burnt in gold and silver censers". At a later date, an apocryphal (Story or statement) tale credits the Empress Noor jahan with discovering the attar of roses. She is said to have noticed the rose-oil floating on the surface of her bath-water and, thus, the legendary attar of rose was born.
- At nawabi banquets, guests were welcomed with attar. They were sprinkled with rose-water at the gate and then phayas, small swabs of cotton dipped in attar, would be offered to them on silver trays decorated with flowers. Even the containers spelt luxury; attar daans were made of carved ivory or chased silver in the shape of mangoes or preening peacocks. The dressing table of a medieval lady's boudoir would have a lacquer box holding a row of small cut-glass vials of attar. The silver rosewater sprinklers were shaped like long-stemmed flower vases and covered in filigree work.
- Indian cities like Delhi, Agra, Kannauj, Lucknow, Jaunpur, Ghazipur, Aligarh, Bharatpur, Mysore, and Hyderabad, emerged as centers of the national and international trade in perfumery and other aromatic compounds, and were known for their quality attars across Asia, Europe and Africa.

Chapter 2

Importance and Opportunities of cultivation of medicinal and aromatic plants in India

Medicinal Plants

Medicinal plants are those plants which are rich in secondary metabolites and are potential sources of drugs. These secondary metabolites include alkaloids, glycosides, coumarins, flavonoids, steroids etc. These plants form the main base for the manufacture of drugs of Indian systems of medicine (Ayurveda, Unani, Siddha) and Homeopathy. These plants are found in various parts of the country in different environmental and climatic conditions. Plants which grow wild in forest regions, classified as minor forest produce, supply a substantial amount of raw material required for the indigenous drug industry.

Importance of cultivation of medicinal plants in India

1. India is one of the few countries where almost all the known medicinal plants can be cultivated in some part of the country of the other. Among the various plants in great demand in the country and abroad are Opium poppy, tropane alkaloid bearing plants, sapogenin bearing yams, senna, psyllium husk and seeds and cinchona.
2. The ancient Indian System of Medicine (ISM) is predominantly plant based making use of most of our native plants. It caters to almost the entire rural population of our country mainly because of the scarcity of modern allopathic healthcare in our villages.
3. ISM offers most appropriate or first line therapy against many diseases like jaundice, bronchial asthma, rheumatoid arthritis, diabetes etc., for which allopathic medicines have as yet no cure. It is well known that most allopathic medicines produce many side-effects. It is for this reason that more and more people in the western societies are showing increasing interest and preference for organic drugs and their preparations.
4. India has about 2,000 species of medicinal plants and a vast geographical area with high production potential and varied agro-climatic conditions. Most of these plants can subsist under stress conditions and are thus suited even for rain-fed agriculture. Cultivation of medicinal plants offers considerable scope for rural employment and export for foreign-exchange earnings.
5. India is already a major exporter of medicinal plants. It is estimated that rupees 86 crores worth of raw materials and drugs from medicinal plants are exported from India. It holds monopoly in the production and export of psyllium and senna and is second largest exporter of Opium latex.
6. Many of the medicinal plants required by the trade are gathered mainly from the wild growth thus depleting the vegetation of its valuable medicinal plant wealth (e.g: Rauvolfia, Dioscorea). On account of this practice, many species of medicinal plants in our country have become extinct or endangered. This should be prevented and herbal gardens and gene-banks covering important medicinal plants should be established to conserve them.

Opportunities for Medicinal Plants Cultivation

1. The World Health Organization (WHO) has emphasized the need for better utilization of the indigenous system of medicine, based on the locally available medicinal plants in the developing countries. In the USA and UK, plant-based drugs are being used in

recent years on a considerable scale. The former USSR countries, East European countries and China have adopted an integrated system of allopathic, traditional and folk systems of medicine. During the last two decades, there has been a tremendous transformation of medical systems in the world. Owing to the realization of the toxicity associated with the use of antibiotics and synthetic drugs, Western countries are increasingly aware of the fact that drugs from natural sources are far more safer. Therefore, there is an upsurge in the use of plant derived products.

2. Medicinal plants and their derivatives will continue to play a major role in medical therapy in spite of advances in chemical technology and the appearance of cheap, synthesized, complex molecules from simple ones through highly specific reaction mechanisms. The reaction involved is either difficult or expensive to duplicate by classical chemical method. For example, in Vitamin A, disogenin and solasodine of plants, where stearic forms are possible, chemical synthesis yields a mixture of the isomers which may be difficult to separate. The product obtained by synthesis may therefore be toxic or have a different therapeutic effect than what is obtained in nature.
3. Drug development out of medicinal plants is less costly than synthetic drug development. Reserpine is a good example of this. The synthesis of reserpine costs approximately Rs.1.25/g, whereas, commercial extraction from the plant costs only Rs.0.75 /g.
4. The vast range of agro climatic conditions in India, varying from alpine/mild temperate to tropical regions with abundant rains and sunshine make it an ideal place for the luxuriant growth of flora. India is endowed with incredible natural plant resources of pharmaceutical value. Despite comprising only 2% of the land mass, India is blessed with 25% of the biodiversity of the world. Over 7000 species of plants found in different ecosystems are said to be used for medicine in our country. The Indian pharmacopoeia records about 100 medicinal plants available in India and their preparations. Out of these, quite a few are also recorded in the pharmacopoeias of other countries of the world and there is a growing demand for them in the international market.
5. There has been a tremendous upsurge in the demand for phyto-pharmaceutical raw medicinal herbs and vegetable drugs of Indian origin from the Western nations. There is also an increase in domestic demand for raw material used for perfumeries, pharmacies and bio-pesticidal units. The demand for traditional herbal drugs is also increasing rapidly mainly because of the harmful effects of synthetic chemical drugs and also because of an expansion of pharmacies manufacturing natural drug formulations.
6. Our country is the proud possessor of an impressive medical heritage which encompasses various systems of medicine, viz., Ayurveda, Siddha, Unani, folklore and grandma medicine. India has an invaluable treasure trove of various scriptures on diverse medical systems.
7. India is the source of cheap labor and skilled manpower which readily absorbs technological change and also adopts the same.
8. Being strategically located in the world map, India could become a potential supplier of phyto-pharmaceuticals, alkaloids and raw medicinal herbs for the emerging world market. At present, India is not self-sufficient in pharmaceutical products, and drugs worth millions of rupees have to be imported every year by the pharmaceutical industries in order to meet the national demand for drugs. Hence it is necessary to

bestow utmost attention to check the import by producing the raw material and fine chemicals within the country.

9. In addition, these crops have many virtues like drought hardiness, capability to grow on marginal lands. They are relatively free from cattle damage and hence, can be profitably grown in areas where stray cattle or wild animals or pilferage is a major problem. As it is, medicinal plants are better earners than many of the field crops. Since they are new crops, there is an immense scope for further improvement in their productivity and adaptability, in order to obtain further increase in returns. They are suitable for incorporating into various systems of culture like intercropping, mixed cropping and multitier cropping.

Distribution of medicinal plants

Country or region	Total number of native species in flora	No. of medicinal plant species reported	% of medicinal plants
World	297000	52885	10
India	17000	7500	44
Indian Himalayas	8000	1748	22

AROMATIC PLANTS

The plants which possess essential oils in one or more plant parts are known as aromatic plants. For example, Wood - sandal; Bark - cassia; Foliage - lemon grass; Flowers - jasmine; Fruits - citrus; Seeds - coriander. Essential oils are secreted in oil glands.

Essential oil

These are complex mixture of odoriferous steam volatile compounds, which are deposited by plants in sub- cuticular spaces, granular hairs, cell organelles, excretory cavities, canals and heart wood.

Uses of aromatic plants

1. In food and flavour industry - spices and condiments
2. In perfumery, soap and cosmetics
3. Pharmaceutical and drug industries.
4. To manufacture pesticides, disinfectants due to antifungal, antiseptic and insecticidal properties.
5. In pain industry - as solvents.
6. Distilled wastes are used in manufacture of card boards, cheap paper, packing material.

Present status of Aromatic plants

The world's total production of essential oils is estimated at about 1,00,000 – 1,10,000 t and India stands third with a share of 16-17%. In value terms again, India's position is No.2 and its share is 21- 22%. This is because of the mint revolution in North India. Brazil with its production of citrus oil at 40000 t is the largest producer of essential oils in the

world. However, its share in value terms is 90% while USA is the largest producer and consumer of essential oils.

Importance of Aromatic Plants

Aromatic plants are from a numerically large group of economically important plants. The demand for essential oils, aroma chemicals drugs and pharmaceuticals in the world market is increasing since two decades. Aromatic compounds are present in plants i.e. in root, wood, bark, foliage, flower, fruit, seed etc.

1. Aromatic plants produce essential oils, perfumes and flavours are in use with our civilization since several thousand years.
2. Due to Vast area and varied agro-climatic condition, it can be commercial cultivated in different part of India successfully.
3. Essential oils and aroma chemicals are indispensable in various human activities.
4. They are adjuncts of cosmetics, soaps, pharmaceutical preparation, perfumer confectionery, ice-cream, aerated waters, disinfectants, agarbatti etc.
5. Some of the important aromatic plants like Lemon grass, Citronella, Palmarosa, Vetiver, Geranium, Lavender, Dawana etc. have great demand in our country.

Opportunities of Aromatic plants cultivation

1. It is realized now that perfumes and essential oils are not the articles of luxury as they were in the past. The demand for essential oils is increasing day by day with the advancement of education and prosperity in the country.
2. Fragrance plays a vital role in securing consumer acceptability in almost every product used. Essential oils are now a basic raw material for consumer products meant for mass consumption. At least two hundred essential oils are used often and another eight hundred find occasional application. Similarly, about a dozen expressed oils, and a dozen flower absolutes and a few oleoresins and gum resin oils are also used.
3. There is a definite trend seen in the revival of plant-based aromatic chemicals in reports from medical centers regarding the potential carcinogenic hazards of synthetics.
4. Aromatic plants and essential oils freshen the environment.
5. They also represent renewable resources.
6. The search for natural resources has been intensified as synthetics have failed to provide versatility and a situation of saturation and later stagnation started developing. Improved instruments and chemicals also and thus helped in the search for new aromatic compounds.
7. The aroma therapy is gaining momentum across the world and the interest in aromatics for their therapeutic value is also increasing due to the worldwide scare of the side-effects of synthetics and the revival of interest in herbs.
8. Natural essential oils have the potential of being very safe insecticides. One good example in this regard is of the essential oil obtained from *Acorus calamus* which has ß-asarone as an active principle, and produces sterility among a variety of insects of either sex. It has been found very effective and safe for the storage of food grains.
9. Apart from the above facts, essential oil crops are much better earners and, value-wise, their transportation cost is also much lower. Aromatic crops ought to get a high priority, next to food.

10. The growing and processing of aromatic crops is labour-intensive and, hence, generates lot of employment.
11. Their spent waste can be converted into boards and can be used as a mulching material or ploughed back into the soil to improve its tilth.
12. Most of these raw materials are produced in the tropics, in the developing countries of Asia and Africa from where they go to Europe and the USA for use in the manufacture of perfumery chemicals, cosmetics, food flavours and a host of other consumer products which, in turn, are distributed all over the world.
13. Thus, they provide a natural asset to these countries for the export trade.

Despite many odds, India has still been maintaining a leading position in the production and trade of several essential oils. However, it is now facing stiff competition from other developing countries in several traditional commodities, both for quality and price, any slackness at this stage in these parameters may be disadvantageous to India in terms of international trade. It, therefore, needs intensive research efforts in farm production and processing technology. In many developing countries, there is now organized cultivation of these crops. Standards are being set for the presence of overall composition of the produce meant for use in industry and export.

There are several new species being introduced into the market as new sources of aromatic materials and these are being widely utilized in the industry. It is an opportune time for us to make organized efforts in the introduction of several new aromatic species of industrial utility into Indian agriculture and encourage the production and utilization to sustain the fast expanding domestic industry, as well as for export.

Essential oil industry is not strong in India because:

1. Farmers are not aware of the significance and profitability.
2. Lack of marketing facilities.
3. High initial investment.
4. Price fluctuation
5. Competition for land domestically.
6. Lack of scientific knowledge on cultivation.
7. Deadly diseases like spike disease of sandal wood or wilt of Geranium
8. Lack of germplasm collection and maintenance.
9. Larger quantities are required.
10. Lack of testing facilities.
11. Cheaper synthetic substitutes.
12. Dearth of trained personnel.

Chapter 3

Constraints in cultivation and maintenance of MAPs

Although, India is a leading exporter of medicinal plants in the world, the rate of growth of these crops in relation to their economic prospects is not at all satisfactory. The reasons for this apparent backwardness are many and varied.

1) So far, there has been no organized research set-up to continually recharge scientific inputs in order to make their cultivation not only economically viable but also more profitable, so that they can claim their due share in the cropping systems of the country.

2) Inspite of the thrust given by the government of India through the institutions like the Central Institute of Medicinal and Aromatic Plants (CIMAP) Lucknow (UP) and Directorate of Medicinal & Aromatic Plants Research (DMAPR), Anand (Gujrat) National Botanical Gardens, Forest Research Institutes, the replenishment of renewable inputs like quality planting material of improved varieties, developing extension literature, organizing training and quality testing, are very limited because of the number of medicinal plants as well as their divergent uses.

3) The other major constraint is marketing of the cultivated raw material because of the quality considerations. Lack of testing facilities at the procurement and trading centres together with unscrupulous market handling, results in wide fluctuations in prices, often going down to uneconomic and unrealistic levels. Thus, speculative trade has been one of the most serious deterrent to the development of this enterprise.

4) The systematic cultivation of a few medicinal plants has been found to be a discouraging enterprise, mainly because of the uneconomical price they command. For example, the sale price of *Phyllanthus amarus* is as low as Rs.10/kg, making it a commercially unviable proposal. There is a need for the user industry to come forward and ensure that the cultivated product is going to be homogeneous, in comparison to those collected from natural sources, where there is possibility for wide variation.

5) Although most of them are industry oriented crops, the pattern of land-holdings does not lend itself for commercial cultivation on an extensive scale. In case of a few plants, viz., aonla, asoka, arjun, bael, nutmeg, neem, the cultivation involves a long gestation period due to which many farmers are reluctant to grow them.

6) Unstable market conditions have also kept farmers away from taking up cultivation of these crops.

7) In the phyto-pharmaceutical industry, presently, no quality standards have been fixed, either for the raw material or the final product and, as such, one finds wide variation in the quality specifications.

8) Difficulty in proper identification of medicinal plants has led to the use of adulterants or mimics. Physical verification is also a difficult proposition, mainly because the plant part used in many cases like the barks, roots, etc., show close resemblance. The only way to check adulterants would be by chemical examination.

9) The package of practices for number of medicinal plants has not been standardized to suit different agro-ecological conditions.

10) The supply of raw material for the phyto-pharmaceutical industry is virtually monopolized. It is found that supply and price patterns are often determined by the minor forest produce contractors/gatherers.

11) In a number of cases, the produce has to be used fresh for which instant transportation is a must, and in many cases it cannot be stored for long periods as this would entail fumigation which at times, results in chemical contamination of the raw material and eventually the final product, because of its residual effect. Generally, the maximum period for which plant material should be stored is around 5-6 months and no more.

In addition to this, inefficient organization, lack of research, unplanned exploitation of natural resources, failure to grow them on a large scale, inferior methods of production, malpractices and adulteration are some of the reasons for present poor state of affairs. It is unfortunate that with almost all types of climate and soil existing in our vast country, the possibilities of raising large-scale plantations of essentials oil bearing plants on scientific lines has not been explored. It is a pity that interspaces in the perennial plantations, vast stretches of forests and lands as barren, waste and marginal are lying fallow, when they can be gainfully used to raise aromatic raw materials. The inadequate research support for the cultivation of aromatic crops and extraction of essential oils and perfumes is visible in spite of many of the institutions that undertake research on aromatic crops in India.

To overcome these constraints, it is necessary to organize the cultivation of medicinal crops on specific regional basis and organize their marketing on similar lines as that of other cash crops like coffee, tea cardamom, to maximize their production and returns.

Production Technology of Ashwagandha

Common Name	:	Winter cherry, Indian Ginseng, Asgandh
Botanical Name	:	*Withania somnifera*
Family	:	Solanaceae
Ch. No.(2n)	:	48
Origin	:	East Asia & Africa
Economic Part	:	Root

Name ashwagandha is made of two words i.e. Ashwa means horse and gandha mean smell reflecting that roots have horse like odour.

Economic part: Roots, bark, seed and leaves

Chemical constituent: The major alkaloid present in roots is Withanine.

Uses

- It is considered as wonder herb with multiple medicinal properties. It has many uses such as:
- Roots are used for curing bronchitis, stomachache, lung inflammation and skin diseases.
- Leaf paste and root paste are used to relieve joint pain and inflammation
- The leaves are used for providing comfort during eye-diseases
- Seeds are diuretic in nature

Distribution

It is found throughout the drier parts of India particularly in states of M.P., Gujrat, Rajasthan, Western UP, Punjab, Haryana, Maharashtra, Karnataka, Kerala and Himalaya upto height of 1500m. In M.P., about 4000-5000 ha of land is under cultivation of Ashwagandha. The estimated production of its roots in India is 1500 MT, while the annual requirement is about 7000 t, necessitating increase in its cultivation and improving productivity. Ashwagandha has been identified by NMPB as one of the thirty-two priority medicinal plants and is one of the top ten traded herbs. It is cultivated under rainfed condition in marginal soils by small and marginal farmers.

Morphology

It is a small, erect, branched, woody shrub that grows up to 1.50 M tall. Roots are fleshy, tapering, whitish brown. Leaves are ovate and flowers are greenish. The mature fruits are orange-red berries.

Fig: Ashwagandha Plant (Vegetative stage, Fresh fruit, Dried root and Dried fruits)

Climate

It is grown in sub-tropical, low rainfall regions. It is grown as long duration, winter annual (240 days) on marginal lands. Late winter shower favour its good root development. The sub-tropical areas receiving 500 to 750 mm rainfall are suitable. It requires relatively dry season during its growing period. Temperature between 20°C to 35°C is most suitable for its cultivation.

Soil

It can grow well in wide range of soil types. But it prefers well drained, medium red and black soil with good drainage. The soil should have pH range of 7.5 to 8.0. Black or heavy soils having good drainage are also suitable for its cultivation.

Propagation:

It is raised from seeds. Seeds do not have dormancy. The seeds harvested from previous season having good quality should be used.

Sowing method

Seeds are generally sown directly in field during August end. Line to line method is preferred as it increases root production and helps in performing intercultural operations smoothly. For better germination of seeds, the seeds may be soaked in 500 ppm of Gibberellic acid overnight, washed and then treated Dithane M-45 (Indofil M-45) at the rate of 3 g/kg seed to protect the seedlings from the seed borne diseases. The seeds are usually sown 1-3 cm deep. Seeds should be covered with light soil. Line to line distance of 30 cm and plant to plant distance of 10 cm should be maintained. A light shower should be given after sowing of seeds to ensure good germination. In some areas, transplanting is also in practice. The healthy seedling of 25-35 days old can be transplanted in the main field at the recommended spacing.

Fig.: Ashwagandha Seed

Land preparation

In Ashwagandha, roots are the major economic part. Thus, land should be prepared in such a way that it should not have any hindrance in the development of roots and get more length and girth for better quality. The land was ploughed once with MB plough and harrowed

twice to bring the soil to fine tilth after receiving pre- monsoon rain. Well decomposed FYM should be added at the time of land preparation. About 10-20 tonne of farm yard manure per hectare should be mixed into the soil at the time of last ploughing. The field is then levelled by planking.

