MEDICINAL AND AROMATIC CROPS

Dr. K. Rajamani
Dr. L. Nalina
Dr. Laxminarayana Hegde

AGRIMOON.COM
All About Agriculture...

Medicinal and Aromatic Crops

Course Creators

Dr. K. Rajamani
Professor
Department of Medicinal & Aromatic Crops
Horticultural College & Research Institute
TNAU, Coimbatore-3

Dr. L. Nalina
Assistant Professor (Hort.)
Dept. of Medicinal and Aromatic Crops,
Horticultural College & Research Institute
TNAU, Coimbatore-3

Course Moderator

Dr. Laxminarayana Hegde
Associate Professor of Medicinal and Aromatics
Kittur Rani Channamma College of Horticulture
Arabhavi, Gokak Tq, Belgaum Dist

Index

Lesson - 1

History, scope, constraints and opportunities in cultivation of medicinal and aromatic plants

Introduction

Plants have been one of the important sources of medicines even since the dawn of human civilization. In spite 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. Over 60% of all pharmaceuticals are plant-based.

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.

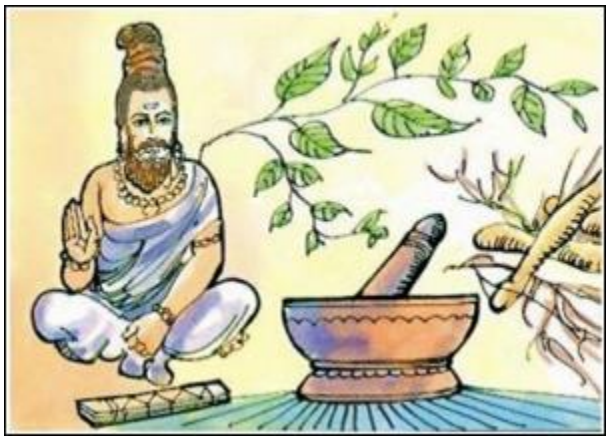
Out of nearly 4, 50,000 species of higher plants available, only a small proportion have been investigated for medicinal properties and still a smaller number of plants yield well defined drugs. The same is the case with lower plants and with plants of the sea origin. Thus, the knowledge of plant constituents gained so far is still meager, considering the huge number of species available in the world. Approximately, only 10% of the organic constituents of plants are reported to be known and the remaining 90% are yet to be explored.

A very small proportion of Indian medicinal plants are lower plants like lichens, ferns, algae, etc. The majority of medicinal plants are higher plants. The major families in which medicinal plants occur are Fabaceae, Euphorbiaceae, Asteraceae, Poaceae, Rubiaceae, Cucurbitaceae, Apiaceae, Convolvulaceae, Malvaceae and Solanaceae.

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), 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' 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, yarrow and groundsel 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 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 importance of plants

Plants have been used by the mankind since prehistoric times for getting relief from sufferings and ailments. Primitive people, when injured in battle or when they had a fall or cut, instinctively resorted to materials available at the reach of hand for stopping the flow of blood or for relieving from pain and, by trial and error, they learnt that certain plants were more effective than others. Man has also gained such knowledge from his observation of birds and animals which use plants for curing their ailments. Even today, we find that the domestic dog and cat, when they suffer from indigestion or other ailments, run to the field, chew some grasses or herbs and vomit to get cured. The folk medicines of almost all the countries of the world abound in medicinal plants wealth, rely chiefly on herbal medicine, even today.

Today, chemical and pharmaceutical investigations have added a great deal of status to the

use of medicinal plants by revealing the presence of the active principles and their actions on human and animal systems. Investigations in the field of pharmacognosy and pharmacology have provided valuable information on medicinal plants with regard to their availability, botanical properties, method of cultivation, collection, storage, commerce and therapeutic uses. All these have contributed towards their acceptance in modern medicine and their inclusion in the pharmacopeias of civilized nations.

The practices of indigenous systems of medicine in India are based mainly on the use of plants. Charaka Samhita (1000 BC-100 AD) records the use of 2000 plants for remedies. Ancient medicine was not solely based on empiricism and this is evident from the fact that some medicinal plants which were used in ancient times still have their place in modern therapy. Thus for example, 'Ephedra' a plant used in China 4000 years ago is still mentioned in modern pharmacopoeias as the source of an important drug, ephedrine. The plant Sarpagandha (Rauvolfia serpentina) which was well known in India as a remedy for insanity is in existence today for curing mental ailments. Quinine, another important anti-malarial drug of modern medicine, was obtained from the cinchona tree.