Varieties

Important varieties are Jawahar Asgandh 20 released in 1989 from JNKVV, Regional Station, Mandsaur. Jawahar 134 was released in 1998 by AICRP on MAPs, Mandsaur centre. One variety released from CIMAP is Poshita. Other varieties are Pratap and Chetak.

Manures and fertilizers

Optimum crop nutrition should be ensured as excess or deficit of any essential plant nutrient may decline the production as well as quality of the produce. Soil testing should be done before applying the nutrients. Use of organic manures preferred over inorganic sources of nutrients for growing of ashwagandha. Organic manures like, farm yard manure, vermicompost, green manure etc. may be used as per requirement of the crop. Generally, its fertilizer requirement is very low. Farmers rarely give inorganic fertilizers, but crop responds well to application of 10 t FYM or one tonne vermicompost and 20:40:20 NPK kg/ha.

Irrigation

Ashwagandha is usually grown as rain fed crop where irrigation facilities are not available. However, for irrigated crop there should be access to a clean and reliable source of good quality irrigation water. Excessive rainfall or water is harmful for this crop and not require irrigation, if monsoon is well distributed throughout the growing season. However, one or two life-saving irrigations can be given if required. Under irrigated conditions, the crop can be irrigated once in 15 days depending on soil type. Organic mulches such as wheat straw or ashwagandha straw of previous crop should be spread in between the rows to conserve the soil moisture, facilitate better water infiltration during excess rains and control weed.

Thinning and weeding

In broadcasting method or sown in line, thinning by hand 25 to 30 days after sowing is needed to maintain a plant population of about 30 to 60 plants per sq. m. Weeds should be managed before they start competing with the crop for nutrients and light. One hand weeding at an early stage is sufficient to enable the ashwagandha plants to take over the growth of weeds. At later growth stages, the weeds are get suppressed by its smothering effect. Care should be taken during hand weeding that the roots should not be damaged by hoe. Use of chemical herbicides is restricted for weed control in medicinal crops hence, alternative methods of weed control such as use of organic mulches to control weeds should be preferred as they inhibit the weed growth as well as conserve the soil moisture. Two weedings are required, first within 20-25 days of sowing and the other after 20-25 days of first weeding.

Harvesting

Harvesting should be done at the right stage to ensure maximum levels of active ingredients and better quality. Ashwagandha 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 when leaves start drying and berries become yellow red. Root size, root and shoot biomass and alkaloid content were found maximum in 180 days crop

which should be considered as best harvesting time for ashwagandha. Ashwagandha should be harvested in the dry weather and not in rain or in early morning when there is dew on the ground. Harvesting is done by uprooting the whole plant without damaging the roots. There should be sufficient moisture in the soil at the time of harvesting for easy uprooting the plants. Weed plants or any inert material should not be harvested with the crop plants.

Post-harvest handling

The roots are separated by cutting the stem 1 to 2 cm above the ground, the roots are washed, cut into 7 to 10 cm small pieces and dried in sun or shade. Roots should be dried to 10 - 12 % moisture content. Roots can be graded in to 3-4 grades as follows. :

l. A grade root: Root pieces up to 7cm length and diameter 1.0 - 1.5 cm, solid, bright and pure white.

2. B grade root: Root pieces up to 5 cm length and diameter 1 cm, bright and white.

3. C grade root: Root pieces up to 3-4 cm length, diameter less than 1 cm, solid, side branches.

4. Lower Grade: Small root pieces, semi-solid, very thick, yellowish, and chopped.

Yield

On an average from one-hectare crop under commercial cultivation, approximately 6-8 quintals of dried roots and 50-75 kg seeds can be obtained. Cultivation of one hectare ashwagandha crop may cost 10,000/- and gives return of 30,000 per hectare. However, it depends on the demand and supply at a given time in the market.

Marketing and export

The Neemuch and Mandsaur markets of Madhya Pradesh are popular world over for Ashwagandha.

Chapter 5

Production Technology of Periwinkle

Common Name	:	Periwinkle, Sadabahar, Sada phuli
Botanical Name	:	*Catharanthus roseus*
Family	:	Apocyanaceae
Ch. No.(2n)	:	16
Origin	:	West indies
Economic Part	:	Leaves, seeds, roots, flowers

Importance

Periwinkle is a perennial ornamental herb found throughout India on waste lands and sandy tracts. It has medicinal importance owing to the presence of indole alkaloids raubasin (ajmalicine) and serpentine in its root which have anti-fibrillic and hypertensive properties. The leaves contain two alkaloids viz., Vinblastine and Vincristine which form the constituents of patented cancer drugs and vincristine alkaloids are distributed in different parts of the plant but the roots contain the maximum (0.75 t to 1.20%) followed by the leaf (0.60 to 0.65%). Vincristine sulphate is being marketed under the trade name ONCOVIN, which is used against acute leukemia and vinblastine sulphate as VELBE to cure Hodgkin's disease.

Uses

1. Leaves used in curing blood cancer
2. Leaves useful in treating menstrual disorders, diabetes mellitus.
3. Decoction of leaves & roots active on hypertension.
4. Roots control high blood pressure.

Origin and distribution

The plant is native of Madagascar and from there, it has spread to India, Indonesia, Indo-China, Philippines, South Africa, Israel, USA and other parts of the world. In India, it is being grown in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat and Assam in an area of about 3000 ha. The USA is the world's largest user of this plant as raw material. A single firm which has the patent to manufacture Vinblastine and Vincristine sulphate has been consuming more than 1000 t of leaves annually. West Germany, Italy, Netherlands and the UK are interested in the roots. The total demand from these countries is more than 1000t of roots annually.

Botany

It is a perennial herb, often grows in garden for its pink and white flowers which bloom throughout the year. It bears flexible long branches with simple opposite leaves. Flowers 2-3 in cymes, axillary and terminal clusters. Fruit is a cylindrical follicle with many black seeds.

Climate

The distribution of the plant shows that there is no specificity in its climatic requirements. It comes up well in tropical and subtropical areas. However, the growth in tropical areas is better than in the subtropical areas, where its growth is slow due to the low temperature in winter. It can be successfully grown up to an elevation of 1300 m above sea level. A well distributed rainfall of 100 cm or more is ideal for raising this crop on commercial scale under rain-fed conditions.

Soil

The crop is hardy and grows well on a wide variety of soils, except those which are alkaline or waterlogged. Deep sandy loam to loam soils of medium fertility are preferred for its large scale cultivation because of better development of roots and also easy to collect at harvest time. pH should be upto 8.5.

Propagation

The plants can either be propagated by seeds or vegetatively through cuttings. Since plants propagated by cuttings flower earlier than the plants from seeds, it is recommended that for drug production the plants should be grown from seeds and for seed production from cuttings.

i) Propagation by seeds

Fresh seeds collected a few months in advance are preferred for sowing as they lose viability on long storage. The seeds can either be directly sown in the field or a nursery can be raised and the seedlings are transplanted.

Direct Sowing

This method is best suited for large areas where labour is expensive as it reduces the cost of production. The land is ploughed twice and brought to fine tilth. Weeds, stubble and pebbles are removed. The field is divided into plots of convenient size and the soil is mixed with the recommend dose of manures and fertilizers. The seeds at the rate of 2.5kg/ha are broadcasted at the onset of monsoon in June – July, in lines spaced 30 -45 cm apart and lightly covered. Since the seeds are very small, for ease in handling and distribution, they are mixed with sand about 10 times their weight. Germination takes place after about 7 – 8 days. After germination is complete the seedlings are thinned at a spacing of 30 – 40 cm within the row. The flowering starts 40 – 45 days after sowing

Nursery preparation and transplanting

When seed supply is short this method can be followed. The other advantage of this method in comparison to direct sowing is that healthy and vigorously growing seedlings can be selected and the inferior ones can be discarded. The seeds are sown in well prepared, raised nursery beds in March – April in rows spaced at 8 – 10 cm apart and about 1.5cm deep. About 500 gm of seeds will be enough to raise seedlings to cover 1 ha area. After two months of germination, the seedlings are ready for transplanting into the field. The seedlings are transplanted at a spacing of 45 x 30 cm in the field. A population of 74, 000 plants per ha may be accommodated.

Vegetative propagation

To raise plants by this method, soft wood cuttings obtained from the lateral shoots have proved better than either hard or semi hard wood cuttings. Cuttings of about 10-15 cm length with a minimum of 5-6 nodes are ideal and result in about 90% rooting. Soaking the cuttings overnight in NAA solution of 25 or 50 ppm concentration has been found to further improve rooting to the extent of 96%. This method can be profitably used for multiplying the clones which have high alkaloid content and also where seed alone is to be produced.

Types and varieties

Three variants in periwinkle are there which are with (i) rose purple flowers (roseus), (ii) white flowers (alba) and (iii) white flowers with a rose purple spot in the centre (Ocilatta). The first type is being cultivated because of its higher alkaloid content. Recently, two white flowered varieties named “Nirmal” and “Dhawal” have been released by the CIMAP, Lucknow, which although equal in active principles are reported to yield a higher biomass.

Manures and fertilizers

FYM is applied at the rate of 10 – 15 t/ha to obtain good growth and yield. If irrigation is available, green manure crops can be raised and ploughed into the field at the time of flowering. In case organic manure is not applied it is advisable to apply a basal dose of 20 kg N, 30 kg P2O5 and 30 kg of K2O per hectare per year. In addition, a top dressing with 20 kg nitrogen can be given in two equal split doses during the season.

Irrigation

In places where rainfall is evenly distributed throughout the year, the plants do not require any irrigation. However, in areas where rainfall is restricted to a few months in a particular period, about 4-5 irrigations will help the plants to give optimum yield.

Weed control

The crop requires two weeding in the initial stages of its growth. The first weeding may be done after about 60 days of sowing and the second at 120 days of sowing. Mulching the field with cut grass or rice straw will also minimize the weed growth.

Harvesting and processing

i. **Leaves, stem and seeds**: For leaves, leaf stripping twice, first after 6 months and the second after 9 months of sowing can be taken. A third leaf stripping is also obtained when the whole plant is harvested. After the plant is harvested, it is dried in the shade.
ii. **Roots**: The crop is harvested 12 months of sowing. The plants are cut about 7.5 cm above the ground level and dried for the stem, leaves and seeds. The field is then copiously irrigated and when it reaches proper condition for digging, it is ploughed and the roots are collected. The roots are washed well and dried in the shade. For seeds, it has to be collected from matured pods 2 to 3 months before the harvest of the whole plant. The aerial part of the plant between 7.5cm and about 25 cm above the ground level is taken as the stem for the purpose of marketing.

Yield

Under irrigated conditions, about 4t/ha of leaves, 1.5t/ha of stem and 1.5t/ha of roots, on air dried basis may be obtained. Whereas, under rain-fed conditions, the yield will be about 2 t/ha of leaves and 0.75t/ha each of stem and roots on air dried basis. The total alkaloid content in the leaf varies from 0.15 to 1.34 % of which the average content of Vinblastine is 0.002% while that of Vincristine is 0.005%

Production Technology of Sarpagandha

Common Name	:	Candrabhaga, Chotachand, Serpentine root & Chandrika
Botanical Name	:	*Rauvolfia serpentina*
Family	:	Apocynaceae
Ch. No.(2n)	:	22
Origin	:	South East Asia
Economic Part	:	Roots

Importance and use

The roots of sarpagandha have a 400 years history of use in treatment of snake bite, insect stings and nervous disorders. About 30 alkaloids are known to exist in this plant. The most important are reserpine, serpentine, ajmaline, ajmalicine and rauvolfinine. Reserpine is the compound / active principle used for hypertension as a life-saving drug in allopathic system of medicine. The total alkaloid content varies from 1.7 to 3% of the dried roots. The drugs and the alkaloids obtained from the plant are used in allopathic system in the treatment of hypertension and as a sedative or tranquilizing agent. The fresh roots emit a characteristic acrid aroma and are very bitter in taste. The roots possess high alkaloid concentration. Roots are mainly collected from forests.

Fig.: Sarpagandha Roots

Origin and distribution

Sarpagandha is indigenous to the moist, deciduous forests of south East Asia including Myamnar, Bangladesh, Sri Lanka, Malaysia and the Andaman Islands. In India, it is found in the central regions like Uttar Pradesh, Bihar, North Bengal, parts of Western Ghats and Assam.

Plant Description

It is an erect evergreen, perennial under-shrub, and 75 cm to 1 m in height. Its leaves are simple, elliptical, bright green and pointed. The inflorescence is many flowered corymbs with white or pink flowers. The fruit is a drupe. Root is prominent, tuberous, usually branched; 0.5 to 2.5 cm in diameter grows up to 40to 60 cm deep into soil. The root bark constitutes 40-60% of the whole root, is rich in alkaloid.

Fig.: Sarpagandha Flowers

Varieties

Jawaharlal Nehru Krishi Vishwa vidhyalaya, College of Agriculture, Indore released 'RS-1' for commercial cultivation. The RS-1 culture gives 50-60% seed germination even after storing it for seven months and the yield of air dried root gives upto 25 q/ha, contain 1.641 to 2.94% of total alkaloid.

Soil

The plant requires slightly acidic to neutral soils for good growth with medium to deep well-drained fertile soils. The ideal pH for this crop is from 4.6-6.2. Clay-loam to silt-loam soils, rich in organic content are suitable for its commercial cultivation.

Climate

Sarpagandha can be grown under a wide range of climatic conditions. A climate with a temperature range of 10-30^{o}C seems to be well suited for this plant. It grows well in frost-free tropical to sub-tropical situations under irrigation. The areas with high rainfall and properly drained soil are best.

Propagation

Sarpagandha can be propagated by seeds and also by vegetative means like root cuttings, stem cuttings, leaf cuttings and root stumps.

Seed propagation

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

Fig. Sarpagandha Seed

In Maharashtra and Madhya Pradesh, April end, in West Bengal first week of May or little later, and in Jammu & Dehradun during third week of May are found to be most suitable time for sowing seed in the nursery. The nursery is prepared by raised beds of 10 x 10 m dimension under partial shade made up of one-third of well matured FYM and leaf mould, and two-thirds amount medium of silt-loam soil. About 500 m^2 seed bed area is sufficient for raising seedlings enough for planting one-hectare land. The seeds sown, 2-3 cm apart in rows in shallow furrows during April end. The furrows are then covered with a fine mixture of soil and FYM. Beds are kept moist by light irrigation. Germination starts after 15-20 days and continues up to 30 to 40 days.

Root cutting

Nearly 5 cm long root cutting are planted during spring season closely in nursery beds containing well manured FYM, sand and saw-dust. The beds are kept moist through watering. The cuttings begin to sprout within 3 weeks. These can be planted in field during rainy season after 8 to 10 cm rains are received; the seedlings are transplanted at 45 cm row

to row and 30cm plant to plant distance. In this manner, an estimated 100 kg of root cuttings are found sufficient for planting one hectare area.

Stem cuttings

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

Root stumps

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

Transplanting

Seedlings of 40-50 days, which have 4-6 leaves, are ready for transplanting. Well decomposed FYM@ 25 -30 t/ha is added during land preparation. The seedlings are transplanted in the furrows. About 15 cm deep furrows are dug at a distance of 45cm. A spacing of 30 cm between the plants should be maintained. Seedlings are carefully dugout and the taproot is cut. They are then dipped in a 0.1 % solution of fungicide before planting to protect them against soil borne fungus causing damping off disease. Sarpagandha takes a long duration (18 months onwards) as it is slow growing crop particularly in the initial stage. About 80,000 – 1, 00,000 number of seedlings are required/ha as a sole crop.

Manures and fertilizers

Application of 25-30 tonnes of well decomposed FYM at the time of land preparation and 10kg N, 60 kg P2O5 and 30 kg K2O per hectare as a basal dose. Later two equal doses of N, each of10kg/ha in moist soil is given at 50 days and 170 days after planting.

Irrigation

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

Weeding

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

Intercropping

It is possible to grow intercrops in sarpagandha plantations particularly were good irrigation facilities are available. Soya beans and onions or Soya bean and garlic can be intercropped in sarpagandha plantations.

Harvesting

The roots are harvested at 2-3 years after planting i.e., from 18 months onwards. The roots are dugout in winter (December) when the plants have shed their leaves, are richer in total alkaloid content than the roots harvested in August. Care should be taken to keep the root bark intact as the bark constitutes 40-56% of the whole root and has a higher alkaloid content. At harvest the root may be found to go up to 40 cm deep in the soil. Application of a light irrigation if possible will make digging easier. After digging, the roots are cleaned, washed and cut into 12 to 15 cm pieces for convenience in drying and storage. The dry roots

possess up to 8-10 per cent of moisture. The dried roots are stored in polythene lined gunny bags in cool dry place to protect it from mould.

Yield

A yield of 2200 kg per hectare of air dried roots has been obtained from 2-year old plantation and3300kg per hectare from 3-year-old plantation, under irrigated conditions on sandy, clay loam soil.

Production Technology of Dioscorea

Common Name	:	Dioscorea/medicinal yam
Botanical Name	:	*Dioscorea floribunda*
Family	:	Dioscoreaceae
Ch. No.(2n)	:	18-36
Origin	:	Central America
Economic Part	:	Tuber

Importance and chemical composition

Diosgenin, a steroidal sapogenin obtained from the rhizomes of various species of Dioscorea, is the major base chemical for several steroid hormones including cortisones, sex hormones, other corticosteroids and the active ingredient in the oral contraceptive pills. The other important sapogenins found are yamogenin, botogenin and kryptogenin. Minor sapogenins like pannogenin and tigogenin are also found in certain cases. It is estimated that the world production of diosgenin is 1000 tonnes. Mexico is the largest producer of diosgenin, producing about 750 tonnes annually. In India, it is mainly cultivated in north-eastern states and also in Goa, mainly under contract cultivation.

Morphology

Plants are perennial, climbing herbs with tubers or rhizomes. Approximately 600 species have been reported to occur throughout the world, mostly in tropical and subtropical regions and, to a limited extent, in temperate regions also. Of these, only 15 species are known to contain steroidal sapogenins, chiefly diosgenin. Out of the various species tested, *D. composita* and *D. floribunda* found growing wild in Central America and *D. deltoidea*, found in the North-western Himalayas, are the main species from which diosgenin is extracted commercially. All the three species are dioecious.

Fig.: Dioscorea tubers

Species and varieties

***D. deltoidea* (2n=20)**

It is an indigenous species found growing wild in the North-western Himalayas. It produces very slender vines and is very weak. It is propagated by tuber pieces, but the regeneration of tubers is so slow that it takes about 7-10 years to fully develop even in its natural habitat of temperate regions. Hence, the cultivation of the species on a commercial scale is not attractive to farmers.

***D. floribunda* (2n=36)**

It is a native of Mexico (Central America) and is grown in Karnataka, Goa, Assam, Meghalaya and the Andaman Islands. This species can be very easily propagated from tuber pieces and seeds. The plant is dioecious in nature, a robust climber twining to the left. The branches are thick and it produces yellow, compact tubers at a shallow depth. The diosgenin content varies from 2-7% depending upon the age of the tubers. The seeds germinate within 3-4 weeks and produce vigorous seedlings that establish well in the field.

Varieties

Three varieties of *D. floribunda* have been released for cultivation. The varieties FB (C) -1 strain and Arka Upkar were released from the Indian Institute of Horticultural Research (IIHR), Bangalore, while Pusa-1 by the Indian Agricultural Research Institute, New Delhi. These three varieties adapt well to tropical and subtropical regions. The salient features of these varieties are as follows:

FB (C)-1

This is a composite strain from introduced clonal material from Central America. The plants are vigorous and relatively free from pests and diseases. The tuber yield is 20000-25000 kg/year (1kg/plant) or 60000 kg for a 2-year-old crop (2.5 kg/plant). The diosgenin content of the dried roots varies from 2.5 to 3%.

Arka Upkar

A high yielding clonal selection from FB(C)-1 with intense dark-green leaves and a vigorous growth. The tuber yield exceeds 60000 kg (in a 2-year-old crop) and the diosegenin content ranges from 3.5 to4.0%.

Pusa-1

A selection from germplasm with a tuber yield of 1.5 kg/vine after 18 months.

D. composita

This species is also a native of Mexico and has been domesticated in several tropical countries.

Cultivation

Soil

It can be grown in several types of soils. Light or sandy soils require heavy irrigation and fertilization whereas heavy clay soils restrict tuber growth and harvest and often create waterlogging. The best yields are obtained in medium loam and in deep soils which are rich in organic matter. In red soils, the best growth has been observed for both *D. floribunda* and *D. composita*. It tolerates wide variation in soil pH, but highly acidic and highly alkaline soils should be avoided.

Climate

The different species of Dioscorea are found growing in different climates, but while *D. floribunda* and *D. composita* are more suited to the tropics, *D. deltoidea* is reported to be a suitable species for temperate locations. It grows well in the temperate regions of Kashmir and Himachal Pradesh.

Land preparation

The field should be ploughed and harrowed several times, leveled properly and drainage channels should be made. Since yams have a high requirement of organic matter of good tuber formation, are commended quantity (20-25 t/ha) of FYM is incorporated at the time of land preparation. A spacing of 45 x 30 cm for a 1-year-old crop and 60 x 45 cm for a 2-year-old crop in *D. floribunda* is found to be optimum under irrigated conditions. For planting, deep furrows are made at 60 cm distance and sprouted tubers are planted in furrows at 5 cm depth. After sprouting is completed, earthing up is done, utilizing the soil from the ridges. *D. composita* and *D. deltoidea* are reported to give higher yields at spacing of 60 x 30 cm.

Propagation

The yams can be propagated either by seeds, rhizome pieces or stem-cuttings. In India, commercial plantations are raised from tuber-cuttings. Seed progeny is variable and takes a longer time to start yielding tubers, compared to plants raised from tubers. The choice of propagating material will depend on the cost of planting and the prevailing climatic conditions of the region.

a) Propagation from tuber pieces

This crop grows best from tuber pieces. Tubers or rhizomes are divided into approximately 50-60 g pieces for planting. The growth of plants is slow and the yield lower if smaller pieces are used for planting.

There are 3 types of pieces

(1) Crowns (stem end),
(2) Medians (middle portion)
(3) Tips (distal ends).

Crowns produce new shoots within 30 days of planting, while the others take nearly100 days to sprout. Besides, the crown portion contains less diosgenin compared to the median and the tips, hence the later can be used for the extraction of alkaloids and the former can be used for propagation. But, if there is a shortage of planting material, the median and tips can also be used for planting. In order to avoid the rotting of tubers (before sprouting), only healthy tubers should be selected. The healthy tubers must then be dipped in benlate fungicide (0.3%) for 5 minutes followed by dusting the cut ends with 0.3% benlate powder before planting or storage. Before planting the tubers directly in the main field, they should be stored in a moist, well-areated rooting medium until shoot growth commences. The benlate-treated tuber pieces should be kept in raised beds in the shade, covered with sand and watered daily. After 30 days the sand may be removed and the sprouted crowns taken out and planted in the field. The median and tip portions are again covered with sand and watered regularly. Subsequently, after 60-75 days when they have completely sprouted, they can also be planted in the field.

Season of planting

The tuber pieces can be planted either in February-March or June-July. In Karnataka, February-March planting is better. For medians and tips, it is better to plant from the middle of January because they take more time to sprout compared to the crowns. The new sprouts will grow vigorously during the rainy season which commences from June.

b) Propagation by seeds

Propagation through seeds is much more successful in *D. floribunda* and *D. composita*, as compared to the other temperate species. The seed has a wide membranous wing that can be removed without affecting germination. The seeds can be sown either in raised beds in the shade (with a mixture of loamy soils and FYM) or in polythene bags (filled with sand, soil and FYM; 2:1:1). The planting depth should not be more than 1.25 cm and frequent watering of the beds is essential. The seeds germinate within three weeks and are ready for transplanting in 3-4 months. The seedlings should be supported immediately. The best season for transplanting the seedlings to the field is just before the start of rains, i.e., in June in South India, but in North India, this can be done at any time except during the winter.

c)Propagation by stem-cuttings

D. floribunda can be propagated by stem cuttings with 80% success. The vines should be raised from50-100 g tuber pieces in the green house. One or two month-old vines are taken and cut into single node cuttings, each with one leaf. They are planted in sand-beds keeping the leaf blade above the sand. Before planting, the cuttings should be treated with 100 ppm 2,4-D and 0.1% benlate for 4hours. The beds should be watered regularly, after rooting the cuttings are transplanted to polythene bags and produce about ten leaves in a period of two months. Propagation of *D. floribunda* can also be done by air-and ground-layering. Application of NAA at 100ppm was found to be most effective for getting 80-90% rooting.

Provision of support

The vines need support for their optimum growth, as this exposes the maximum number of leaves to sunlight. The system tried successfully at Bangalore consists of 2 m-high, stone pillars spaced 9 m apart in the field. Galvanized wires (Nos.6 and 8) are used on the boundaries and the interconnecting wires can be of 12-gauge thickness. The vines are supported on coir ropes tied to the wires and pegged to the ground by wooden stakes.

Manures and fertilizer

A well decomposed FYM of 20-25t/ha is applied while preparing the land. Yams respond very well to fertilizer application. A fertilizer dose of 300 kg N, 150 kg P2O5 and 150 kg K2O/ha, has been found to be optimum for a one-year-old crop of *D. floribunda*. The entire quantity of P should be applied as a basal does, while N and K are given in four equal split doses at bimonthly intervals commencing from 2 months after sprouting. For *D. deltoidea*, for a 4-year-old crop, the recommended fertilizers under Kashmir conditions are 40 kg N, 80 kg P2O5 and 60 kg K2O in split doses at an interval of one month from the time of planting in the first year and the same quantity in the second year. In the third year, only N at 30 kg/ha has to be applied in two split doses. For increasing the tuber yield and diosgenin content, the application of S, Ca and Mg has also been recommended.

Irrigation

The crop needs irrigation frequently during summer months. An interval of 4 to 5 days in summer and 7 to 10 days in winter is desirable for the proper growth and development of this crop and for economic yields.

Interculture

In the initial stages, yam plantations require more frequent hand-weeding than in the later stages. Chemical herbicides have also been tried, but are not recommended commercially. Studies have revealed that it is feasible to intercrop medicinal yam with short duration crops like cowpea, cluster beans and kidney beans, where irrigation is available. This practice not only minimizes the growth of weeds but also gives additional returns. Apart from this, intercropping also helps in reducing the requirement of nitrogen as these crops are leguminous.

Harvesting, yield and processing

Studies have shown that the growing of *D. floribunda* as a two-year crop is economical. An average yield of 15 to 20 t/ha of fresh tubers can be obtained during the first year, and up to 40 to 50 t/ha during the second year. The diosegnin content of the tubers tends to increase, on an average, from2.5-3.0% in the first year to 3.0-3.5% in the second year. The cost of cultivation is, however, much less during the second year. The *D. deltoidea* should be harvested only after three years to get the optimum yield from the crop with the maximum diosgenin content. Generally, the tubers are harvested during February-March. Harvesting can be done by manual labour with pickaxes. The tubers are harvested when the plants are in a dormant condition to obtain the maximum yield of diosgenin.

Processing

The tubers are dried under sun to 6-7 per cent moisture which takes about a week to fully dry the material. The dried tubers are solvent extracted to isolate diosgenin.

Production Technology of Isabgol

Common Name	:	Isabgol or Blonde psyllium
Botanical Name	:	*Plantago ovata*
Family	:	Plantaginaceae
Chromosome No. (2n)	:	8
Origin	:	Persia and West Asia
Economic part	:	Husks and Seed

Uses

- It is an anti-diarrheal drug.
- It is used for treating constipation and other intestinal disorders.
- The seed has also cooling and demulcent effects.
- The seeds and husk are used to cure inflammation of the mucous membrane of gastro-intestinal membranes(ulcers).
- It is also used in dyeing and calico printing.
- In the ice cream as stabilizer.
- The seeds show coolant, diuretic, laxative, expectorant, refrigerant properties.

Fig.: Isabgol Husk and Seed

Importance

Its husk and seed have been used in indigenous medicine for many centuries. It derives its name from two Persian words, ‘asp’ and ‘ghol’ meaning a ‘horse –ear’ referring to its characteristic boat-shaped seeds. The husk of the seed is economic part and it contains colloidal mucilage mainly consisting of xylose, arabinose, galacturonic acid. The husk has the property of absorbing and retaining water and it works as an anti diarrhoeal drug. It is beneficial in chronic dysenteries of amoebic and bacillary origin. It is also used for treating constipation and intestinal disorders as it works as calorie free fiber food, promoting regular bowel movement. The seed has also cooling demulscent effects and is used to cure inflammations of mucous membrane of gastro intestinal and urinary tracts.

Distribution

It has been introduced in India and cultivated specially in Gujarat and some parts of Rajasthan. At present, isabgol has acquired the place of ‘dollar earner’ crop of North Gujarat.

Area and production

It is cultivated in about 50,000 hectares in India, with major areas falling under Gujarat and Rajasthan. The estimated annual production of isabgol is 50 metric ton and India earns foreign exchange valued up to Rs.80 crores every year through export of psyllium husk.

Plant morphology

It is 10-15 cm tall short-stemmed annual herb. Flowers in terminal spikes; fruit is a capsule. The flowers are white in colour and minute. It is highly self-pollinated. The capsule is ovate, 8mm long, releasing the smooth, dull, ovate seeds. The seeds are covered with a translucent membrane, known as the husk. The husked seeds are dark red and hard.

Fig. : Vegetative Stage

Varieties

Gujarat Isabgol-1 and Gujarat Isabgol -2 are the two varieties of this crop released by Gujarat Agricultural University. Another variety, 'Niharika', a mutant has been released by the CIMAP, Lucknow, as a high yielding variety.

Soil

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.

Climate

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 30^0C.

Land preparation

Field must be free of weeds and clods. The number of ploughing, harrowing and hoeing depends upon the soil conditions, previous crop and degree of weed infestation. The recommended dose of FYM (10-15t/ha) is applied to the field 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.

Seed sowing

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.

Manures and fertilizers

The FYM at the rate of 10-15tonnes /ha is applied during land preparation. Isabgol does not require application of heavy doses of fertilizers. A fertilizer dose consisting of 50kg N, 25kg P2O5 and 30kg K2O/ha gives maximum seed yield. The full dose of P and K along with half

of the N is given as a basal dose. The second split of N is applied as a top dressing after one month of sowing.

Irrigation

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

Harvesting, processing and yield

Blooming begins two months after sowing and the crop become ready for harvest in February-March (110-130 days after sowing). When mature, the crop turns yellowish and the spikes turn brownish. The seeds are shed when the spikes are pressed even slightly. At the time of harvest, the atmosphere must be dry and there should be no moisture on the plant, harvesting will lead to considerable seed shattering. Hence, the crop should be harvested after 10 am only. After two days, they are threshed with the help of tractor during early morning. Water is sprinkled over the heap for easy threshing and separation.

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.

Production Technology of Opium Poppy

Common Name	:	Opium poppy/Posta/White Poppy/Afim
Botancial Name	:	*Papaver somniferum*
Family	:	Papaveraceae
Chromosome No. (2n)	:	22
Origin	:	Mediterranean region
Economic part	:	Capsule latex, seed, fruit, bark and petal

Importance and chemical composition

It is an annual herb grows up to a height of 60-120 cm. It is an important medicinal plant, the source of over 40 alkaloids including psychoactive agents, a great boon to psychiatry for the treatment of mental and nervous diseases and to medical research. The commercial product 'Opium' is an addictive narcotic obtained from the latex of capsules of the opium poppy, the source of a number of very valuable alkaloids like morphine, codeine, narcotine, papaverine and thebain. The seeds do not contain any alkaloids, but are also reported to contain a high percentage of linoleic acid which lowers blood cholesterol in the human system. The alkaloids, morphine and codeine, are widely used as sedatives to relieve pain and induce sleep, in addition to their use against cough. Opium is a very valuable but dangerous drug.

In India, this plant is mainly cultivated for its latex (opium) and the seeds come as a byproduct. These seeds are quite a rich source of fatty oil and protein and, in many countries of Europe, employed as a major source of cooking oil. The seed is also an important culinary item in India. It is extensively used in the preparation of native confectionery, pastries and bread. In some places, the young plants are also consumed as a leafy vegetable.

Uses:

- It is a well-known sedative having sedative effect, so used in the diarrhea and pains in the body.
- The ointment of opium can be used as local anesthetic in piles etc.
- In Ayurveda, it is used as sleep inducing and anti-diarrheal drug.
- Its syrup is given for cough.
- Semi-dried oil used in manufacture of paints and in artist's ink.

Origin and distribution

It is originated in the western Mediterranean region and from there it has spread through the Balkan peninsula to Asia Minor and India. Since antiquity, its cultivation has been in vogue in Italy, Greece and Asia Minor. It was during the 15th century that the herb was introduced in India. Its cultivation is confined to states of MP, Rajasthan and UP.

Area and production

India produced 1,465 t of opium annually and forms over 90% of the world production. In India, all the opium of commerce is now grown mainly in the states of Uttar Pradesh, Madhya Pradesh and Rajasthan covering an area of 18000 ha.

Description of the plant

The poppy is a small, erect, herb attaining a height of 120 cm with large, serrated leaves and attractive brightly coloured (white, pink, purple, red and variegated) flowers. The main shoot and branches terminate into large, oblong to globose capsules, filled with small white, flat seeds. The seeds are whitish-yellow, grey-brown, reddish-brown or black, and rich in oil.

Fig. Opium Poppy field

Climate

It is a crop of temperate region but it can be grown successfully during winter in sub-tropical climate. Crop needs long cold season (20°C) with adequate sunshine in the early season for a healthy vegetative growth; heavy rains after sowing cause loss in seed germination. Warm, dry weather with a temperature of 30-35°C is required during the reproductive period. Cloudy weather, frost, hailstorms and high gusty winds, particularly during lancing, causes immense damage to the growing crop. Dry, warm weather conditions in February-March favour a good flow of latex and results in higher yields.

Soil

The opium crop needs deep clay loam, highly fertile and well – drained soils with a pH range of 6.0 to 7.5. Such soils, containing adequate organic matter, retain moisture and there is no need of irrigation during lancing. However, with adequate manuring and use of fertilizers even light, loam to sandy-loam lateritic soils can give high yields under good management.

Varieties

The most popular varieties grown in the country remain in the field from 140 to 160 days. Some of the varieties are Talia, Ranghatak, Dhola Chota Gothia; MOP-3, MOP-16 and Jawahar Aphim 16 from JNKVV Mandsaur station; Shama, Subhra and Shweta from

CIMAP, Lucknow; BROP 1 (Botanical Research Opium Poppy-l) from NBRI, Lucknow; Kirtiman from NDUA&T, Faizabad; Chetak from SKRAU, Udaipur; Trishna from NBPGR and Sujata from RRL, Jammu (now renamed as IIIM).

Sowing

Poppy seeds should be sown in a well prepared soil. The field should be given 5-6 cross ploughings followed by planting. The land should be divided into small plots to facilitate irrigation. The seeds should be treated with thiram to protect the seeds against soil borne pathogens. The seeds are sown between late October to mid-November. Seed rate is 7-8 kg/ha for broadcast method and 4-5 kg/ha for line sowing. After sowing, seeds are covered by a thin layer of soil followed by a light irrigation. A spacing of 30x30 cm is followed.

Fertilizer application

The crop requires nutrients required for flowering and capsule formation. Farm Yard manure @ 20-30 t/ha is generally applied by broadcasting while the field is prepared for transplanting. Besides, 60-80 kg of nitrogen and 40-50 kg of P_2O_5 per hectare is recommended. No Potash is applied. Half of N and entire of P are applied at the time of transplanting and remaining half dose applied at rosette stage.

Irrigation

The first irrigation is given, immediately after sowing, if there is not enough moisture available in the soil. For subsequent irrigations, 7-10 days irrigation schedule is the optimum depending upon the weather and soil conditions. A total of 10 to 15 irrigations are required for this crop.

Flowering and fruit-set

After about 90 to 100 days of sowing, the plants which are waist-high begin to flower, i.e., flowering will take place during first week of March, if the crop was sown during the second fortnight of November. Usually after 3 days of flowering, the petals fall off and after another 10-14 days the capsules are ready for lancing.

Lancing and latex collection

Lancing is the process in which incision is made on the capsule. Opium starts flowering in 95-115 days after sowing. The petals start shedding after 3-4 days of flowering. The capsules mature after 15-20 days of flowering. Lancing of the capsules exudes maximum at this stage. This stage can be visually judged by the compactness and a change in the colour from greenish to light green coloured ring in the capsule. The stage is called as industrial maturity. Lancing may be done with a knife having 3-4 equi-spaced pointed ends which does not penetrate more than 1-2 mm in the capsule. Too deep or too shallow incision is not advisable. Lancing may be done early in the morning before 8.00 am at two days interval in each capsule. The length of the incision should be 1/3 or less than the full length of capsule.

Harvesting of seeds

The capsules, after the lancing operation and collection of opium latex, are allowed to dry on the plant itself. The drying process takes about 20-25 days after the lancing is completed. In India, the capsules are plucked by hand and the seeds are separated after breaking the capsules by hand. A dry capsule weighs about 7g and it contains 11 to 12 thousand weighing about 3.5 to 4g.

Fig. Poppy Seed

Yield of raw opium and seed

On an average 50-60 kg/ha of raw opium and 400-500 kg/ha of seeds are obtained in India.

Production Technology of Ammi majus

Common Name	:	Honey plant
Botancial Name	:	*Ammi majus*
Family	:	Apiaceae
Chromosome No. (2n)	:	22
Origin	:	Egypt
Economic part	:	Flowers and Fruits

Ammi majus L., a member of family Apiaceae, is an important medicinal plant. The botanical name *Ammi majus* L. is derived from two Greek words - Ammi (Dioscorides), from the Greek term 'ammos' meaning sand and refers to the plant's habitat and 'majus' meaning bigger or larger. It is thought to be originated in Egypt.

Uses

The seed are the main source of xanthotoxin. It is widely used for the treatment of skin disorders such as psoriasis and vitiligo (acquired leukoderma). It is used as an emmenagogue to regulate menstruation, as a diuretic, and for the treatment of leprosy, kidney stones, and urinary tract infections. *A. majus* fruit and Trigonelafoenum-graecum seeds are commonly used for a variety of kidney disorders and as diuretics. The seed is contraceptive, diuretic and tonic. It is rich source of furocoumarins which acts as natural pesticides against a wide range of bacteria, fungi, nematodes, insects and viruses. The fruits are rich in tannin, cellulose and proteins.

Distribution

In India, it was first introduced in the Forest Research Institute, Dehradun, in 1955 through the efforts of UNESCO. It cultivation was started on trial basis in several parts of the country especially in states of Tamil Nadu, Gujrat and Uttar Pradesh. Now it is cultivated successfully in Uttar Pradesh, Gujrat, Himachal Pradesh, Tamil Nadu and Karnataka.