The knowledge about the use of medicinal plants has been accrued through centuries and such plants are still valued even today, although synthetics, antibiotics, etc. have attained greater prominence in modern medicine. It is, however, a fact that these synthetics and antibiotics although they often show miraculous and often instantaneous results, prove harmful in the long run and that is why many synthetics and antibiotics have now gone out of use or have been specified to be prescribed strictly under medical supervision. In the case of most medicinal plants, however, no such cumulative derogatory effect has been recorded and that is why many of the medicines obtained from plants are still widely used today.

It is also true that lately, inspite of the rapid progress and spread of modern medicine, the popularity of herbal medicines is gaining momentum.

Besides the above, the following are some of the reasons that make the large scale cultivation of medicinal plants inevitable.

1. In nature, there remains a wide variation among the plants with regard to their active principles. As only the best among them are used for cultivation, it enables us to obtain raw material of homogenous quality with high potency.
2. It is easy to grow and fulfill the commitment of large scale demand through cultivated sources rather than from natural sources, which mainly depend on nature for their regeneration and availability.
3. The increasing pressure of population and the development of roads into remote areas have resulted in deforestation and the eventual loss of natural plant resources.
4. In many cases, the important plant parts used are roots or the entire plant, results in destructive collection/ extractive methods, which results in the extinction of many species and ecotypes.
5. Despite the fact that our forests are the major resource base for medicinal plants as many of them appear in wild, the importance of conservation has not been clearly spelt out. Any long-term strategy includes the conservation of biodiversity and support to the communities which are solely dependent on forests for their livelihood.

6. The unauthorized collection of minor forest produce by persons who are led by the burgeoning demand for raw medicinal plant parts has led to the deprivation of the rights and opportunities of the forest-dwelling communities.
7. Since government of India provides policy support for promoting Indian system of medicine, the pharma industries look for organized supply of quality raw materials in larger quantities.

Future prospects and constraints

A comparative analysis of the prospects and constraints of the medicinal plant-based drug industry in our country reveals the following.

Prospects

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 costlier 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 phytopharmaceutical 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 biopesticidal 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 phytopharmaceuticals, 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 multi tier cropping.

Constraints

1. 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.
2. 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.
3. In spite of the thrust given by the government of India through the institutions like the Centre for Medicinal and Aromatic Plants (CIMAP): the Regional Research Laboratories (RRL), at Jammu, Bhubaneshwar and Jorhat; Directorate of Medicinal & Aromatic Plants (DMAPR), National Botanical Gardens, Forest Research Institutes, state Cinchona Directorates in Tamil Nadu and West Bengal, 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.
4. 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.
5. 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.
6. 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.

7. Unstable market conditions have also kept farmers away from taking up cultivation of these crops. The prices of certain crops like Holostemma annulare fluctuate greatly; the price of the crop/kg ranged from Rs. 70/kg in 1993 to Rs. 240/kg in 1990.
8. In the phytopharmaceutical 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.
9. 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.
10. The package of practices for number of medicinal plants has not been standardized to suit different agro ecological conditions.
11. The supply of raw material for the phytopharmaceutical industry is virtually monopolized. It is found that supply and price patterns are often determined by the minor forest produce contractors/gatherers.
12. 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.
13. 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 maximise their production and returns. In fact, in some states like Tamil Nadu, there are some organized production systems like contractual farming, group farming which are exclusively engaged in the production, procurement and marketing of these crops.

Future prospects and constraints

1. India with its vast biodiversity and potential for commercial exploitation, could become a world leader in the supply of raw material for the phytopharmaceutical industry.
2. By drawing up a comprehensive strategy for the cultivation and conservation of medicinal plants in league with the forest departments, many threats outlined earlier could be turned into opportunities for successful commercial exploitation without tampering with the interest of the communities involved in the collection of medicinal plants.
3. The introduction of medicinal plants into the crop rotation especially in dry land and watershed areas could provide a strong thrust to the cultivation of medicinal plants.

Aromatic crops

- Out of the nearly 4,50,000 species known to mankind , about 2000 species, which come from about 60 botanical families, contain essential oils. The families-Pinaceae among the gymnosperms, Apiaceae, Myrtaceae, Rutaceae, Lauraceae, Lamiaceae, Asteraceae (dicots), Poaceae, Aracaceae, Zingiberaceae and Amaryllidaceae (monocots) among the angiosperms, account for a large number of plants bearing essential oils of commercial importance.

- The volatile oils occur in varied parts of the plant anatomy-in some cases being found all over the plant body, in others being restricted to one special portion of the plant. Thus, in the conifers, of which the pine is a type, volatile oil is found all over the various parts; whereas in the rose, the oil is confined to the petals; in cinnamon, to the bark and the leaves; in the orange family, chiefly to the flowers and the peel of the fruit; in aromatic grasses and mints, to the leaves, in ambrette, cumin, fennel, etc, in seeds and in vetiver in the roots. In plants, these essential oils are produced in specialized glandular cells. In the case of the leaves and petals, the essential oils are contained in the innermost membrane of the cell-wall in parenchymatous tissue. In other plants, they accumulate as floating drops in the protoplasm (e.g.terpenes in orange peels) or in separate cell cavities.