Morphology

It is a herbaceous annual growing upto a height of 0.75 to 1.15 m. The stem is round, erect and solid with tap root system. Leaves are large 5-8 cm long, alternate, and light green, compound, pinnately divided and lanceolate in shape. The inflorescence is umbel, axillary and terminal in position having white flowers. Calyx tube is adnate to bracts, 5 in number and teethed. Petals -5, epigynous, distinct and bifid. Stamens - 5, epigynous, alternate with petals. Ovary is inferior, 2 celled, disk epigynous, 2 lobed, ovule solitary in each cell. Style - 2, stigma is minute and capitulate. The flowering is seen after 3-4 months of seed sowing. Fruit is pod, ribbed, ellipsoid, greenish brown in colour, turning reddish brown on maturity and is ready within 30-35 days from blossoming of flower. The seeds are flat bearing thin wings, having a characteristic odour becoming strong on crushing with extremely pungent and slightly bitter in taste.

Fig. *Ammi majus* inflorescence

Climate

It requires moderate climatic conditions for luxuriant growth. Initially, a mild cool climate is required during vegetative phase. During maturity, a warm and dry weather is required. The temperature should be in range of 27-32 ^{0}C for optimum growth of the plants. The extremely high and low temperature hamper the growth of the plants and ultimately crop yield. The areas having excess rains are not suitable for its cultivation.

Soil

The crop can be cultivated in wide range of soil types. However, it prefers well-drained, sandy loam to clay loam type soils. The soils should be rich in organic matter, fertile and well drained. The area should be well leveled with a slight slope to drain off excess water during the rainy season. The problematic soils are not suitable for its cultivation.

Propagation

It is propagated through seeds. Seeds can be sown directly in the field or first raised in nursery. In case of direct sowing method, about 10-12 kg/ha seed is required. However, later method is generally followed by most of the farmers. The seeds required for sowing should be gathered from selected plants when the umbels are fully mature and the seeds are about to be ripe.

Nursery raising

Seed-beds of convenient length and breadth and 15-18 cm in height are made in well-prepared land. FYM or poultry manure is added in the top 10 cm of the soil. The seeds are sown in the month of September-October in rows 10 cm apart, and covered with a layer of rice-straw, wheat-straw or dried grass. About 1.5-2.0 kg of seed is required for raising crop in one ha area. After sowing seed, beds are watered frequently. The seeds germinate in 10-15 days. The mulch is removed after the seeds have germinated. The seed beds should be kept weed-free by frequent weeding.

Transplanting

The field for transplanting is prepared by proper ploughing, leveling and making plots of convenient size. As the seedling are ready, they are carefully removed to avoid any type of damage to roots. Seedlings are transplanted at a distance of 45x60 cm or 45x30 cm. Transplanting is done in the month of October-November. A light irrigation may be given immediately after transplanting.

Varieties

There are two varieties namely Suttons and Monoica in the crop.

Manures and fertilizers

It response to application of nutrients. An Application of 80-100 kg N, 100-120 kg P_2O_5 and 40 kg K_2O per hectare is optimum for the good growth of plants. The entire quantity of P and K should be applied as a basal dose with 50%of the N at the time of field preparation and remaining 50% of N is applied at the time of thinning.

Irrigation

The irrigation frequency depends on climatic conditions, soil moisture status and crop growth stage. As, it is an herbaceous in nature, so moisture availability has a direct on vegetative growth and flowering. The field should be irrigated immediately after transplanting and thereafter at an interval of 7-10 days depending on weather conditions.

Intercultural operations

Due to the herbaceous nature of the crops, it is very sensitive to competition by weeds for space, light, moisture and nutrients. So weeding should be done as weeds appear so as to keep the field weed free. Later weedings can be done as per requirement. In between weedings, hoeing should also be carried out to allow proper loosening of soil.

Harvesting

It is a crop of 5-7 months duration. The flowering is initiated in the month of December. The flowering and maturity of inflorescence going on for a longer duration therefore harvesting of the crop is extended for a long period. The delay in harvesting of primary umbel results in shedding of seeds. So the umbels should be harvested as and when mature to avoid shattering and wastage of seed. Therefore, harvesting at every 3-4 days interval is recommended. Manual handpicking is generally done. The harvested produce is kept in shady well ventilated place and thereafter threshing operation is carried out.

Yield

The seed yield varies depending on variety, planting time, spacing, intercultural operations and harvesting stage and method. On an average, seed yield of 1000-1200 kg per hectare is achieved in well managed fields.

Chapter 11

Production Technology of Belladonna

Common Name	**:**	Belladonna/Deadly Night Shade
Botanical Name	**:**	*Atropa belladonna*
Family	**:**	Solanaceae
Chromosome No. (2n)	**:**	72
Origin	**:**	Southern and Central Europe
Economic part	**:**	Leaves, flowering top and roots

The name of the plant comes from the Greek word "Atropos" and refers to one of the three Fates in Greek mythology, who cut the thread of life. "Bella-donna" is an Italian phrase meaning "beautiful lady." This name was given to the plant because the ladies of Venice used *Atropa belladonna* as a cosmetic (due to the mydriasis caused by its use). The plant is also known as "deadly nightshade."

Distribution

Atropha belladonna is found in the United states, Europe, North Africa and Western Asia. It is endemic in areas of the Mediterranean countries (including Greece), countries in western Europe, and from these areas it spread to the Himalayas, and it has been introduced even to North America.

Species

It comprises of four species, the commercial drug is obtained from the leaves, flowering tops and roots of *A. belladonna* Linn., also known as European belladonna and *A. acuminata* Royle, often referred as 'Indian Belladonna'.

Uses

All parts of the plant contain the alkaloids atropine, hyoscine, and scopolamine, making it poisonous and hallucinogenic. The highest concentration of alkaloids is found in mature fruits and green leaves. Atropine is the principal alkaloid in mature fruits (98%). It is estimated that the fruits of the plant, which have the shape and size of berries, contain 2 mg of atropine. Atropine and scopolamine are the two most important belladonna alkaloids. These alkaloids are associated not only with *Atropa* belladonna, which produces mostly atropine, but also with other solanaceous plants such as *Datura stramonium* (Jimsonweed), *Hyoscyamus niger* (henbane), and *Scopolia carniolica*. The latter two plants produce scopolamine. Belladonna leaves are widely used for the manufacture of tinctures and plasters. The drug serves as an anodyne, sedative, stimulant, anti-diuretic, anti-asthmatic, antispasmodic, anti-inflammatory. It is also used in the treatment of renal and bilary colic, stomach disorders and to stop sweating. The roots are primarily used in the external treatment of gout, rheumatism and other affiliations.

Morphology

The height of the plant *Atropha belladonna* is about 1.5 m. It has a thick, fleshy, whitish and branched root. It is made up of five lobed calyx. The leaves of this plant are simple, dark greenish in colour, ovate and alternate in nature. Berries are more toxic in nature. It has

purplish coloured stem. Finally, it's flowers are in solitary bell shape. The flowering time is June to September. The toxic alkaloids are present in the seeds.

Fig.: Flower and Fruit

Soil

It grows well in deep fertile soils of medium texture, which are rich in humus. Heavy clay soils which are water-logged should be avoided to cultivate this crop. It can grows in uncultivated barren lands.

Climate

It is a temperate crop. It behaves as a perennial in temperate climates and gives maximum herbage and alkaloid yield. In sub-tropical areas, it can be grown as a winter crop. However, the plant behaves as an annual as it dies during the summer months and hence the yield is poor. The *belladonna* grows under the shadow of the trees and on the hills.

Propagation

The crop is propagated through seeds extracted from berries collected usually from September-November. About 4kg of seeds will be required to raise seedlings for one hectare of land. Seeds may be treated with 80 per cent sulphuric acid at the time of sowing for 2 minutes to improve the germination.

Nursery raising

It can be cultivated by direct sowing, but raising nursery gives best results. The nursery may be raised from the second week of May to the end of autumn (September to October) under sufficient shade. The land should be ploughed well so as to give a fine tilth. Raised beds of size 3m x 1msurrounded by drainage and irrigation channels to be made and apply well decomposed FYM to the soil. Seeds pre-treated with fungicides like Mancozeb (10 g per kg of seeds) may be mixed with fine soil (1:4 ratio) and sown in the nursery beds. Beds is covered with a layer of FYM and then with straw. Watering of beds should be done

immediately after sowing with a can. The seeds germinate in 3 week's time. Seedlings will be ready for planting in the field when they attain a height of 15-20 cm after 8-12 weeks.

Broadcasting

About 20kg of seeds are required for sowing one hectare of land by broadcasting.

Transplanting

The ideal time for planting in the field is March-April or October-November. Before planting, the seedlings are treated with fungicide. Seedlings are planted at a spacing of 50-60 cm in rows kept 60-70 cm apart. It is always safer to plant the seedlings on raised beds with 1 m wide strips or ridges as it avoids water logging and facilitates irrigation. The field may be irrigated immediately after transplanting.

Varieties

Srinagar: It is selection developed by Regional Research Laboratory. It contains 0.6 per cent alkaloid.

Manures and fertilizers

It is an exhausting crop, hence a basal dose of 25-40kg N, 40-60 kg P205 and 30-50kg K2O per hectare is recommended. An additional dose of 60-80kg N is applied in 3-4 split doses as a top dressing at monthly intervals after every harvest.

Irrigation

Belladonna has a high water requirement and it should be irrigated frequently once in 10-15 days during the dry period. Normally, 6-7 irrigations are required during the dry months. Care should be taken to avoid water logging.

Inter cultural operations

Belladonna should be kept free from weeds by frequent weeding and hoeing.

Harvesting

The first harvest of the leaves is available three months after planting. Harvesting should be done as soon as the plants start flowering, as it is the period when alkaloid content is higher. The leaves are cut with the help of pruning scissors. Leaves are dried immediately after the harvest under shade or sun or artificial heat with or without fans for air circulation. Leaves should be turned over frequently while drying. The roots are also harvested after 3 years. After the harvest, they are washed, cut into 4 inches length, split length wise if thick and shade or sun dried.

Yield

During the first year, an average of 600 kg of dry herb is obtained. The yield increases to 1500 kg per hectare during 2nd and 3rd year. The yield of dry roots will vary from 170 to 335 kg per hectare.

Production Technology of Cinchona

Common Name	**:**	Cinchona
Botanical Name	**:**	*Cinchona ledgeriana*
Family	**:**	Rubiaceae
Chromosome No. (X)	**:**	17
Origin	**:**	South America
Economic part	**:**	Bark

Importance and Uses

It has about 65 species. Among these species, *Cinchona succirubra, C.officinalis, C.ledgeriana, C.robusta* and *C.hybrida* are grown commercially for cinchona bark which is the source of quinine and other anti-malarial drugs. In addition, more than twenty other alkaloids have been isolated from cinchona, of which cinchonidine, quinidine and cinchonineare the most important. The alkaloids exist chiefly as salts of quinic and cinchotannic acids and their relative concentrations vary in different species. The leaves contain 1% total alkaloids. Besides, quinine was in use as an anesthetic as a substitute for cocaine. Its anesthetic action is prolonged. It has been used as a sclerosing agent in the treatment of internal hemorrhoids and varicose veins. Quinine protects the skin against sunburn. It is a bitter tonic, stomachic and appetizer.

Fig.: Profuse flowering

Fig.: Individual Flower of Cinchona

Distribution

It is confined to some parts of West Bengal, Tamil Nadu and Karnataka in an area of about 6000 to 8000 ha.

Soil

It prefers a light, well drained, virgin forest soil, rich in organic matter with no possibility of subsoil water-logging and with a high moisture holding capacity. It prefers acidic soil (pH 4-6 to 6.5). The calcium requirement of this crop is high.

Climate

It grows best in tropical climates at altitudes of 1800 m. However, the other species grow well in areas with an average minimum temperature of 13.5^{0}C and a maximum of 21^{0}Cwith a mean relative humidity of 83%. The growth is very poor at temperatures below 7^{0}C or above26^{0}C. It grows well in places where the annual rainfall is a little less than 200 mm and is well distributed over at least eight months of the year. Cinchona is susceptible to frost and hence, is not grown on very high hill ranges.

Land preparation

For raising cinchona plantations, virgin forest soils are best suited. The forest is cleared and the ground is leveled and dug to a depth of 1½ ft to improve the soil structure and to remove stones, if any. About a fortnight prior to planting, pits of 60 x 60 cm are dug and filled up with top soil and well decomposed organic matter.

Propagation

It is propagated both by seeds as well as vegetative by cutting, stooling, layering and cleft grafting, veneer or side-grafting and patch-budding. As most of the species of cinchona are

highly heterozygous, vegetative propagation is preferred. But, in India, cinchona is propagated by seeds as itis comparatively less expensive.

Seeds propagation

Its seeds are small and light and loose viability on storage. The seeds are generally sown during April in sloping beds, 12x4 ft, and covered with a thatched roof. While sowing, the fresh seeds are scattered thickly on the surface and covered with a thin layer of fine sand. The beds are then lightly watered using a spray can. The seed germination is noticed, out of which only about 10% of the seedlings will be suitable for transplanting after eliminating all the weak, lean and lanky seedlings. Seedlings are transplanted when they are about four months old, with two pairs of leaves. The seedlings will be ready for planting in the main field during mid-May of the succeeding year when they are about 14-18 months old and 30-60 cm in height.

Vegetative propagation

Among vegetative methods of propagation, patch-budding, soft terminal cuttings and layering have recorded the best results. A high percentage (85%) of success is obtained in patch-budding in the period from March to the middle of June. Patch-budding is usually done in the nurseries or plantations, in situ on plants which are one to two years old.

Transplanting

Planting is done before the onset of heavy rains. The soil should be sufficiently moist at the time of planting. The planting is done in open pits at a spacing of 120x120 cm or 150x150 cm or dense planting of about 8000 plants per hectare is done. The plants are gradually harvested from 3-5 years, until about 800 plants remain in one hectare after 25 years. Young cinchona plants need shade which is provided by planting shade plants like *Alnus nepalensis, Erythrina indica, Albizzia stipulata* and *Grivellea robusta*, 20 ft. apart.

Varieties

It is a naturally cross-pollinated plant, due to which a great deal of admixture has taken place among the various species and the present stands of cinchona are only crosses between these various species. An outstanding clone – No.701 – containing over 12% of quinine sulphate in the bark has been spotted by the Tamil Nadu Forest Department and is propagated on an extensive scale in the Nilgiris and Anamalai hills.

Manures and fertilizers

Application of a fertilizer mixture containing N, P and K gives best results. Liming is done for the soil if the pH is 5 or lower. Nutrients are supplied @ 115 kg N, 105 kg P2O5 and 115 kg K_2O/ha in the form of triple super phosphate, muriate of potash and ammonium sulphate. The quinine content in cinchona is known to increase with the age of the trees, under favourable nutritional conditions.

Weeding

Weeds have to be removed at regular intervals, particularly in young plantations.

Harvesting

By judging the amount of vegetative growth, the trees are coppiced when they are 6 to 8 years old. Coppicing involves pruning the trees at a height of 5 cm (2 inches) from the ground-level. The left over stump regenerates to produce a large number of shoots, but only two or three of these are retained and allowed to grow further. The rest of the coppices are removed. A second coppicing is done 8-10 years after the first coppicing, where only about 2

to 3 shoots are left to grown further. The plants are uprooted in the 30th year when their vigor declines. The major harvest is obtained at the time of the first two coppicing and only little yield of bark is obtained from the dead and drying trees and pruning. The first set of yields is obtained in the third year after planting. The bark is separated from the coppices by beating it with a mallet and is then peeled by hand or a knife. The peeled bark should be dried immediately to prevent the loss of alkaloids, preferably in the shade. In rainy weather, drying is done in special sheds or by means of artificial heat.

In well-established plantation, drying is done in well-regulated ovens. For this purpose, hot air ovens, regulated by 70^0C, are employed. The long, strips of bark are cut into small pieces and fed into the upper end of a long, slightly inclined, rotating, cylindrical oven. The dried product contains 10% moisture; the dried bark is then packed in gunny bags. The dried bark is called 'Druggists' bark (quinine content 1.8-2%) in trade.

Yield

During the first two coppicing, a yield of 4000 kg of dry stem bark per hectare is obtained. At the final stage of uprooting the tree, the yield of the bark may be about 6000 kg/ha.

Fig.: Removal of Bark

Fig.: Bark after drying

Isolation of Quinine

The alkaloids are extracted from the powdered bark. Quinine is isolated from the total alkaloids of the bark as quinine sulphate. The commercial preparations contain cinchonidine and dihydroquinine also, and the quinine may be purified by recrystallization to constant specific rotation. The crystalline, efflorescent trihydrate is a white, odourless, intensely bitter, micro-crystalline powder.

Production Technology of Pyrethrum

Common Name	**:**	Pyrethrum
Botanical Name	**:**	*Chrysanthemum cinerariaefolium*
Family	**:**	Asteraceae
Chromosome No. (X)	**:**	9
Economic part	**:**	Flower

Pyrethrum

The term pyrethrum is applied to the dried flower–heads of *Chrysanthemum cinerariaefolium.* The plant is cultivated for its flowers, whose developing seeds or achenes consist of 3 pairs of esters: pyrethrin I, Cinerin I, Jasmolin I, Pyrethrin II, Cinerin II and Jasmolin II**,** which are collectively referred to as pyrethrins.

Uses

Pyrethrum is one of the safest insecticides known. It has very low mammalian toxicity and is metabolized if accidentally swallowed. It disturbs insects forcing them to move out of their hiding places. It also possesses an instantaneous "Knock-down effect". It is useful for the preservation of food grains, in the preparation of insect-resistant packaging, mosquito repellent aerosols and coils. It is an excellent household insecticide. About 70% of the world's production finds its way into fly-sprays and insecticidal aerosols,20% is used in mosquito coils and the balance in other formulations-powder, ointments and creams.

Fig.: Flowering Stage

Distribution

Kenya and its neighbours Tanzania and Rwanda produce over 80% of the total pyrethrum produced in the world. At present, it is successfully grown in several parts of India (Kashmir, Kodaikanal, Lucknow) on a commercial scale.

Morphology

It is a perennial herb which grows up to 60 cm tall.

Soil

Pyrethrum thrives best on well-drained, sandy soil. Red laterite loams and light and medium loam soils are also suitable. The yields are considerably lower in poorly-drained soils. It can grow on mountain slopes and wastelands, but too rich soils and water-logged conditions are unfavourable for its growth.

Climate

It grows best in areas which have a mild, cool, dry climate with a short, mild winter and a cool summer. A period of chilling, in which the temperature falls below 17° C, for about six weeks, is necessary for flower-bud initiation. In places where the winters are long (November to March) and the summers are warm, there is only one flush of flowering in May and June. It grows well in places where the annual average rainfall is about 1000 mm and the elevation between 1500 to 2400 m.

Varieties

There are three varieties of pyrethrum viz., KKL-1 released from TNAU, 'Hansa' and 'Jhelum' released from CIMAP, Lucknow for cultivation. Recently, 'Sel-2' with 86% more flowers than 'Hansa' has been developed at the Kodaikanal Centre of CIMAP.

Propagation

Pyrethrum is propagated by seeds. The seeds required for sowing should be gathered from selected plants when the flowers are fully mature and the seeds are about to be shed. The seeds tend to lose viability on storage. In case of vegetative propagation, healthy plants are pulled up from the ground, the splits of which are used for planting. In certain areas it is better to plant the splits in nurseries before they are planted in the main field.

Nursery raising

Seed-beds of convenient length and breadth and 15-18 cm in height are made in well-prepared land. FYM or poultry manure is added in the top 10 cm of the soil. The seeds are sown in rows 10 cm apart, and covered with a layer of rice-straw, wheat-straw or dried grass. The beds are watered frequently. The seeds germinate in 5-10 days. The mulch is removed after the seeds have sprouted. The seed beds should be kept weed-free by frequent irrigation. The seedlings will be ready for planting after 8- 12 weeks. Nurseries are raised either in spring (April-may) or in autumn (October-November) and, in irrigated areas, from March to November. The ideal time for planting is spring (March-April) or autumn (October-November). However, the seedlings can be planted during any time of the year, if irrigation facilities are available.

Land preparation

The land is prepared well by 2 to 3 ploughing followed by leveling, harrowing and clearing of weeds and stubble. Organic manure, if available may be applied at the time of the last ploughing. It is desirable to make ridges 45-50 cm apart if the land is flat. In undulating land, the area should be terraced.

Planting

The seedlings are planted at a distance of 27-45 cm in rows and 45-60 cm apart. Ridge-planting is preferred to flat-planting as it facilitates inter culture and irrigation and avoids water-logging.

Manures and fertilizers

Application of 40-60 kg N, 40-50 kg/ha P and 50-80 kg/ha K is optimum for the good growth of pyrethrum in the first year. The entire quantity of P and K should be applied as a basal dose with 50%of the N at the time of planting and the remaining 50% of N is applied in split doses. The fertilizer application should be repeated every year. P and K are generally applied in spring at the time of the first harvest, while N is applied in two split doses in the months of March and April.

Interculture

Proper weeding and hoeing are necessary to obtain a good yield. Both can be done by a tractor drawn cultivator, and hand-hoes can be used in small terraces. The first hoeing can be done in autumn after the last crop is harvested, followed by two weedings and hoeings in spring.

Irrigation

Pyrethrum does not need irrigation if the rainfall is well distributed. However, under irrigated conditions, weekly irrigation during the peak season gives better results. Under irrigated conditions, it is observed that the pyrethrum plants start flowering after 1 year instead of 2 years under un-irrigated conditions. The crop should be irrigated frequently during the dry months. The crop should also be irrigated after the fertilizer application.

Harvesting and processing

The plants flower within one year of transplanting. The crop gives a poor yield in the first year and the optimum yields are obtained only during the 2nd and 3rd year. In Kenya and the Nilgiris in India, three harvests of flowers are obtained as the flowering in these areas continues for 9 months. In temperate areas like Kashmir, the first harvest is obtained at the end of June or in the 1st week of July. The flowers should be picked when ⅔rd of the disc-florets are open and the ray florets are horizontal. The harvesting of immature or over-mature flowers decreases their pyrethrin content. The flowers are picked at fortnightly intervals in India. There is a gradual fall in the pyrethrin content of harvested flowers after the third year of planting. The yields tend to become uneconomical after 3-4 years and replanting is necessary. Light pruning at the beginning of the dry season, after picking the flowers, is required to keep the plant sturdy.

Drying

The harvested flower-heads are usually dried immediately in the sun. They are thinly spread on straw mats and turned over frequently in order to avoid fermentation. At night they are kept under cover. Dehydration is complete in 5-7 days. The ideal method of drying is to use hot-air driers, in which the temperature should not exceed 80^0C. The loss in weight will be about 65-75%. It is safer to dry it in the sun when the acreage is small and there is no chance of rain during the harvesting season. However, in larger farms, the use of air-driers is essential in order to dry the harvested flowers in time. Mechanical driers have been designed for drying pyrethrum flowers.

Yield and pyrethrin content

The average annual yield in Kashmir is about 250 kg/ha, against 700 kg/ha in Kenya and 500 kg/ha in Nilgiris. The yield in the first year, as reported from Kodaikanal, is about 450 kg/ha. The total pyrethrin content is reported to be 1.0-1.5% in India, while the average content in Kenya is 1.4% and the highest is 2.1%.

Table: Other relevant species of Medicinal Plants

Common Name	**Botanical Name**	**Family**	**Uses**	**Economic part**	Active ingredient
Field bindweed	*Convolvulus arvensis* L.	Convolvulaceae	Root purgative, used as nervous and brain tonic improving memory, used in hypertension, anxiety and stress	Roots	Convolvulin, scammonic acid
Jungli haldi	*Curcuma aromatica*	Zingiberaceae	Rhizome tonic, carminative, stomachic, diuretic , antihepatoxic, used in sprains and bruises	Rhizome	Curcumins, Curcuminoids (diferuloyl methane), Dihydrocurcumin
Kali haldi	*Curcuma caesia* Roxb.	Zingiberaceae	Aromatic, stimulants, carminative used in sprains and bruises	Rhizome	Alkaloids, flavanoids, tannins, Saponins
Sati/ Kachura	*Curcuma zedoaria* Rosc.	Zingiberaceae	Rhizome stomachic, cooling, diuretic, carminative applied to bruisesand pain.	Rhizome	Alkaloids, flavanoids, tannins, Saponins
Gudamar	*Gymnema sylvestre*	Asclepiadaceae	Antidiabetic, enhances sugar absorption	Leaves	Gymnemic acid, guramin, gymnemasaponin, triterpenes saponins, hydroxylongispinogenin
Bhui amla	*Phyllanthus amarus*	Phyllanthaceae	Used in syphilis, leucorrohea and rheumatism	Whole plant	Phyllanthine, hypophyllanthine, flavonoids, astralgin, quercetrin
Kantkari, Katili bhatkataya	*Solanum virginianum* L.	Solanaceae	Cough, asthma	Fruits	Alkaloids, glycosides, saponins
Gokshsru, Bindii	*Tribulus terrestris* L.	Zygophyllaceae	Fruit cooling, diuretic, aphrodisiac, used in painful mictutrition, calculus affection, improve blood glucose and cholesterol level.	Root Fruits	Flavonoids, flavanol glycosides, steroids, saponins

Prishniparni, Pithava, Dabra	*Uraria picta* Desv.	Fabaceae	Fruit applied to sore mouth of children's	Roots	Steroids, flavanoids, terpenoids, glycosides, saponins
Dhataki	*Woodfordia fruticosa* Kurtz.	Lythraceae	Liver disorder, astringent used in menorrhagia	Bark Flowers Roots	Phytosterols, glycosides, alkaloids tepenoids, flavanoids
Sweet kutaj/Indrajau	*Wrightia tinctoria* R.Br.	Apocynaceae	Bark tonic, seed aphrodisiac	Flower Fruits Roots	Flavanoids, lupeol, stigmasterol, campesterol
Aparjita	*Clitoria ternatia*	Fabaceae	Seeds are used as purgative and roots as cathartic, diuretic and purgative, also employed in weakness of sight, sore throat and mucous disorder, in tumors and dropsy.	Seeds	Kaempferol, Quercetin and Myricetin
Thorn Apple/Datura	*Datura stramonium L.*	Solanaceae	Leaves and seeds are narcotic and sometimes used for criminal poisoning. Drug consists of dried leaves, flowering tops and seeds which are used in treatment of asthma	Leaves and seeds	Hyoscyamine and atropine
Bael, Golden apple	*Aegle marmelos*	Rutaceae	Pulp aromatic, cooling and laxative, astringent, antiulceric, antidiarroheal, antidysentric	Fruit leaf	Marmalosin (fruit), marmesin, furocoumarin, rutin , Aegeline (leaf)

Production Technology of Citronella grass

Common Name	**:**	Citronella grass, Java Citronella
Botanical Name	**:**	*Cymbopogon winterianus*
Family	**:**	Graminae/Poaceae
Ch. No. (2n)	**:**	20
Origin	**:**	South and Central America
Economic Part	**:**	Leaves
Chemical constituent	**:**	Citronellal

Uses

The oil is used mostly in perfumery, both directly and indirectly. Soaps, detergents, household cleansers, insecticides, etc. are often perfumed exclusively with this oil. It is also a valuable constituent in perfumery for soaps and detergents. The greatest importance of Citronellal lies in its role as a starting material for further derivatives. Hydroxycitronellal can be prepared from citronellal and it is a key ingredient in compounding. Hydroxycitronellal is one of the most frequently used floralizing perfume materials. For soap perfumes, a slightly rougher grade is used. High grade is used in flavour compositions. Citronella oil is classified in trade into two types, i.e. Ceylon citronella oil obtained from *Cymbopogon nardus* a rather inferior type, while the Java citronella oil obtained from *C. winterianus* is considered a superior type. Java citronella oil has higher alcohol content (90-95%) than the Ceylon type (60-71%).

Types

It is of two types- Ceylon type and Java type. Ceylon type oil is obtained from the species- *C. nardus* and Java type oil is obtained from –*C. winterianus*. The oil of Java type is superior over Ceylon type as it contains about 30-38% of Citronellal compared to Ceylon type is 20-25%.

Distribution

It is cultivated in high rainfall tracts of Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur covering an area around 4500 ha approximately. It is also cultivated in small scale in Karnataka, Maharashtra, Coastal Andhra Pradesh and Orissa.

Morphology

It is an aromatic perennial herb with fibrous roots, erect over 2 m tall, with smooth leaves and bearing a large inflorescence.

Soil

It has been found to grow well under varying soil conditions, but the sandy loam soil with abundant organic matter is most suitable. Heavy clay soils and sandy soils do not support good growth of the plant. The plant has been found to grow well under a pH range of 5.8-6.0. Prolonged water stagnation in soil is undesirable for growth of plant.

Climate

Citronella thrives well under tropical and subtropical conditions. It prefers a warm climate with plenty of sunshine and annual rainfall of about 200-250 cm well spread over the year. Places having high humidity are more suitable for its growth. Although 180-120 m altitude is

optimum, the plants are reported to grow well at the altitudes between 1000-1500 m. Prolonged drought is harmful for growth and development.

Fig.: Citronella grass

Varieties

JavaSel 2, Jorlab 2, Mandakini, Manjiri and Manjusha, Jorhat-2, CIMAP Bio-13 and KS-CW-SI are the high yielding varieties of citronella grass.

Mandakini

A clonal selection, gives a little less herb yield (35 t/ha) and oils (118 kg/ha). The variety is suitable for hills and Tarai tracts of Himalayas (CIMAP, Lucknow).

Manjusha

A clonal selection, gives a herbage yield of 43 tons/ha and 150 kg/ha of oil per annum. The variety is suitable for indo-gangetic plains (CIMAP, Lucknow).

Manjiri

This variety has been released by University of Agriculture Sciences, Bangalore. It is an elite mutant clone of Manjusha M3-8. It has been found to possess 50-90% more oil, high cirtonellol content. It has profuse tillering and rapid growing ability thus producing a high herb yields.

Propagation

It is a perennial grass, however, it does not produce viable seeds, therefore, the species can be propagated only vegetatively by rooted slips. This is achieved by splitting well-grown clumps. A year-old clump yields on an average about 50 slips. The clump is gently separated into a number of slips and each slip contains 1-3 tillers. These slips are the unit of

propagation and on planting establish themselves as plants or bushes. Fibrous roots and leaves should be trimmed off the slips before planting.

Season of Planting

Although the plantation of Java citronella can be initiated anytime during the year, onset of monsoon is the best time. The land should be prepared to fine tilth by discing and tilling. There should be enough moisture in the field at the time of planting.

Method of Planting

The slips should be taken from healthy, vigorously growing and young bushes and should be planted soon after the bushes have been dug up and the slips have been separated out. If the planting is delayed, the slips may partially dry up resulting in poor plant population. The slips are planted vertically, about 10 cm deep. Planting is done at a distance of 45 cm x 40 cm. The planting should be done in such a way that the excess water is drained off quickly. This is because plants are extremely sensitive to temporary water-logging, which adversely affects the growth of the plant. It is better to plant citronella on ridges to avoid water-logging. The field should be irrigated immediately after planting, if there are no rains within next 24 hours. One hectare requires 1,50,000 to 2,25,000 slips with 2-3 slips per pit in the commonly adopted system of planting.

Fig.: Slips for planting

Manuring & Fertilization

It is a soil exhaustive crop and it requires liberal application of fertilizers. The crop requires FYM 10 t/ha and NPK at 25:40:40 kg/ha as basal dose. It generally requires high dose of nitrogen for good growth. So 75 kg N/ha can be applied in 3 equal splits of 25 kg each at 3, 6 and 9 months after planting.

Intercultural Operations

Citronella plantation should be kept weed free. When the plants have established themselves and formed bushes, the problem is not so severe because of the very nature of growth of the bushes. The bushes do not allow weeds to grow around them by cutting off the sunlight. However, in the newly established plantations and after each harvest, the weeds grow in the inter-row spaces and weeding is essential. This can be economically accomplished by running cultivator in between the rows.

Irrigation

It requires sufficient moisture for good growth and yield of the leaves. In the areas where annual rainfall is about 200-250 cm, well distributed over the year and the humidity is high, supplemental irrigation is not necessary. In drier months, however, irrigation is provided twice a week during the first month of planting and thereafter once in 5 days.

Harvesting

Citronella is cultivated for essential oil. Although, all the plant parts contain oil, leaves contain the maximum amount of oil. Therefore, only the leaves should be harvested. Harvesting is done by sharp sickle at about 20-45cm above the ground. The number of harvests, which can be taken during a year, depends upon the growth of the plants. Under favourable conditions, upto 4 harvests can be obtained in a year. The leaves are ready for first harvest, about 6 months after planting. The second and subsequent harvests can be taken thereafter at 2.5 -3 months interval. Harvesting too soon and too late affects the quality of oil adversely. The delay also causes the leaves to dry up resulting in decrease in yield of oil. While harvesting, only the leaf blade should be cut and the sheath should be left. This is because the sheath contains only little and poor quality oil. Its plantations remain productive for 5-6 years but the yield of leaves and oil is highest during second and third years, after which it starts decreasing. It is recommended that the plantation should be uprooted after 3-4 years and rotated with some small legume species.

Yield

The oil yield varies with locality, season, fertility of soil, irrigation, management and method of distillation. On an average, the oil content is about 1% on the basis of fresh weight of leaves. Depending upon the nature of growth, the yield of fresh leaves is about 15-20 tonnes/ha in the first year and 20-25 tonnes/ha in the second as well as in the third year, after which the yield declines. Oil yield is about 140-150 kg/ha during the first year, 200-300 kg/ha during the second- third year, 200 kg/ha during the fourth year and 100 kg/ha during fifth year.

Production Technology of Khus grass

Common Name	**:**	Khus grass/**v**etiver grass
Botanical Name	**:**	*Vetiveria zizanoides* L.
Family	**:**	Poaceae
Ch.No. (2n)	**:**	20 and 40
Origin	**:**	India
Economic Part	**:**	Roots
Chemical constituents	**:**	Vetiverol, Vetiverone, Vetivernate

Uses

Vetiver oil is obtained by steam distillation of its roots. Oil is one of the finest oriental perfumes with a persistent fragrance. Oil of vetiver, patchouli and sandalwood in combination with jasmine and gardenia complex, is the base of the famous *Crepe de Chine* perfume. In blended perfumes, oil of vetiver acts as excellent fixatives for volatile compounds. It is known for its cooling properties. Its oil is used in the manufacture of soaps, cosmetics, perfumery, agarbathis, soft drinks, pan masala etc. Therapeutically, vetiver oil has a relaxing effect on the nervous system, relieving tension and stress. It can be used to good effect in the treatment of insomnia. In India, vetiver oil is known as the oil of tranquility (calm/peace). In baths or in massage, vetiver is beneficial in the treatment of the symptoms of disorders such as arthritis, rheumatism and a chin, stiff muscles. It is warming and comforting and will help to relieve the tension that is often associated with chronic pain. In skin care, the antiseptic and slightly astringent properties of vetiver can be used to good effect in the treatment of oily skin that is prone to spots.

Fig.: Khus grass

Distribution

Haiti, Indonesia and Reunion produce most of the world's vetiver oil. In India, it is cultivated in the states of Rajasthan, Uttar Pradesh, Karnataka, Tamil Nadu, Kerala and Andhra Pradesh, with an annual production of about 20 tons of oil. The vetiver oil from North-Indian origin is considered to be the best in the world market.

Climate

It prefers a mild climate, but can be grown under both wet and dry or arid tropical conditions. It is extremely hardy and can tolerate submergence for a considerable period as well as withstand drought situation. It grows luxuriantly in areas having rainfall of 100-200 cm and a temperature of 30-40^{0}C.Under temperate or warm winter hill areas, the growth remains stunted.

Soil

It grows in any type of soil but a rich and fairly well drained loam soil is considered best. The loamy soils, which are loose in texture having pH of 6-8 are ideal for root growth and harvesting as well. It also grows on a variety of problematic soils like waterlogged soils, sandy soils and areas with high water table and flood prone. A luxuriant growth of healthier root is obtained from plants growing under warm and damp conditions on rich, temporary undated, marshy land. Compact and heavy soils may be avoided.

Propagation

It can be propagated through tillers and slips. Tillers take longer time for growing and therefore, slips are the better planting material for propagation. Plants are cut at 25-30 cm above ground and dug out for preparation of slips. The clumps are divided into slips with 2-3 tillers. From an average sized clump about 20-30 healthy slips can be obtained. The top of the slips are cut down before planting to prune transpiration loss, thus giving a better chance for survival of the slips.

Land preparation

Field should be free of perennial weeds and shrubs. After clearing, the land is deep tilled. With the onset of pre-monsoon shower, final land preparation is done. For uniform cropping and higher root yield, fields are laid out into beds of convenient size.

Planting time

With pre-monsoon shower, April-August is considered most ideal time for commercial cultivation. The best planting time to get higher oil yield under S-Indian condition is June-July. In flood affected areas, crop should be established before floodwater submerges it. Therefore, it should be planted before 2 months ahead of normal flood.

Planting

Slips are planted in pits, 5-8 cm deep made with a pointed stick. 2-3 slips are planted in each pit. This is done to meet any causalities and also to get a thick stand of plants. The soil around the slips is pressed firmly and leveled. Slips are planted in lines at 45 x 30 cm spacing. Flat-bed planting followed by ridging (after 30 days of planting) produces higher roots and essential oil. One hectare requires 1,50,000 to 2,25,000 slips with 2-3 slips per pit in the commonly adopted system of planting. If planting is done during rain free period, field should be irrigated immediately after planting. Although the growth may be slow initially, the plants develop quickly once roots are established.

Fig.: Slips for planting

Varieties

KS-1, KS-2 and Sugandha (tetraploid)are released from CIMAP. Hybrid 7 and Hybrid 8 are released from IARI New Delhi.ODV-3 released from Lemongrass Research Station, Odakkali. Other varieties are Gulabi, Dharaini, Kesar etc.

Manures and Fertilizers

Application of FYM @ 10 ton/ha and 60 kg of N, 22.5 kg in each of P_2O_5 and K_2O/ha is found to be efficient in increasing the yield of vetiver. However, in poor soils 40kg each of nitrogen, phosphorus and potassium per acre is applied before final ploughing. In the first year, depending on soil fertility and crop growth, 20 kg N may be top-dressed at about 4 months after planting. In second year of crop growth, 40 kg nitrogen is top-dressed after rain in June.

Intercultural operations

Initial growth of vetiver for first 60-70 days is very slow, hence inter row space virtually remain vacant allowing infestation and faster growth of *kharif* weeds which compete with crop plants for light, moisture and nutrients. 2-3 weeding at an interval of about a month are needed during the initial period of growth. In the second year, one weeding is done before harvest to facilitate the harvesting and avoid of any root of weeds getting mixed with roots of the crop.

Earthing up

Earthing up after weeding is beneficial to the crop. Earthing up encourages root growth at the crown due to better rhizospheric environment provided to the growing plants.

Shoot cutting

The cutting of aerial portion with commencement of winter (November) increases tillering and consequently gives more roots per plant. Shoot cutting is done twice during the crop cycle. First shoot cutting is done at 30 cm height in planting year to achieve regeneration for

second year, while second time cutting is done at 15-20 cm height before harvesting to facilitate digging of roots.