History

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. Plants have played a central part in many cultures over many eras. On a close study of the subject, it soon becomes clear just how vast was the knowledge of ancient civilizations including that of Egypt, India, Arabia, China and Greece about plants, their properties and their uses.

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 tale credits the Empress Noorjehan 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; attardaans 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 rose-water 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.

Present status

The world's total production of essential oils is estimated at about 1,00,000 – 110000 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.

Most of the essential oils produced are marketed within the country. Also, many of them are exported. These oils are very expensive and earn good revenue in terms of foreign exchange.

The export of perfumery products from India has risen to Rs. 630.28 crores during 2000-01. India also imports some of these items worth nearly Rs.265.58 crores annually. Among the essential oils exported from India are Japanese mint oil, peppermint oil, sandalwood oil, jasmine and tuberose concretes and many other natural and synthetic perfumes in small quantities. Besides menthol, attars (all-kinds), red sandalwood powder, synthetic camphor, thymol, pepper oil ginger oil, davana oil and spearmint oil are also exported. India also imports a variety of essential oils such as geranium, anise, patchouli, orange, lavender, nutmeg, peppermint, citronella (Java), synthetic essential oils, etc, along with many other natural and synthetic perfumes.

CONSTRAINTS

According to one estimate, against the world trade of Rs.11,900 crores, the Indian share is only 2%. This clearly indicates that the rate of growth of these crops in relation to their economic prospects is not at all satisfactory. Perhaps 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.

Future Prospects

The future for aromatic crops, however, seems bright due to the following reasons

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. 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. 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. On the other hand, aromatic plants and essential oils freshen the environment. They also represent renewable resources.
2. 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.
3. 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.
4. 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.
5. 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.
6. The growing and processing of aromatic crops is labour-intensive and, hence, generates lot of employment.
7. 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.
8. 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.
9. 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.

*****  *****

Lesson - 2

Coleus - Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and processing, contract farming

Importance and chemical composition

Coleus forskohlii Syn. Coleus barbatus, Plectranthus forskohlii, belonging to the family Lamiaceae is a well known plant through out the country and one of the most significant medicinal crops for its tuberous roots. The dried roots are found to be a rich source of forskolin and are used for treating hypertension, glaucoma, asthma, congestive heart failures and certain types of cancer. The tuberous roots, resembling a carrot in shape and brown in colour, are the commercial parts. The plant is known as 'Pashanbhedi' in Sanskrit and 'Patharchur' in Hindi. Recent discoveries have indicated that the forskolin is useful against cholesterol and also used in cosmetics.

The species came into commercial cultivation after the discovery of forskolin, a unique adenylate cyclase activating drug which is highly useful in activating the cardio vascular system. The dry roots contain forskolin with content ranging from 0.10 to 0.80 per cent. One of the Indian medicinal plants which were very little known until a few years ago has now been raised as a single medicinal crop of international importance.

Origin and distribution

The crop has been distributed all over the tropical and sub tropical regions of India, Pakistan, Sri Lanka, tropical east Africa, Brazil. In India, it is found in the sub tropical Himalayan regions from Kumaon to Nepal. It is cultivated in parts of Rajasthan, Maharastra, Karnataka and Tamil Nadu. In Tamil Nadu, it is cultivated for more than 25 years.

Area and Production:
There are about 10,000 ha are under this crop in the country.
The annual estimated production is 2000 ton dry roots/annum

Description of the plant

The plants produce thick roots in the form of elongated tubers. Radially spread roots are fasciculate, succulent, tortuous with 1.0 to 3.0 cm thickness and 20 cm length.

The inner roots are orange coloured, and has the characteristic pungent odour. The plants have square stems branched where nodes are often hairy. Leaves are pubescent, narrowed into petiole. Though it is a biennial, it is cultivated as an annual.


Cultivation

Soil

C. forskohlii thrives better in well drained soils with a pH ranging from 5.5 -7.0. It does not require very fertile soils and can be economically grown under marginal soils.

Climate

Coleus is a crop of the tropics and is found growing well at an altitude of about 2400m under tropical and sub tropical conditions. It grows well under humid climate with a RH ranging from 83-95% and a temperature range between 10-25O C for its successful growth.

Varieties

A selection, K-8 is reported to give 0.5% forskolin and a higher tuber yield. A new variety 'Aisiri' with forskolin content of 0.7% released from UAS, Bengaluru.

Propagation and planting

Coleus is propagated by terminal cuttings. Normally, 10-12 cm long cuttings comprising 3-4 pairs of leaves are preferred. These cuttings are either rooted in nursery and then planted in the main field or planted directly in the main field.

The ideal season for planting Coleus is from June to July with the onset of South west monsoon. Before planting, the field is ploughed deep soon after the receipt of pre monsoon showers and brought to fine tilth. The crop loves high amount of organic manure and about 25 t FYM/ha is applied. Ridges and furrows are prepared at 60 cm spacing. The height of the ridge should be 15 cm from ground level. The cuttings are planted at 30 or 45 cm distance depending on the soil type. While planting, care should be taken to see that minimum of two nodes should be underneath the soil. Watering should be done before and after planting.

Under drip irrigation system, raised broad row ridges of 90cm width are prepared at 60 cm interval and planting at 60 cm spacing between rows are planted. The space between two plants should be 45 cm.

Manures and Fertilizers

The crop requires plenty of organic manure. In addition to 25 tonnes of FYM, addition of 1 ton vermicompost, 150 kg of neem cake, 500 kg of gypsum are applied to condition the soil and to improve its fertility by organic means. Many farmers adopt organic farming by avoiding chemical

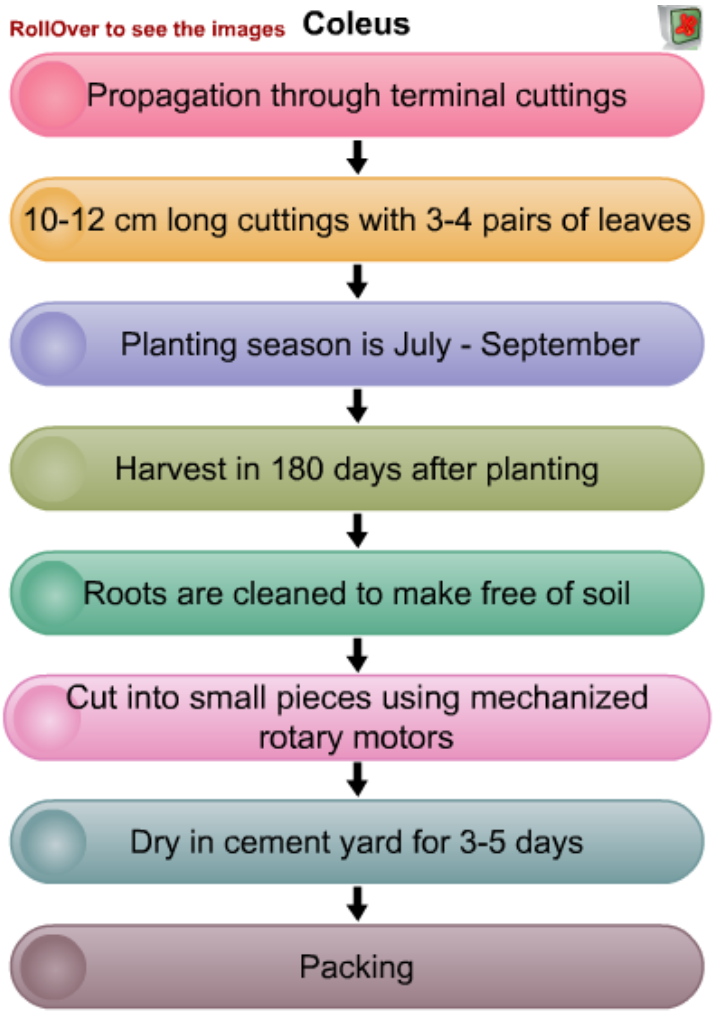
fertilizers and pesticides. 'Panchagavya' 3% organic spray is given along with root drenching.
A fertilizer dose of 40 kg N, 60 kg P2O5 and 50 kg K2O per hectare is recommended for Tamil Nadu. Half the dose of N, the whole P and K may be applied as the basal dose followed by the remaining half N, 30 days after planting as top dressing.

Irrigation

The first irrigation is given immediately after transplanting. In the initial phase, the crop is irrigated once in three days and there after, weekly irrigation is enough to obtain good growth and yield.

Weeding and earthing up

Two or three weedings are given and after the second weeding, earthing up is given. As the roots are shallow, deep digging should be avoided.



Harvesting, processing and yield

- The crop is ready for harvest in 180 days after planting. Flowers if any should be nipped-off during the growing period to obtain more root biomass.
- The roots are harvested either by ploughing using a bullock or by tractor. The tubers can also be manually dug and taken with least damage.
- The roots are cleaned making free of soil and transported for drying. The roots are cut into small pieces using mechanized rotary motors.

- The root bits are spread thinly on the cement yard and allowed to dry for 3-5 days. The roots get completely dried and are packed.