Inter cropping

Vetiver slips are planted in rainy season at a spacing of 45 x 30 cm. The crop growth in initial stages is very slow and inters row space remains free for weed infestation, which grow at a faster rate and compete with crop plants for moisture and nutrients. The open space can be used efficiently for raising intercrop without affecting the main crop yield. Growing of early maturing pulses like green gram, black gram, cluster bean (French bean) in *kharif* and toria and coriander in the subsequent *rabi* season found to improve the productivity and also give higher net profit per unit time and space. Cowpea, *Dhaincha* seed can be sown in the row spaces and incorporated after 50-60 days of growth as green manure. This will add organic matter, which ultimately is helpful for better root growth.

Harvesting

Harvesting is done in between 15-18 months (Dec-Feb)to get fully developed root system and high quality of oil. Harvesting earlier than 15 months after planting, the immature roots yield oil of poor quality with green earthy odour. Properly developed somewhat thicker roots, yields an oil of better quality and its optical rotation and specific gravity are higher, the odour fuller, richer, more lasting. Oils derived from older roots are usually of darker colour than the oils distilled from the younger roots. If the roots stay in ground for over two years, the yield of oil diminishes considerably as the root system tend to become woody and loss in essential oil content and the oil becomes very viscous with a dark colour but of high quality.

The roots that possess the following characteristics have good oil content. It should

1. Be slightly reddish brown
2. expose a hard surface when the skin is peeled off
3. be thick, hard, long and wiry and
4. give a very bitter taste when chewed.

Digging

The stem portion is cut at a height of 15-20 cm and the clumps are uprooted. About 50-60 % of the roots come away with the clump when dig out by spade or tractor drawn single disc leaving the rest in the soil. The clumps are beaten on a piece of log to remove earth adhering to the roots and the roots are separated from the plants with a sharp knife. As far as possible, re-digging the soil also collects the roots left in the soil. One irrigation may be given before harvesting to facilitate digging if available. For mechanical harvesting a disc plough with single disc mounted on a tractor can be used which uproot the roots from 30-35 cm depth. This process saves manpower and also gives about 15 % higher root recovery over manual digging. The length of the roots varies from 10-35 cm according to the condition of growth, soil, climate etc. of the locality. Thicker roots produce more oil. Very light or almost white roots contain very little oil.

Washing/Cleaning

The harvested roots contain large quantities of earth sticking to them. Immediately after harvest, the roots are washed gently in clean running water to remove the adhering earth taking care so that the finer roots are not lost.

Drying

Cleaned roots are spread on drying grounds. The roots are turned over at regular intervals until dry. During this process foreign matter if any is removed from the mass. The cleaned and dried roots are sent to distillery or storage shed where they are allowed to mature. Drying is done under shade for 1-2 days, which improves the olfactory quality of the essential oil. Prolonged drying in the sun reduces the oil yield. Dry roots can be stored in shade for 60-70 days without loss of oil but quality improves appreciably.

Yield of roots

The age, the soil, climatic conditions and also the strain are important factors governing the yield of roots. On an average one hectare of vetiver plantation yields 5-7 tones of roots which on distillation yield 15 to 16 kg of oil. Roots yield 1.00 to 1.50 per cent of oil on dry weight basis. The colour of the oil is light yellow and oil contain 65-75 % vetiverol.

Distillation

The essential oil is extracted from the roots by steam distillation. Freshly harvested roots on distillation give higher yield of oil than stored roots; the yield decreases progressively with the period of storage. The roots are soaked for 18-20 hours in water prior to distillation to render the root material soft and thereby further facilitate release of oil. Fresh roots when cut to lengths 2.5 cm – 5 cm increases recovery. As the most valuable quality constituents are contained in the high boiling fractions, the roots must be distilled for a prolonged period ranging from 20-24 hours. North Indian varieties yield 0.4 to 0.8 of oil. During distillation two fractions-lighter and heavier oils are obtained. In the start highly volatile lighter fraction released first and a considerable amount of which may escape before it gets cooled and collected in liquid phase. To avoid this loss, a piece of *marking* cloth after cleaning is tied at delivery outlet in the swollen balloon shape in the receiver keeping it submerged in water. The lighter fraction that is likely to escape along with the steam/gas or running distillate water would be trapped in the cloth. As the distillation progress the heavier fraction will get deposited in the cloth and the lighter will pass through cloth and get collected in the receiver. At the end of the distillation the cloth is squeezed to get the oil. This piece of cloth is repeatedly used till tear off. Before thrown off, the cloth may be washed by diethyl ether (solvent) to get back the adhering oil. This practice helps in increased recovery of oil. Traditionally copper vessel with S.S condenser is found good for vetiver since the oil react with free copper turns bluish in colour which fetches more prices in perfumery market. The traditionally distilled oil which often called “Ruhekhus” done in Kannauj type “Deg Vopka” although recovery is comparatively low fetches the highest price in perfumery market.

Quality aspects

Distillation technique plays an important role in oil quality. By adopting the right steam pressure and by adjusting the post-harvest treatment of roots, yield as well as quality can be

improved. There are hundreds of small constituents in vetiver oil. However, the 'Khusimol' content in oil, minimum of which should be 14% or more and low in caryophyllene. Besides extraction procedures the oil quality is governed by varietal selection, harvesting at proper age (15-18 months) and during dry period only.

Bi-products

Roots left after oil extraction is used for making cartons and many handicrafts items like Mats, Aasa (for sitting), pen-stand etc. A simple *sharbat* (syrup) can be prepared by using water obtained during distillation, which on analysis found to be tasty and best for health also.

Production Technology of Sweet Flag

Common Name	**:**	**Bach, Acorus, Sweet calomel**
Botanical Name	**:**	***Acorus calamus* L.**
Family	**:**	**Araceae**
Chromosome No. (2n)	**:**	**24**
Origin	**:**	**North America**
Economic Part	**:**	**Rhizome**

It is also known as Acorusor Sweet calomel. This medicinal plant is called as Bach or Gorbach in Hindi; as Vacha, Ugragandha or Bhadra in Sanskrit. Its leaves possess a lemony scent and the roots also have a sweet fragrance. Sweet flag has long been known for its medicinal value and its aroma makes its essential oil valued in the perfume industry.

Uses

It has a very long history of medicinal use in many herbal traditions. It is widely employed in modern herbal medicine as an aromatic stimulant and mild tonic. In Ayurveda it is highly valued as a rejuvenator for the brain and nervous system and as a remedy for digestive disorders. It is said to have wonderfully tonic powers of stimulating and normalizing the appetite.

Origin and Distribution

Sweet flag is a native to most Northern latitude countries around the world, widely dispersed around the USA. It is found wild or cultivated in India and Sri Lanka up to 1800 meters.

Description

Sweet Flag is a perennial herb, semi aquatic, marshy plant with a creeping and much branched, aromatic rhizome. The rhizome is cylindrical about 19-25 mm in diameter and 10

Fig.: Sweet Flag Plant

cm long. It is light brown outside, white and spongy inside. The leaves are thick, erect and sword shape, when bruised emits strong scent. Sweet flag produces small yellow flowers on a spike. Plants rarely flower or set seed.

Climate

It's a hardy plant found growing from tropical to sub-tropical climates. Plenty of sunshine should be available to the plant during its growth and after harvesting for drying the rhizomes. Temperature ranging from 10°C to 38°C and annual rainfall between 70 and 250 cm are best suited for its cultivation.

Soil

It grows well in clayey loams, sandy loams and light alluvial soils of river banks. Cultivation should be avoided in places where there is no irrigation facility.

Propagation

It is propagated through rhizomes. Rhizomes obtained from earlier planting are kept preserved in the soil and constantly kept moist. After emergence, the rhizomes are cut into small pieces and planted. Sprouted rhizome pieces are planted at a spacing of 30 x 30 cm and depth of 4cm in the month of July-August. The best time for planting is the second fortnight of June. As the growth rate is very fast, sprouts are visible on the second day of planting.

Land Preparation

The land should be ploughed twice or thrice prior to the onset of rains. The land should be prepared like paddy fields.

Fertilizer

Compost/FYM @15 t per hectare along with phosphorus and potassium is applied. One third of N along with 50 kg of P and 25 kg of K is the basal requirement. The second dose of N should be given after one month of planting as broadcast and a third dose should be applied after two months of planting.

Irrigation

The river or canal banks where the land is saturated with water is very suitable for its growth. The initial level of water standing in the field should be 5 cm and later increased to 10 cm. Irrigation can be avoided in the rainy season, however, if there is prolonged dry spell it must be irrigated at an interval of 2-3 days.

Inter-culture

Timely weeding and hoeing to control the spread of weeds and to obtain good yield is essential. After each weeding the growing plants are pressed down into the soil.

Harvesting

After 6-8 months, in December, the lower leaves turn yellow and dry indicating their maturity. The field should be partially dried only leaving sufficient moisture for uprooting the plant. In case of large scale cultivation, rhizomes may be removed by passing the plough.

Post-harvest Operations

The uprooted rhizome is cleaned after washing with water and cut into size of 5-7.5 cm length and fibrous roots removed.

Drying

The cut rhizomes are dried by spreading under the shade so that the amount of oil present in it is not harmed.

Fig. Dried rhizome

Yield

The yield depends upon various factors such as variety, planting distance and management practices. The average yield is approx. 4.22 t of dry rhizomes or 10 t of fresh rhizomes per hectare.

Production Technology of Lavender

Common Name	**:**	**Lavender**
Botanical Name	**:**	***Lavendula angustifolia* Linn.**
Family	**:**	**Lamiaceae**
Chromosome No. (2n)	**:**	**42**
Origin	**:**	**Mediterranean region**
Economic Part	**:**	**Flower**

It is a small genus of perennial aromatic herbs, semi-shrubs or shrubs of Lamiaceae family. It includes about 28 species. The three species extensively utilized for extracting essential oils are True Lavender (L. *angustifolia*), spike lavender (L. *latifolia*) and Lavandin (L. *hybrida*). True lavender is one of the most important essential oils used in the perfumery industry. Spike lavender yields inferior oil, which is less fragrant than that of the true lavender and rosemary. Lavandin possesses the characteristics of both the parents and yields oil which combines the fragrance of true lavender with the camphoraceous harshness of spike lavender. However, lavandin oil is not as fine as lavender.

Uses

Lavender oil has a delightfully clean, refreshing and sweet odour. The oil of lavander is used as a substitute for true lavender oil. It is of considerable value in the soap industry. On account of its microbicidal action, it is nowadays finding increasing use in the form of aerosols, for disinfecting houses, classrooms and public halls in Europe. The oil is also used in medicine as a flavoring agent and sometimes as a carminative. Lavender flowers are used in making sachets and potpourri.

Distribution

In India, it has been successfully cultivated on an experimental scale in the Kashmir Valley. Presently, lavender is also grown in low rainfall areas and on the slopes of hills in Himachal Pradesh and Uttar Pradesh.

Climate

It is a temperate plant. It does well only in those areas which have cold winters and cool summers. Due to its very deep root-system, lavender grows very well on sloping lands, thereby checking soil erosion to a great extent. It is resistant to drought and frost. Lavender can be grown successfully on arable lands at very high altitudes.

Soil

Light, well-aerated, dry and calcareous soils with enough nutrients are best suited for lavender cultivation. Poor carbonate and sandy soils are also suitable, but water-logged soils

are unsuitable. The crop is reported to give high herb- and oil-yields in neutral and alkaline soils (pH 7.0 to 8.4).

Description

It is perennial, herbaceous, bushy plant with straight, woody branches, the lower of which are leafless, putting out numerous herbaceous stems to a height of 1 m. The flower is mauve to violet shade, tinged with a light blue.

Varieties

In Bulgaria, six new varieties have been evolved through selection programmes. These are Kazanluk, Karlovo, Hemus, Aroma, Svezhest and Vanets. In addition, a few Soviet varieties, i.e., Stepnyay, Goranya, Prima, Record, French Bareme and Lambris are also known. Out of the Bulgarian material introduced in Kashmir' by the CIMAP, Lucknow, which is reported to yield 80 to 100% more oil than the existing Bulgaraian varieties. The oil of the present variety is superior to the old Bulgarian variety, 'Karlovo', Some of the other important high-yielding clones are: AM-1, AM-2, AM-3,A-5,A-7,A-8,A9,B-2 and B-11.

Propagation

Lavender may reproduce itself in two ways: by seeds and vegetatively. Seed reproduction is cheap and quick. However, due to cross-pollination, a great variety of generation forms are observed, which complicates lavender cultivation and harvesting at the most suitable time.

Nursery raising

Seed propagation

The seeds are sown in nursery-beds in autumn (November-December). For 1 sq. m. area, 0.2-2.5 g seeds are required. The seed-sowing depth is 1-2 cm. The seeds germinate in spring (April) at 14- 15^0C. The seedlings should be pruned periodically to avoid follicle formation and to achieve regular growth of the young plants.

Fig.: Seed

Vegetative propagation

Vegetatively, lavender is propagated by cuttings. These are obtained from the annual and biennial branches of the mother plantation during October-November in the plains and in February-March on the hills. The cuttings should by 8-10 cm long with intact vegetative tops. The cuttings are treated with 500 ppm IBA to obtain 95% rooting. Beds are made and covered by a 5cm thick layer of organic manure and sand (1:1), topped by 3-4 cm of clean river sand. The cuttings are struck at 5 x 5 cm or 4 x 5 cm from each other, and in depth: 2/3 of the length of the cutting. The soil around the cuttings should be pressed down and immediately watered. A glass of polythene cover should be used over the beds, as well as mats in places that have severe winters.

Transplanting

The seedlings or rooted cuttings or slips or suckers are planted at a distance of 1.20-1.40 m between the rows and 3.5-4 cm within the row. About 20,000 plants/ha give the highest yields.

Fertilizers

Generally, a basal does of 20 kg N, 40 kg P_2O_5 and 40 kg K_2O is applied before planting. While 80 kg of N/ha is applied in four split doses during each year.

Irrigation

During the dry periods, the crop must be irrigated frequently to obtain a good spike-yield.

Interculture

During the first two years of planting, 2-3 cultivations along the rows and 5-6 cultivations between the rows to a depth of 8-10 cm are required. This keeps the soil loose and free of weeds and helps in the proper development of the plants. Regular weeding and hoeing are also done to keep the field free from weeds.

Harvesting

The plants are harvested once blooming has started. The whole plant leaving the basal one-third of the plant for natural regeneration is harvested. The fresh herbage is used for steam distillation.

Extraction of essential oil

The herbage is distilled using steam distillation method. The essential oil content in different varieties varies from 0.5% to 1.1% with 0.8% as the average oil content.

Yield

Third year plantation yields on an average 2000 kg of herbage per hectare.

Production Technology of Geranium

Common Name	**:**	Rose geranium, Scented Geranium
Botanical Name	**:**	*Pelargonium graveolens*
Family	**:**	*Geraniaceae*
Chromosome No.	**:**	88
Origin	**:**	South Africa
Economic Part	**:**	Leaves, flowers, tender shoots
Chief constituent of oil	**:**	Geraniol (68-75 %), citronellol (23-40%)

It is one of the important aromatic plants, yielding an essential oil which is highly priced for its very profound and strong rose-like odour. 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.

Uses

The pure 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 than20 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.

Types

There are two types of geranium:

1. Algerian or Tunisian type

This type of geranium has slender erect plants with dark pink flowers. It contains 0.3 % oil with 57% 1-citronellol. It is being grown in the Nilgiris and is unsuitable for wet conditions. This variety yields 50-60% more oil with a more delicate odour than that of the Reunion type.

2. Reunion or Bourbon type

This type produces more bushy growth with light-pink flowers. The oil has higher 1-citronellol (59.4%). It is grown in the Nilgiris and Anamalais, and more suitable for wet conditions.

Distribution

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 geranium oil is estimated at 250-300 t, whereas the demand is more than 500 t annually. The first planting of high-yielding *Pelargonium graveolens*, introduced from Reunion Island was grown at Yercaud by a French planter, 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, in and around Bangaluru in Karnataka and altitudes of Jammu and Kashmir.

Plant Description

Itis a bushy, aromatic plant. Stem is cylindrical, woody at the base, pubescent, green when young and turning brown with age. Leaves are alternate, stipulate, simple, with 5 primary lobes and secondary lobes and densely pubescent. Leaves are highly aromatic in nature. The inflorescence is umbellate and hairy. Flower is bisexual, hypogenous, with a pink corolla. There are 10 stamens, the filaments are sub equal, united at the base; the anthers are 7, The ovary is hairy, superior, pentacarpellary and syncarpous; the style is hairy, breaking up distally into five stigma.

Fig. Scented geranium **a)** Vegetative stage **b)** Flowering stage

Climate

It can be grown in temperate, subtropical and tropical climates at various altitudes ranging from 1000 to 2200 m. It thrives best in subtropical climates with a temperature ranging from 5 to 23 ^{0}C. However, temperatures below 3^{0}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 ^{0}C in the plains when grown under irrigated conditions.

Soil

It 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.

Propagation

It is easily propagated by cuttings, since there is no seed setting in 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 at200 ppm. The cuttings are planted in raised beds 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 of the cuttings 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 a0.2% Urea solution at bi-weekly 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.

Planting

About 30,000 cuttings are required for planting an area of 1 ha. 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. They must be 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 geranium tolerates short periods of drought, water-logging of the crop must be completely avoided.

Varieties

Hemanti, Bipuli and Kunti are varieties released by the CIMAP, Lucknow for cultivation in plains of North India. KKL-1, Kelkar, Ooty, and IIHR Sel-8 are the other varieties available in this crop.

Manures and Fertilizers

It responds well to major and micro-nutrients application. Well decomposed FYM @ 15-20 tones, along with 35 kg N,35 kg P2O5 and 35kg K2O/ha are incorporated into the soil in the form of urea, super phosphate and Muriate of potash. 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. In addition, the application of 20 kg/ha of zinc Sulphate and 10 kg/ha of boron has been reported to increase the herbage yield. 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%.

Harvesting

It 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 immediately. 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 of25,000 plants should be maintained in a hectare in a year which, in turn, may yield 15 kg of oil on distillation. 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 geranium crop.

Distillation of Oil

The freshly-harvested terminals are used for the distillation of oil. The plant material is stacked near the stills for about 12 to 24 hours. This results in a slight fermentation and splitting of the glycosides, which increases the yield of oil. The oil is extracted by a simple distillation method. The herbage is tightly packed in a still over the perforated grid and tamped down tightly and the still-head is clamped shut. The steam is generated in a separate boiler and conveyed to the still. The oil volatilizes and escapes along with the steam vapours, which is later condensed by passing it through a condenser with running cold water. The condensed oil is separated from the water by the differential density method and clarified by filtering it with activated carbon.

Production Technology of Patchouli

Common Name	**:**	**Patchouli, Pehpli (hindi)**
Botanical Name	**:**	***Pogostemon patchouli***
Family	**:**	**Lamiaceae**
Chromosome No (X).	**:**	**16**
Origin	**:**	**South East Asia**
Economic Part	**:**	**Leaves**

The plant is a perennial, small bushy herb which yields fragrant leaves containing very sweet smelling oil.

Uses

The essential oil extracted is used in perfumery, toiletry and tobacco. The essential oil is one of the best fixatives for heavy perfumes which impart strength, character, alluring notes and lasting qualities. It is a perfume by itself and is highly valued in perfume, soaps, cosmetics and flavour industries.

Distribution

It is cultivated in coastal regions of Tamil Nadu, Karnataka, Assam and West Bengal. It is cultivated in around 600 ha area and producing 20 tonnes of oil per annum.

Soil

It is a hardy plant and adopts itself to a wide range of soil conditions. However, a deep loamy soil, rich in humus and nutrients, with a loose friable texture and without impervious layer at the bottom is the best for optimum production. The pH of the soil must be between 5.5-6.2.