- On an average, a yield of 1500 kg of dried tubers per hectare is obtained. If proper cultivation practices are followed, a yield of 2500 kg of dried tubers can be expected per hectare.

Contract farming

- In Tamil Nadu, the contract production system is in practice.
- The firms enter into bilateral agreement with the growers and an area of about 4000 ha are being covered under the system.
- The major areas in Tamil Nadu include Salem and Namakkal districts.
- The firms offer insurance coverage, timely input supply and technical advise and guarantees buy back.

*****  *****

Lesson 3

Glory lily- Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, supporting system, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

Glory lily or the lily flower (*Gloriosa superba* Linn,) belongs to the family Colchicaceae. In Kannada, it is called 'Agnishike',' Indrana huvu', while in Hindi it is called 'Kalihari'. In tamil, it is commonly known as 'Kanvazhipoo', 'Kanvazhikizhangu'. The plant has been used in the Indian system of medicine since time immemorial. Its tubers are reported to have been used as a tonic, antiperiodic, antihelminthic and also against snake bites and scorpion stings. The drug is a gastro intestinal irritant and may cause vomiting and purging. It is sometimes used for promoting labour pains and conversely also an abortifacient. It is considered useful in colic, chronic ulcers, piles and gonorrhea. It is used in local applications against parasitic skin diseases and as a cataplasm in urological pains. The leaves when applied in the form of a paste to the forehead and neck are reported to cure asthma in children. The leaf juice is used against head lice.

- The medicinal properties of the drug are due to the presence of alkaloids, chiefly colchicine and gloriosine.
- Colchicine is used in the treatment of gout; a common disorder in the temperate parts of the world.
- Gout is caused by the deposition of microcrystals of uric acid in the joints.
- In addition, these alkaloids are also used as polyploidizing agents in polyploid breeding in crop research.
- The colchicine content varies from 0.15 to 0.3% in the tubers, and in the seeds it ranges from 0.7 to 0.9%. The crop is grown mainly for its seeds which are in great demand within the country and in the international market.

Origin and distribution

- Glory lily is a native of tropical Asia and Africa.
- The genus derives its name from the Latin word gloriosus referring to the flowers.
- It is found growing throughout tropical India, from the North-west Himalayas to Assam and the Deccan peninsula, extending up to an elevation of 2120m.
- In Karnataka, it is commonly found growing all along the Western Ghats.
- It is also found growing in Madagascar, Sri Lanka, Indonesia and in the adjacent islands.
- The area under this crop in India is around 3000 ha.
- The genus *Gloriosa* is comprised of about 10 to 15 known species. The important species found in India are, *G.superba* and *G. rothschildiana*.

Area and production

Tamil Nadu leads in production of glory lily in India with an estimated area of **3000 hectares** with annual production of **1000 ton dry seed.**

Description of the plant

- It is herbaceous climbing perennial, growing between 3.5 to 6m in length, but usually trained at 1.5m above ground level.
- The vines are long, weak- stemmed with tuberous roots that support themselves by means of cirrhosed tips.
- The leaves are ovate, lanceolate, acuminate, the tips spirally twisted to serve as tendrils.
- The flowers are large, solitary.
- In the bud stage, the petals hang down over the ovary and on maturity, they assume an erect position, leaving the ovary with its stigma exposed at right angles.

Cultivation

Soil

It prefers sandy loam soils on the acidic pH with good drainage, for its successful growth. In Southern India, it is found growing luxuriantly in red and black loamy soils which have a good amount of humus with a medium water holding capacity. A soil pH range from 6-7 has been found suitable for raising the crop.

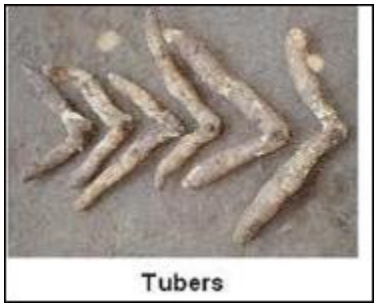
Climate

It is a tropical plant and comes up well in warm humid regions. Under natural conditions, it is found growing up to an elevation of 600m from sea level. An annual rainfall of about 370 cm, well distributed throughout the year, is ideally suited and requires frequent irrigations upto the flowering in dry periods. The temperature favourable for its growth and flowering are 15-20°C at night. The relative humidity should be high. However continuous cloudy weather is congenial for the pathogen Curvularia, which is a very serious threat, resulting in 75 to 80% mortality of the vines.

Propagation

It is commercially propagated from its underground, V-shaped rhizomes or sexually propagated by seeds. The plants raised from seeds take nearly three to four years to flower. Hence, except for experimental purposes, seed propagation is not favoured by the growers.

Glory lily produces a bi-forked tuber during the growing season and each of these forks has only one growing bud. Tubers should be handled carefully, as they are brittle and liable to break easily. If the growing bud is subjected to any kind of damage, the tuber will fail to sprout. Since the vigour of the vine and its flowering and fruiting ability depends on the size of the tubers, it should not weigh less than 50-60g. The plants raised from smaller tubers do not produce flowers during the first year. The dormant tubers start sprouting from the month of May. About 2.5 to 3.0t of tubers are required for planting on one hectare. In order to avoid rotting of the tubers before sprouting, only healthy tubers should be selected for planting. The selected tuber pieces should be treated with suitable fungicides, preferably emisan @ 0.08%



Tubers

Field preparation and planting

The field should be ploughed and harrowed several times until it is brought to fine tilth. All the grass stubbles and roots should be removed. The field must be leveled properly and drainage arrangements made to avoid water logging during the rains. The field is then divided into subplots of convenient sizes. About 15-20t/ha of FYM or compost should be mixed well into the soil. About 30cm deep furrows are opened at a spacing of 45-60cm. The treated tubers are planted at a depth of 6-8cm, keeping a plant to plant distance of 30 to 45 cm, depending upon the type of soil. Closer spacing has been reported to favour cross pollination, thereby improving the fruit set.

Manures and fertilizers

A fertilizer dose of 120kg N, 50kg P2O5 and 75 kg K2O/ha is required for a good crop. Of the nutrients, the whole P2O5 and K2O and one third of N is applied as a basal dose and the remaining two-third of N should be given in the first six to eight weeks after planting.

Irrigation

Frequent irrigation is required during the sprouting time to keep the surface soft, so that there is no hard-pan formation in order to facilitate easy sprouting and emergence of the growing tip outside the soil. Irrigation should be withheld until the flowering is over, to prevent rotting of the tubers. Excess watering is harmful to the plants and causes yellow or brown coloured patches on the leaves which fall off prematurely.

Drip and fertigation system

Application of 150:100:300 kg NPK/ha through water soluble fertilizers is recommended for doubling the seed yield.

Crop monitoring

The provision of support is necessary for successfully growing glory lily. Since the stem is very slender, when the plants are about 30-40 cm tall, they should be staked or tied to wires or allowed to climb on some sort of frame. Various standards are used by farmers. The GI trellis wire support system is the commonly adopted practice.