Climate

It prefers warm and humid climate. The crop can be grown successfully on a fairly heavy and evenly distributed rainfall ranging from 150-300 cm per annum. The crop grows well under irrigation in less rainfall areas. A temperature of 24-28 ^{o}C and an average atmospheric humidity of 75 % are ideal. It grows successfully upto an altitude of 800 to 1000 m above sea level.

Varieties

The important varieties are Johore, Singapore, Java, Malaysia and Indonesia.

Propagation

It is propagated by stem cuttings with 4-5 nodes and about 15-20 cm length. The first 2-3 pairs of leaves of the cuttings are carefully removed and planted in the nursery beds at a spacing of 2-3 cm apart. The beds are then hand watered and provided with shade. Cuttings root in about 4-5 weeks and in about 8-10 weeks they are ready for transplanting. Earthen pots and polythene bags can also be used for raising the nursery stock.

Transplanting

Transplanting of rooted cuttings is always done during monsoon season to obtain maximum establishment and to minimize the cost of watering. Rooted cuttings are transplanted generally in the evening in the field. Usually, the planting is done at 60 x 60 cm apart and around 28,000 rooted plants are required per hectare.

Irrigation

The field is irrigated immediately after transplantation. During early stages, shade and sufficient moisture are most important requirements for survival of these plants. The field is irrigated frequently until the plants establish, thereafter irrigation schedule is modified depending on water holding capacity of the soil and weather conditions. Immediately after transplanting, the field must be irrigated every day for the first 3 to 4 days and subsequently on alternate days for 10 to 15 days. Depending on the type of soil and climatic conditions, irrigation is provided once or twice a week for a period of three weeks. The crop is highly susceptible to water logging.

Nutrition

It requires rich soil in order to obtain optimum yield and better quality of the oil. The FYM is applied @ of 10 to 20 tonnes per ha at the time of land preparation. Normally, a basal dose of 25 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare is given in the form of Urea, Superphosphate and Muriate of Potash. After about two months, 25 kg N in the form of urea is applied as top dressing. Likewise, for each harvest 50 kg N is applied in two split doses, the first dose just after the harvest and the other about two months later. In total, 150 kg N per hectare per year is applied to the crop. In zinc deficient soil, 25 - 50 kg zinc sulphate per hectare is applied. Micronutrients and growth regulators are sprayed after every harvest and after soil tests.

Shading

It is a shade loving plant. It has been successfully grown as an undercrop in arecanut and coconut orchards (under irrigated conditions) in Kerala state. It could also be taken up by planting suitable shade trees. *Gliricidia* or *Erythrina* could be planted well in advance at 5 x 5 m spacing in patchouli field in order to provide the necessary shade.

Harvesting

The first cutting can be taken 5 months after planting. Subsequent harvests can be taken after every 3-4 months depending upon the care taken to grow the crop for 3-4 years. The crop is harvested in cool hours to avoid loss of essential oil and when the leaves have changed the colour but before they turn to yellow or brown. Harvesting is done by cutting the young shoots of 25-50 cm in length, which contains atleast 3 pairs of matured leave.

Curing and yield

After cutting, the stem and leaves are spread out for curing in thin layers on a hard dry surface in sheds, allowing free circulation of air. The process of drying normally takes about three days. Proper drying is of great importance for the quality of oil. During the process, the material should be frequently turned over in order to promote even and through drying and to prevent fermentation. Further, completely dried material is pressed into bales and stored in a cool dry place till distilled. A good crop yields about 2 tonnes of dry leaves per annum and about 50-60 kg of oil per hectare.

Distillation

The oil is distilled from the air-dried herb by using steam or hydro distillation process. The recovery of oil from the shade dried herb varies between 2.5 - 3.5 per cent. The duration of distillation is 8 to 11 hours for complete recovery of the oil. Properly dried leaves produce good oil yield and better quality of oil.

Storage & packing of oil

It is to be ensured that the essential oil does not contain any water before storage. The oil is stored in glass bottles or drums made up of steel or aluminium depending upon the quantity of oil to be stored. The containers are filled up to the brim, tightly capped and stored in a cool, dry & dark place.

Production Technology of Mentha

Common Name	**:**	**Pudina**
Botanical Name	**:**	***Mentha sp.***
Family	**:**	**Labiatae**
Origin	**:**	**Mediterranean region**
Economic Part	**:**	**Leaves**

It belongs to the genus *Mentha*, in the family Labiatae (Lamiaceae) which includes other commonly grown essential oil-yielding plants such as basil, sage, rosemary, lavender and thyme. Within the genus *Mentha*, there are several commercially grown species, varying in their major chemical content, aroma and end use.

The four most commonly cultivated species are:

- Japanese Mint/Menthol Mint (*M. arvensis*)
- Peppermint (*M. piperita*)
- Spearmint (*M. spicata*)
- Bergamot mint (*M. citrata*)

Japanese mint is a primary source of menthol. The main constituents of the oil are menthol (65-75%), menthone (7-10%) and menthyl acetate (12-15%) and terpenes (pipene, limonene and camphene). The fresh herb contains essential oils ranging from 0.4 to 0.6%. The constituents of peppermint oil are almost similar to Japanese mint oil. However, the menthol content is lower in peppermint oil and varies between 35-50%.

Fig.: Mentha plant

Uses

Its oil is used directly in perfumes. Cosmetic preparations like scents, soaps, after-shave lotions and colognes also contain this oil. The principal constituent of spearmint oil is carvone (57.71%) and the other minor constituents are phellandrene, limonene, L-pinene and cinelole. The oil is used mostly as a flavouring in toothpastes and as food flavouring in pickles and spices, chewing gum and confectionery, soaps and sauces.

Distribution

It is believed to have originated in the Mediterranean region and, from there, spread to the rest of the world by both natural and artificial means. Among the mints, Japanese mint is cultivated on a large scale in Brazil, Paraguay, China, Argentina, Japan, Thailand, Angola and India. Peppermint is grown in the USA, Morocco, Argentina, Australia, France, USSR, Bulgaria, Czechoslovakia, Hungary, Italy, Switzerland and on a small scale in many Europe countries. USA is the major producer of peppermint and spearmint. In India, cultivation of mentha is done by the farmers of district Badaun, Rampur, Moradabad, Bareilly, Pilibhit, Barabanki, Faizabad, Ambedkarnagar, Lucknow etc. at large scale.

Climate

Japanese mint can be grown in all tropical and subtropical areas under irrigation. However, it does not tolerate damp winters which cause root-rot. A temperature of 20-25°C promotes vegetative growth, but the essential oil and menthol are reported to increase at a higher temperature of 30°C under Indian conditions. Peppermint and spearmint cannot be grown profitably in tropical and sun tropical areas, especially those areas with very high summer temperatures (41°C) and the ideal yield is obtained only in humid and temperate conditions like in Kashmir and the hills of Uttar Pradesh and Himachal Pradesh. Open, sunny situations without excessive rains during the growing period are congenial for the good growth and development of the oil. Bergamot mint can be grown both in temperate as well as subtropical area. However, the yield is higher in temperate climates.

Soil

Medium to fertile deep soil, rich in humus is ideal for the cultivation of mint. The soil should have a good water-holding capacity but water-logging should be avoided. A pH range of 6-7.5 is best. It can also be cultivated on both red and black soil. In case of acidic soil having pH less than 5.5, liming is recommended.

Propagation

It is propagated through the creeping stolons or suckers. In the case of peppermint and bergamot mint, even runners are planted. The best time for obtaining stolons is during the months of December and January.

Improved Cultivars

(A) Japanese mint

- Himalaya (MAS0-1): It is a selection released by the CIMAP Lucknow which contains 0.8 to 1.0% oil with 81% menthol content.
- Kalka (Hybrid 77): It is a tall, vigorous variety evolved by the CIMAP Lucknow.
- Shivalik: It was introduced from China and released by the CIMAP, Lucknow.
- EC-41911: This is a progeny selection of an interspecific cross between M. *arvensis* and M. *piperita*.

(B) Peppermint

- Kukrail: This is a high yielding variety developed and released by the CIMAP.

(C) Spearmint

- MSS-1: This is a selection from the spearmint cultivars introduced from USA. This variety was released by the CIMAP.
- MESS-5: It is a selection from MSS-1 this variety was released by the CIMAP.

- Punjab spearmint-1: This variety is a clonal selection and Arka, Neera are the recently released varieties from CIMAP.

(D) Bergamot mint

- Kiran

Some other varieties are Gomti, Kosi, Sakshamand and Kushal.

Preparation of Field

It requires thoroughly ploughed, harrowed, fine soil. All the stubble of weeds should be removed before the crop is planted. Mints are planted on flat land or ridges. Hence, flat beds of convenient sizes or ridges are made according to the spacing recommended.

Pl**anting**

The creeping stolons or suckers are planted in shallow furrows about 8-10 cm deep with a row-to-row distance of 45-60 cm. While planting on ridges, the stolons are planted half-way down on the inner sides of the ridges. The plot is irrigated immediately after planting. In low temperature areas, the plants become dormant in November. In order to give a perennial crop (of 3 years only) in peppermint, re-cultivation is done either in autumn (November-December) or in spring (March-April). When peppermint is grown as a perennial crop, the first year crop is called 'Rowmint', while the second and third year crop is called 'Meadow mint'. This practice is not followed in other mints which are to be planted every year.

Planting Time

Planting is done in autumn or spring from the last week of December to the first week of March or from the first week of January to the third week of February. Late planting always gives poor yields.

Planting material

About 400 kg creeping stolons or suckers are required for planting one hectare of land. A hectare of well-established mint, on an average, provides enough planting material for ten hectares creeping stolons or suckers. The stolen are obtained from the previous year's planting.

Fig.: Propagating material

Manure and Fertilizer

Manuring may be done at the time of land preparation by adding FYM @ 25 to 30 tonne/ha. Green manuring may also be done before the mint is planted. Sun-hemp is an ideal green manure crop. Mint crop require high amount of nitrogenous fertilizers because it increase the herbage yield. Generally nitrogenous fertilizers @ 80-120 kg/ha, P 50 kg/ha and K 40 kg/ha is required for a good crop yield.

Irrigation

Water requirement of mint crop is very high and also depending upon the soil and climatic conditions, the crop is irrigated 7-10 times before the first monsoon. The crop requires three irrigations after the monsoons during September, October and November. Sometimes another irrigation is required during winter, if the plant is dormant and there are no winter

rains to encourage proper growth of the underground stems. When mints are grown in temperate climates, only 3-4 irrigation during the period from July to October are required.

Weeding

It require weeding and hoeing at regular intervals in the early stages of crop growth. Frequent weeding is done up to 75 days of planting. The weed growth causes about 60% reduction in herb and oil-yields.

Crop Rotation

Crop rotations help to maintain a reasonable control on weed growth, preserve the fertility of the soil and to obtain higher returns from the land. The important crop rotations followed in Uttar Pradesh are: Mint-maize-potato, mint-early paddy and potato and mint-late paddy and sweet pea.

Harvest

Japanese mint is generally harvested after 100-120 days of planting, when the lower leaves start turning yellow. If the harvesting is delayed the leaves start falling, resulting in loss of oil. Further, harvesting should be done in bright sunny weather. Harvesting consists of cutting the green herb by means of a sickle 2-3 cm above the ground. A second harvest is obtained about 80 days after the first harvest and the third one after about 80 days from the second harvest. Whereas, in peppermint, spearmint and bergamot mints which are grown in temperate climates, the first crop is ready by the end of June and the second in September or October.

Yield

The fresh herb contains 0.4% oil. A good crop of Japanese mint can give yield as high as 48 t/ha of fresh herb. However, the average yield of mints from three cuttings is 20-25 t/ha. The average yield of oil is 50-70 kg/ha. Although bergamot mint as well as Japanese mint give an average yield of 70-100 kg/ha, the yield of peppermint oil is lower with an average of 50 kg/ha

Distillation of Oil

Mint oil is obtained by distilling of the fresh herb. The distillation is done both in primitive and modern stills. In the former, the principle of water and steam-distillation is followed, while in the later, steam generated in a separate boiler is employed. The stems are removed from the dried material prior to distillation, because they constitute 30 to 50% of the material and contain only traces of the oil.

Production Technology of Musk

Common Name	**:**	Musk/Muskdana
Botanical Name	**:**	*Abelmoschus moschatus*
Family	**:**	Malvaceae
Chromosome No (2n).	**:**	72
Origin	**:**	India
Economic Part	**:**	Seed

It is an erect medicinal herb native to India and most commonly known as Latakasturi (Ayurveda), Kattu Kasturi (Siddha), and Ambrette (English). It is a non-toxic plant with edible leaves, flowers and seeds. The flowers and seeds can be eaten raw. Every part of this medicinal plant is used in one or the other way.

Morphology

It is an erect, annual herb covered with hispid hair. It grows up to 2meter tall over rich fertile land. Leaves are palmately lobed with long petioles and bear flowers in upper axil of leaves. The petals are yellow with deep purplish spots at the base. The seeds, seed oil and its concrete are traded.

Area and Production

The crop is cultivated in small pockets all over the subtropical tracts in India. Less than 1000 kg ambrette seed oil is produced annually. The main producers are India, Colombia, Ecuador, New Guinea, Northern Australia, Columbia and Brazil.

Distribution

It is grown as kharif crop in Punjab, Arunachal Pradesh, Nagaland, Tarai areas of Kumaun, Madhya Pradesh, Bihar, Uttar Pradesh, Andhra Pradesh and Telangana. Its seed oil is traded in small quantities only and rarely mentioned separately in trade statistics.

Chemical Composition

The seed of *A. moschatus* contains per 100 g: 1315 g fatty oil and 0.20.6% essential oil. The main constituents of the fatty oil are: palmitic acid, oleic acid, linoleic acid, stearic acid and smaller amounts of myristic acid and palmitoleic acid. When ambrette seed is crushed before steam distillation, the odourless, palmitic acid is distilled over together with the aromatic components yielding a crude oil of paste-like consistency. The aromatic components are concentrated in the outer seed coat and distillation of whole seed gives a liquid essential oil, containing only small amounts of fatty oil, but also a lower yield of essential oil.

Uses

Its aromatic oil is used in perfumery, cosmetics and scents. It imparts musky odour to products like sachets, pan masala and insence-sticks. A large part of the seed crop is exported to European countries.

Soil

Since, it is a hardy plant it grows in a variety of soils. But it prefers well drained loamy to sandy loam soils of 6.0 - 8.5 pH having medium fertility.

Climate

It grows well in warm, tropical and sub-humid climate.

Land Preparation

It requires one ploughing with soil turning plough and two to three cross harrowing with soil pulveriser is essential. Proper leveling is desirable which can be accomplished by planking. The farmyard manure is mixed during land preparation.

Propagation and Seed Rate

It is propagated by seed. The seed rate is 1.5kg/ha. Seed is sown in well prepared field. Seed are sown in row 1 cm deep by dibbling. Under favorable conditions, germination starts 4-15 days after sowing and is completed in 15-30 days. The optimum temperature for germination is about 30°C. The germination rate of good commercial seed is about 85%.

Sowing Time and Spacing

The crop is raised in Kharif season from seed. In row planting, thinning is required. The spacing is 40 cm x 30 cm or 60 cm x 30 cm.

Irrigation

One irrigation is initially required for preparing the land for sowing. It needs 6-7 irrigation at 20-25 days' interval. The moisture in soil at flower bud opening stage is essential for higher seed yield.

Manures and Fertilizer

The crop is a heavy feeder of fertilizers. The FYM @ 5-6 t/ha is mixed at the time of field preparation. A dose of 40, 30 and 30 kg of N, P and k is applied basally, whereas 40 kg each is given at 40 and 90 days after germination.

Weeding

The crop should be kept weed free. Two weeding cum hoeing is recommended. First weeding is usually done by the end of July. Weeding is done manually till the plants grow big enough to suppress the growth of weeds.

Harvesting

Its plants flower in October and may continue till march end. The pods should be picked at weekly interval when three-fourths of them blackish brown. Picking is a hardy task as the plants, including the pods, possess hairs that cause itching. In India, harvesting has often stopped by the end of March, as later harvesting rounds, yield too little to be economical. The seeds also have to be shade dried up to the desired moisture level before storage.

Yield

On an average, seed yield of 1 tonne/ha is obtained.

Chapter 22

Production Technology of Ocimum

Common Name	**:**	Tulsi (Hindi), Ajaka, Manjari (Sanskrit), Thulasi (Tamil), Sacred Basil, Holy Basil
Botanical Name	**:**	*Ocimum sanctum* L.
Family	**:**	Lamiaceae/Labiatae
Chromosome No (2n).	**:**	48
Origin	**:**	S-E Asia
Economic Part	**:**	Leaves and seed

The 'Sacred basil' or 'Holy basil', *Ocimum sanctum Linn.* a biennial shrub 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. Its leaves of on steam-distillation, yield a bright yellow, volatile oil possessing a pleasant odour characteristic of the plant, with an appreciable note of cloves. The plant contains mainly phenols, aldehydes, tenin, saponin and fats. The essential oil components are eugenol, eugenol methyl ether etc.

Uses

The plant is 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 and carotene. The juice of the leaves possesses diaphoretic, 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 ear-ache. An infusion of the leaves is used as a stomachic in gastric disorders of children. 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 diaphoretic in malarial fevers. 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. The volatile oil is reported to possess antibacterial and insecticidal properties.

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.

Description of the Plant

It is an erect, herbaceous, much-branched softly hairy, perennial plant, 30-75cm high. 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, close-whorled.

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.

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.

Field 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

It is propagated through seeds. Seeds are likely to deteriorate in future generations on account of the highly cross-pollinated nature of the crop. Hence, for fresh plantings, fresh seeds from the pedigree stock should be used.

Season

The nursery can be raised in the third week of February and transplanting is generally started in the middle of April.

Nursery raising

Raised seed-beds of appropriate size should be thoroughly prepared, 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 nursery beds. 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 cmx40 cm, 40 cmx50 cm and 50 cmx30 cm to get high herbage and oil-yield per hectare at Lucknow, New Delhi and Indore, respectively. The plots are irrigated immediately after transplanting. The seedlings will establish well by the time of the second irrigation. At this stage, gap filling and replacement of the poor plants is done so that a uniform stand is achieved.

Varieties

Regional Research Station, Jammu has released newer promising types: RRL-01, RRL-02, RRL-08, RRL-07. CIMAP, Lucknow also released 2 var. Vikarsudha and Kushumohak.

Manuring

The application of N @ 150 kg/ha, 120 kg/ha each of P_2O_5 and K_2O is recommended for saline and alkaline soils. The entire dose of P_2O_5 andK_2O are given as a basal dose. Whereas, the N is applied in two split doses, after the first and second cuttings.

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 in a year 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.

Intercultural operations

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

Harvesting

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 oil-yield. 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 25-30 t/ha of fresh herbage can be obtained per ha in first year and in subsequent years, it may even go up.

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, buy 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.

Chapter 23

Extraction, use and economics of drugs and essential oils in MAPs

The essential oils are used in a wide variety of consumer goods such as cosmetics, pharmaceuticals, perfumes, soaps, detergents, toilet products, confectionery food products, soft drinks, distilled alcoholic beverages (hard drinks) and insecticides. The world production and consumption of essential oils and perfumes are increasing very fast. Production technology is an essential element to improve the overall yield and quality of essential oil. The traditional technologies pertaining to essential oil processing are of great significance and are still being used in many parts of the globe. Water distillation, water and steam distillation, steam distillation, cohobation, maceration and enfleurage are the most traditional and commonly used methods. Maceration is adaptable when oil yield from distillation is poor. Distillation methods are good for powdered almonds, rose petals and rose blossoms, whereas solvent extraction is suitable for expensive, delicate and thermally unstable materials like jasmine, tuberose, and hyacinth. Water distillation is the most favored method of production of citronella oil from plant material.