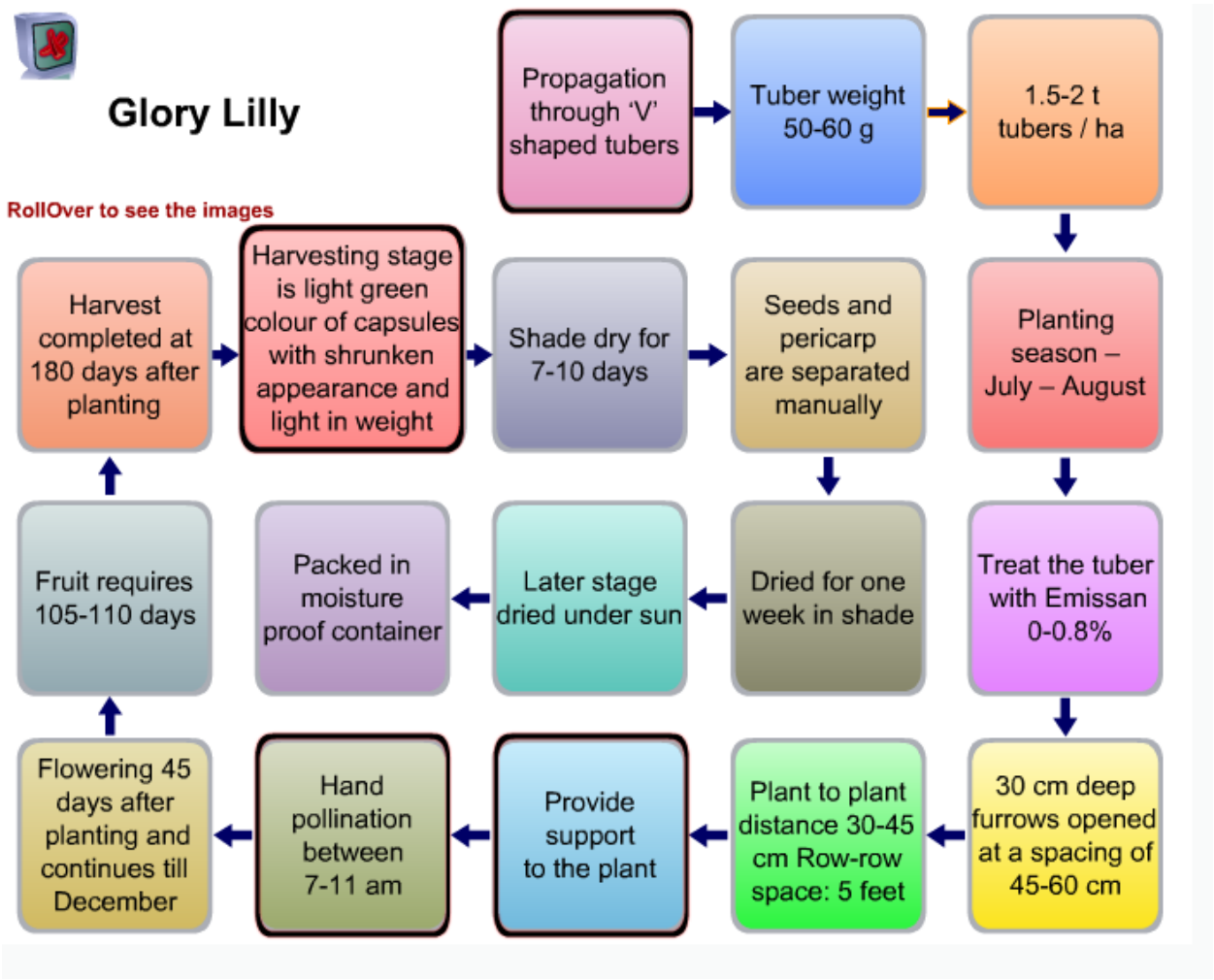
Pollination

The flowers have deflexed stigma which requires assisted pollination. Hand pollination is done between 7-11 am every day. Pollens are collected using brush and dusted on the just opened flowers to ensure maximum seed set.

Weeding

In the initial stages, the glory lily plantation requires frequent weeding to control the weeds which will otherwise compete with plants for moisture and nutrients and will restrict the growth of the

plant. While weeding utmost care should be taken to avoid any damage to the growing tip as once damaged it does not sprout again during the season. Chemical weed control is possible only when there is wide spacing between the rows.



Pests and diseases

Glory lily has few pests and diseases. However, diseases pose a serious threat when they get favourable conditions, causing severe damage. Hence great care has to be taken to control them.

Pests

Lily caterpillar, Green caterpillar: Controlled by spraying quinalphos @ 1000ml/ha

Diseases

Leaf blight: This disease is caused by the fungus Curvularia lunata. The disease can be controlled by spraying 0.2% mancozeb.

Tuber rot or Basal stem rotting and wilting: Controlled by drenching the soil with carbendazim (0.2 %) or Psuedomonas fluorescens @ 0.5%

Harvesting and processing

- Glory lily is a crop of 180 days duration.
- When planted in June, it starts bearing flowers after 55 days and continues to flower and fruit till October.
- The fruit requires about 105-110 days from the set to reach maturity.

- The right stage of harvest is when the capsule starts turning light green from dark green and the skin of the fruit shows a shrunken appearance and becomes light in weight.
- At this stage when pressed the pod gives a crinkling sound.
- After picking, the capsules should be kept in the shade for 7 to 10 days to facilitate the capsule to open up displaying deep orange yellow coloured seeds.
- The seeds and pericarp are separated manually and dried for a week in the shade, by spreading them over any clean dry floor or any platform specially erected for the purpose. At the later stages, the seeds are dried under sun.
- The dried seeds are then packed in moisture- proof containers and stored until they are marketed.

Yield

- The yield of seeds differs greatly, depending upon the size of the tubers used for planting and age of the tubers.
- The average yield is 500 kg dry seed /ha. The seed yield gradually decreases in the third year and thereof.
- Under drip and fertigation system, the seed yield is 1000 kg/ha.

*****  *****

Lesson 4

Senna -Importance, usage, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, crop rotation and intercropping, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Senna (*Cassia angustifolia* Vahl.) belonging to the family Caesalpiniaceae, is a perennial shrub, but grown as an annual in the rainfed areas, mainly for its medicinal properties particularly for its laxative principle.
- This crop is cultivated significantly in Gujarat (Anand), Rajasthan (Jodhpur) and Maharashtra (Pune district) and Tamil Nadu.
- It is extensively cultivated as a rainfed crop in wastelands of Tirunelveli district of Tamil Nadu, by which attains the popular name as "Tinnevely Senna".
- The species was reportedly introduced first in Tirunelveli district during the mid-eighteenth century from Europe and hence the Indian produce as a whole is referred as " Tinnevely Senna ".
- A major part of the produce is exported in the form of leaves, pods and sennoside concentrates.
- Senna is being exported mainly to countries like USA, Germany and Japan. Other senna importing countries are Spain, France, China, Hong Kong, Thailand, Australia and Singapore. Nearly 75 % of senna produced in India is exported, especially through Tuticorin port.
- The available statistics on area of cultivation of senna is around 6,000 ha located in various regions of India and in southern districts of Tamil Nadu, which dominates in commercial cultivation.
- Of late, Gujarat and Rajasthan are emerging as potential suppliers of senna in India.
- The leaves and pods of senna contain sennosides A, B, C and D, which are well known for the preparation of laxatives and purgatives all over the world.
- The drug is used as the most reliable and least harmful laxative agent.
- Senna pods and leaves are also used in the form of decoction, powder and many other herbal preparations. It is popular in European countries for its use along with 'herbal tea'.