Sources of natural essential oil

Essential oils are generally derived from one or more plant parts, such as flowers (e.g. rose, jasmine, tuberose, carnation, clove, rosemary, lavender), leaves (e.g. mint, *Ocimum* spp., lemongrass, palmarosa), leaves and stems (e.g. geranium, patchouli), bark (e.g. cinnamon, cassia, canella), wood (e.g. cedar, sandal, pine), roots (e.g. angelica, sassafras, vetiver, valerian), seeds (e.g fennel, coriander, caraway, dill, nutmeg), fruits (bergamot, orange, lemon, juniper), rhizomes (e.g. ginger, calamus, curcuma) and gums or oleoresin exudations (e.g. balsam of Peru, *Myroxylon balsamum*, storax, myrrh, benzoin).

There are four methods of extracting essential oils from plants: distillation, enfleurage, maceration and solvent extraction. Method to be adopted depends upon the nature of plant material, the amount of oil present and the relative stability of various components.

1. Distillation: Distillation, as the most important process for obtaining essential oil, needs attention first. It may be defined as the separation of the components of two or more liquids by virtue of differences in their vapour pressure.'

There are three types of distillation used:

a. Water or hydro distillation
b. Water and steam or wet steam distillation; and
c. Direct steam or steam distillation.

A) Water distillation: The plant material or crude turpentine oleoresin is immersed in water in a closed still and heated to the boiling point either by direct heat or with the help of perforated steam coils steam jackets.

Advantages: It permits processing of very finely powdered material or plant parts. In case of steam distillation, powdered material form lumps through which steam cannot penetrate. The water distillation apparatus is cheap, easy to construct and suitable for field operations.

Disadvantages: Complete extraction of material is not possible. Certain esters are partly hydrolyzed and aldehydes tend to polymerize. It requires great number of stills, more space and fuel. The high boiling and water soluble constitutes cannot be completely vaporized. It is uneconomical.

B) Water steam distillation: In this method, the plant material is packed on a grid that is above the water level on the bottom of the still. Here the steam is generated and is piped in to the water of the still. The resulting 'wet' steam passes through the aromatic plant material, thus operating at low pressure.

Advantages:

- Higher oil yield.
- Decomposition of oil is less and less fuel and time is required.
- Oil quality produced by steam and water distillation is more reproducible.
- Steam and water distillation is faster than water distillation, so it is more energy efficient. Many oils are currently produced by steam and water distillation, for example lemongrass is produced in Bhutan with a rural steam and water distillation system.

Disadvantages:

- It is not suitable for the materials, which form lumps eg. rose, orange blossoms. The oil of high boiling range requires large quantities of steam for complete vaporization, because of low pressure of rising steam.
- The plant material becomes wet, which slows down distillation as the steam has to vaporize the water to allow it to condense further up the still.
- To avoid that the lower plant material resting on the grid becomes waterlogged, a baffle is used to prevent the water from boiling too vigorously and coming in direct contact with the plant material.

C) Direct steam distillation: In this method, live steam is introduced into the bottom of the still which passes through aromatic material supported on the grids set at intervals. This method is relatively fast. This method is useful for hydrolysis of ester is so desired. In this process, we get more oil recovery.

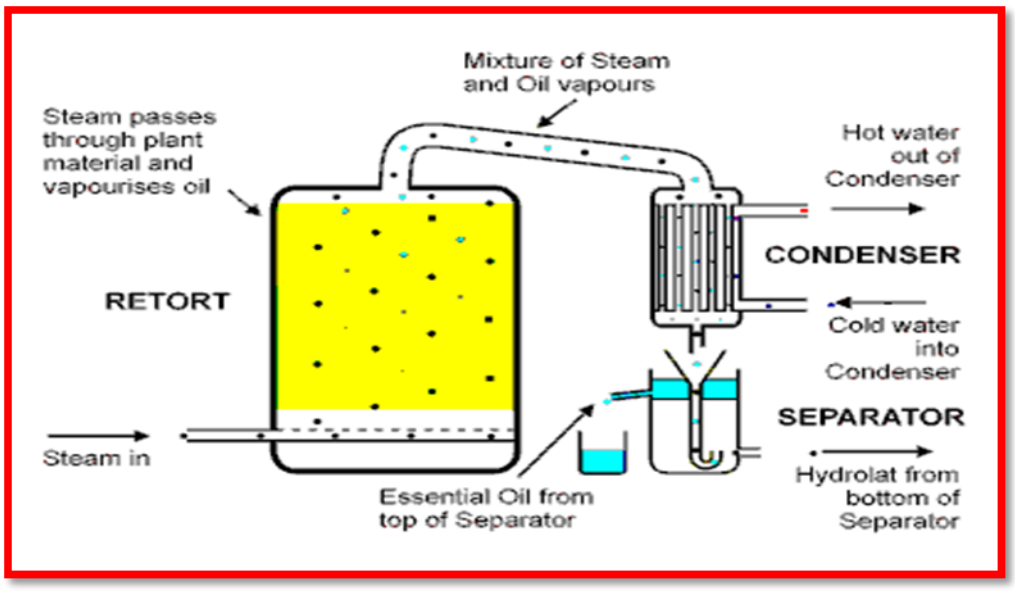

Fig. : Direct Steam Distillation

Advantages of Direct Steam Distillation

- Amount of steam can be readily controlled.
- No thermal decomposition of oil constituents.
- Most widely accepted process for large-scale oil production, superior to the other two processes.

Disadvantage of Direct Steam Distillation

- Much higher capital expenditure needed to establish this activity than for the other two processes.

2. Enfleurage or Cold-Fat extraction method

Despite the introduction of the modern process of extraction with volatile solvents, the old fashioned method of enfleurage, as passed on from father to son and perfected in the course of generations, still plays an important role. Enfleurage on a large scale is today carried out onlyin the Grasse region of France, with the possible exception of isolated instances in India where the process has remained primitive.

The principles of enfleurage are simple. Certain flowers (e.g. tuberose and jasmine) continue the physiological activities of developing and giving off perfume even after picking. Every jasmine and tuberose flower resembles, so to speak, a tiny factory continually emitting minute quantities of perfume. Fat possesses a high power of absorption and, when brought in contact with fragrant flowers, readily absorbs the perfume emitted. This principle, methodically applied on a large scale, constitutes enfleurage. During the entire period of harvest, which lasts for eight to ten weeks, batches of freshly picked flowers are strewn over the surface of especially prepared fat base (corps), let there (for 24 h in the case of jasmine and longer in the case of tuberose), and then replaced by fresh flowers. At the end of the harvest, the fat, which is not renewed during the process, is saturated with flower oil. Thereafter, the oil is extracted from the fat with alcohol and then isolated.

The success of enfleurage depends to a great extent upon the quality of the fat base employed. Utmost care must be exercised when preparing the corps. It must be practically odorless and of proper consistency. If the corps is too hard, the blossoms will not have sufficient contact with the fat, curtailing its power of absorption and resulting in a subnormal yield of flower oil. On the other, if it is too soft, it will tend to engulf the flowers and the exhausted ones will adhere; when removed, the flowers will retain adhering fat, resulting in considerable shrinkage and loss of corps. The consistency of the corps must, therefore, be such that it offers a semi-hard surface from which the exhausted flowers can easily be removed. The process of enfleurage is carried out in cool cellars, and every manufacturer must prepare the corps according to the prevailing temperature in the cellars during the months of the flower harvest. Many years of experience have proved that a mixture of one part of highly purified and two parts of lard is eminently suitable for enfleurage. This mixture assures a suitable consistency of the corps in conjunction with high power of absorption. The fat corps thus prepared is white, smooth, absolutely of uniform consistency, free of water and practically odorless. Some manufacturers also add small quantities of orange flower or rose water when preparing the corps. This seems to be done for the sake of convention. Such additions somewhat shade the odor of the finished product by imparting a slight orange blossom or rose note.

In brief, this method is useful to extract delicate floral scents from flowers that produce essential oils even after being picked (for example, jasmine, tuberose, violets, etc.) or where the oil is affected by high temperature. In this method, a thin layer of purified fat is spread on both sides of a glass plate mounted on one above the other to form an air tight compartment within a frame called a 'chassis' assembled in a cool dark room or cellar. The fresh blossoms are placed over the fat. Every few days, the spent flowers are removed and replaced by a fresh batch until, in about four weeks the fat becomes saturated with the perfume. The flowers are picked off mechanically or vacuum cleaners.

3. Maceration

Certain plant materials require maceration in warm water before they release their essential oils, as their volatile components are glycosidically bound. For example, leaves of wintergreen (*Gaultheria procumbens*) contain the precursor gaultherin and the enzyme primeverosidase; when the leaves are macerated in warm water, the enzyme acts on the gaultherin and liberates free methyl salicylate and primeverose. Other similar examples include brown mustard (sinigrin), bitter almonds (amygdalin) and garlic (alliin). So in this method, successive batches of chopped plant material are digested with hot oil at 45-80^{o} C for several hours. The filtrated is headed with successive batches of fresh flowers up to 20 times. The saturated oil is later placed to alcoholic extraction to retrieve the essential oil.

4. Solvent extraction

Whenever oil with natural flavour is required, direct extraction with solvent such as petroleum ether or benzene is practiced. The solvent is first allowed to run slowly through the flowers, washing out the essential oils and waxes. The 'solvent' is then allowed to evaporate under vacuum, leaving behind a semisolid residue of essential oils and waxes in the retort. The mass is then treated with alcohol to dissolve out the essential oil, the waxes being removed by filtration or precipitated out by freezing. Later, the alcohol can be evaporated to isolate the floral absolute.

Chapter 24

Storage Techniques of essential oils

Aromatic crops are cultivated for their essential oils that are isolated from the plant biomass through different techniques. Quality of the essential oils determines their market value. Quality is assessed through physico-chemical properties and chemical composition of the essential oils. During the steam distillation process, distillation water and essential oil get collected in the receiver of the distillation equipment. Majority of the essential oils float on the distillation waters due to differences in the densities of water and the essential oils. The essential oil is decanted from the receiver, filtered to remove extraneous substances like ash, dust, plant material etc., made moisture free employing anhydrous sodium sulphate and stored in a cool place, away from direct sun light after filling the essential oil up to the brim of the container and tightly stoppering it. Properly cleaned and stored oils retain their quality. However, presence of water, air (oxygen), exposure to sun light were reported to affect the quality of essential oils during storage, the effect of water being more pronounced than light.

The proper storage of essential oils is important to retain their quality until their marketing by the producers or their utilization in flavour and fragrance consumer products by the industry. Water, air, light is reported to influence the composition of essential oils during prolonged storage, if they are improperly stored. During storage of crop and essential oils, following points should be kept in mind to retain their quality.

1. Packed dried crop should be stored in a dry, well ventilated building, with minimal variation in diurnal temperature and with good air ventilation. When necessary, be equipped with air-conditioning and humidity control equipment as well as facilities to protect against rodents, insects and livestock. Shutter and door openings should be protected by wire screens to keep out pests and farm and domestic animals.
2. The floor should be tidy, without cracks and easy to clean. Plant material should be stored on shelves which keep the material a sufficient distance from the walls; measures should be taken to prevent the occurrence of pest infestation, mould formation, rotting or loss of oil; and inspections should be carried out at regular intervals. It is recommended that packed dried crops should be stored: - in a building with concrete floors; - away from the wall; - well separated from all other crops.
3. Continuous in-process quality control measures should be implemented to eliminate substandard materials, contaminants and foreign matter prior to and during the final stages of packaging. Processed medicinal plant materials should be packaged in clean, dry boxes, sacks, bags or other containers in accordance with standard operating procedures and national and/or regional regulations of the producer and the end-user countries.
4. Materials used for packaging should be non-polluting, clean, dry and in undamaged condition and should conform to the quality requirements for the medicinal plant materials concerned. Fragile medicinal plant materials should be packaged in rigid containers.

5. Dried medicinal plants/herbal drugs, including essential oils, should be stored in a dry, well-aerated building, in which daily temperature fluctuations are limited and good aeration is ensured.
6. Fresh medicinal plant materials should be stored at appropriate low temperatures, ideally at 2-8°C; frozen products should be stored at less than -20°C.
7. Small quantity of crude drugs could be readily stored in air tight, moisture proof and light proof container such as tin, cans, covered metal tins or amber glass containers. Wooden boxes and paper bags should not be used for storage of crude drugs.

Chapter 25

Marketing of Medicinal and aromatic plants

With the global development of the pharmaceutical industry and progress in chemical techniques, crude drugs were largely replaced by pure chemical drugs, resulting in a decline of medicinal plant-based therapy, particularly in the developed world. During the recent past, however, there has been a resurgence in the study and use of medicinal plants. Many traditional plant- based remedies are back in use, finding increasing applications either as a source of direct therapeutic agents or as a raw material base for the development and preparation of chemical compounds. The increase in demand for 'natural' medicine is also strongly related to the rise of the green consumption movement. Medicinal plants have additional advantages of simplicity, effectiveness, a broad spectrum of activity and emphasis on preventive rather than curative drug action. WHO estimates that over 80% of the world's population relies on traditional plant-based medicine for their primary healthcare needs.

In international market, MAPs are traded under the “Herbs and Spices” category and they follow the same trade structure and distribution channels of herbs and spices. Very few dealers and brokers deal exclusively with medicinal herbs. In recent years, direct trade between producers/exporters in developing countries (mainly medium and large scale) and processors in consuming countries is increasing. The MAP trade is highly dependent on mutual trust and confidence between the suppliers and the processors. The major herb processors as well as large trading companies establish close relationships with their main suppliers through visits and provide technical assistance services on such matters as harvesting and production. International marketing functions through four major trading participants: importers, processors, wholesalers, and retailers.India’s domestic herbal industry is represented by 8610 licensed herbal units, thousands of cottage level unregulated herbal units and millions of folk healers and household level users of thousands of herbal raw drugs on one hand and a complex trade web on the other that channels the herbal raw drugs from various supply sources to the end users.

India has been the pioneer in using traditional healthcare practices since 4th millennium BC. More than 95 per cent of medicinal plants used by healthcare industry in India are collected from wild and less than 20 species of these plants are commercially cultivated. The world market value for Medicinal and Aromatic plants was USD 1.1 billion in the year 1999, USD 1.8 billion in 2009 and USD 3 billion in 2015. India is home for 17,000 species of flowering plants, out of which 8000 plants are used for medicinal purposes. In terms of volume and value of medicinal plants exported, India stands second in the world.

The collected or processed MAPs from forest or cultivated land can be sold through different market channels in different forms from crude raw materials to improved raw materials or semi-processed materials through consumer products. Collectors generally sell their products without value addition to local traders who sell the products downstream to road head traders. The road-head traders then sell the products to regional traders and finally

to Country level traders. In the case of aromatic plant products, collectors sell to the processors (either directly or through traders) who extract the essential oils and then sell the oil and its by-products to traders and manufacturers in overseas. The main demand for medicinal plants comes from big Indian companies and pharmaceutical concerns. These firms generally buy from traders or middlemen. wholesalers come from time to time to trading towns and road heads - the major collection points in the hills. They have agreements with shopkeepers who, in turn, are in touch with a network of village based traders and collectors throughout the less accessible parts of the country. Several medicinal plant wholesalers use the same network of middlemen to buy material and sell on to their contacts in overseas markets.Market demand & prices demand in global markets is increasing for the MAPs that grow in mountains especially above the elevation of 3000 meters. Recent market trend shows that the use of green products especially health products, flavors and fragrances is receiving increasing attention worldwide. Scientists, researchers and multinational pharmaceutical companies are looking for active substances in the plants for the cure of various diseases, where modern synthetic medicines are proved to be less effective. MAPs are mainly used in pharmaceutical industry for their formulations such as tablet, capsules, powders and extracts. Ayurveda and Traditional Chinese medicines extensively use MAPs in their treatment. In addition, they are used in pharmaceutical research to find out new drug components. Besides they are used in aromatherapy, perfumery industry, health food and dying industries.

Major challenges in trading MAPs both at domestic and international level

Collectors, processors and traders face problems in finding favorable markets due to price factors, quality and quantity considerations. Local and regional price fluctuations as well as the lack of current market and price information affect the income of the actual local collector who is dependent on the middleman or village trader. Financial and logistic constraints make it difficult for local producers and collectors to interact more closely with prospective clients.

- Inadequate knowledge and incomplete information on products, markets and prices on the part of collectors/producers
- Difficult to access appropriate markets and market information.
- No proper recognition of environmentally and commercially sound MAPs.
- Inability to visit traders/buyers or interact closely with them.
- Defective policy and regulatory environment for trading MAPs, which is hindering the business.
- Lack of standardization and consistency in quality for international marketing.
- Astringent phyto-sanitary regulations such as requirement of microbiological test, pesticides and heavy metal test by international markets.
- Uneven distribution of benefits.
- The regulated markets of the MAPs are very less and the herbal mandis are situated in some big cities of the country.
- Even from the GHNPCA the markets for MAPs are situated at a distance of more than 50km for local markets and more than 100 kms for the herbal mandis.

- Due to the distant markets, the transportation cost adds a lot to the total cost of production.
- No cooperatives or APMC's are available for the medicinal plants to regulate their marketing.
- No minimum support price is available for the farmers involved in MAP production.
- The export of MAPs requires the CITES permission which is a very long and hectic process and often discourages farmer interest in the export of his/her produce.
- Due to the lack of technical knowhow, the proper gradation of the cultivar is not done; hence, the producer doesn't get the price in accordance with the quality of produce. Instead the producer often gets the price as a whole of the produce.

Suggested measures for improving the market chain of MAPs, **which include:**

- Formation of co-operatives for the farmers engaged in the cultivation of MAPs so that the producers are aware of the market trends and conditions.
- The farmers and the local people must be made aware about the concept of "Access and Benefit sharing" so as to conserve the precious traditional knowledge about the plants and to protect this asset from being exploited.
- Involvement of various institutions and universities so as to extend the extension programmes into the cultivation of the MAPs. This will help the producers in getting direct scientific help for their crops.
- Well-defined planning for the collection, cultivation and utilization of the medicinal plants to conserve the genetic diversity.
- Advancement of technologies for cost effective production of the MAPs.

It can be concluded that South Asian region is a veritable treasure chest of valuable medicinal and aromatic plants (MAPs)-herbs, shrubs, trees and vines found mostly in fragile ecosystems predominantly inhabited by rural poor and indigenous communities. These MAPs have significant medicinal and commercial value, but are threatened today due to lack of concerted conservation efforts and uncontrolled, exploitative trade practices leading to degradation of natural resources. Appropriate management of MAP resources as well as regulation of their trade can help conserve biodiversity and provide critical rural resources to build sustainable livelihoods.

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Important Medicinal Plants

Ashwagandha
Witahnia somnifera)

Periwinkle
(*Catharanthus roseus*)

Sarpagandha
(*Rauvolfia serpentina*)

Isabgol
(*Plantago ovata*)

Dioscorea
(*Dioscorea alata*)

Opium Poppy
(*Papaver somniferum*)

Safed musli
Chlorophytum borivilianum)

Cinchona
(*Cinchona ledgeriana*)

Brahmi
(*Bacopa monnieri*)

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Important Aromatic Plants

Mentha
(*Mentha spicata*)

Tulsi
(*Ocimum sanctum*)

Geranium
(*Pelargonium graveolens*)

Lemon grass
(*Cymbopogon citratus*)

Palmarosa
(*Cymbopogon martini*)

Khus Grass
(*Chrysopogon zizanioides*)

Lavender
(*Lavandula angustifolia*)

Sweet Flag
(*Acorus calamus*)

Patchouli
(*Pogostemon cablin*)