Origin and distribution

1. There are two sources of senna drug namely, *Cassia angustifolia* Vahl, and *C. acutifolia* Del., *C. angustifolia* commonly called Thirunelveli senna, is indigenous to Somalia, southern Arabia, part of Sindh and Kutch area of Gujarat.
2. C. acutifolia commonly known as Alexandrian senna is indigenous to Sudan and Sinai. It is commonly cultivated in Sudan and Egypt. *C.italica* and *C.obavata* also posses a fair percentage of Anthraquinone compounds.

Description of the plant

- Senna is a small perennial under shrub; leaves are large, compound and pinnate and emit characteristic fetid smell when crushed. The flowers are bright yellow in color and pods are slightly curved, 3.5 to 6.5cm long and 1.5cm broad.

Varieties

ALFT-2

The Gujarat Agricultural University, under the All India Co-ordinated project on Medicinal and Aromatic Plants at Anand, has released a late flowering type 'ALFT-2' through selection, which remains in vegetative stage till 100 days and is suitable for growing as leaf crop.

Sona

CIMAP, Lucknow has released a high yielding variety named 'Sona'.

KKM Sel 1

It is a selection from Thenkalam local, high yielding recording 38.5 per cent higher leaf yield and 69.88 per cent higher pod yield than local. This is highly suited for all soils of Tirunelveli and Tuticorin districts and ideal for rainfed cultivation. The plants are spreading and bushy with 7-8 branches attaining a height of 80-100 cm. The plant has good rejuvenation capacity and suitable for stripping at an interval of 30 days with crop duration of 135-140 days. It yields 918 kg/ha of leaves and 352 kg/ha of pods. The total sennoside content is 2.54 per cent. The dried leaves and pods have good export potential and the medicinal property is utilized in the preparation of laxatives.

Cultivation

Soil

Senna is a hardy plant and thrives on a variety of soils ranging from sandy loam to lateritic soils. In southern Tamil Nadu, the crop is grown on poor and marginal lands under rainfed condition. The soil type in this region is sandy to red sandy soil, with a pH of 7-8.5. In areas of Ottapidaram,

Vilathikulam, Sattur and Virudunagar, senna is cultivated traditionally under black cotton soils.

Climate

Generally, the crop requires an all-round warm and dry weather conditions. It is very sensitive to heavy rainfall, especially at the time of seed sprouting to young seedling stage. Temporary water logged conditions due to continuous rain and low temperature besides, inclement weather at harvest are unsuitable for its cultivation.

Propagation

Senna can be cultivated both as rainfed and irrigated crop, however, in most parts of southern districts, rainfed cultivation dominates and as such, there are two growing seasons, which coincide with the monsoon rain. The first commences with the onset of south west monsoon in June-July and the second during November-December, receding with North east monsoon rain. Wherever irrigation facilities are available, senna can be raised during January-February as irrigated crop.

Seed treatment and sowing

The crop is raised from seeds. Since the seeds have a hard and tough seed coat, a certain amount of abrasing of its surface is necessary to induce germination. This is achieved by pounding the seeds lightly with coarse sand in a mortar.

A traditional method of seed treatment for removing the hard seed coat is mixing the required quantity of seeds with dry and pure sand in the ratio of 1:3 and is gently beaten. Later the seeds are soaked in water for 10-12 hours and then used for sowing. This practice gives about 90 % germination. The seeds exhibit dormancy for 2 months. The land should be thoroughly ploughed, at least two times, and properly leveled for ensuring good drainage. The farmers usually divide the land into small fields enabling for draining the excess rain water and then broadcast the seeds for raising the rainfed crop.

Under irrigated condition, a uniform spacing of 45x30 cm is recommended. Small beds are first prepared and shallow straight lines are formed at 45 cm apart and seeds are dibbled at a depth of 1-2 cm. The seeds start germination in 5-7 days and complete germination in 15 days after sowing. The seedlings are thinned to have a spacing of 30 cm in between plants within 20-30 days after sowing.

Manures and fertilizers

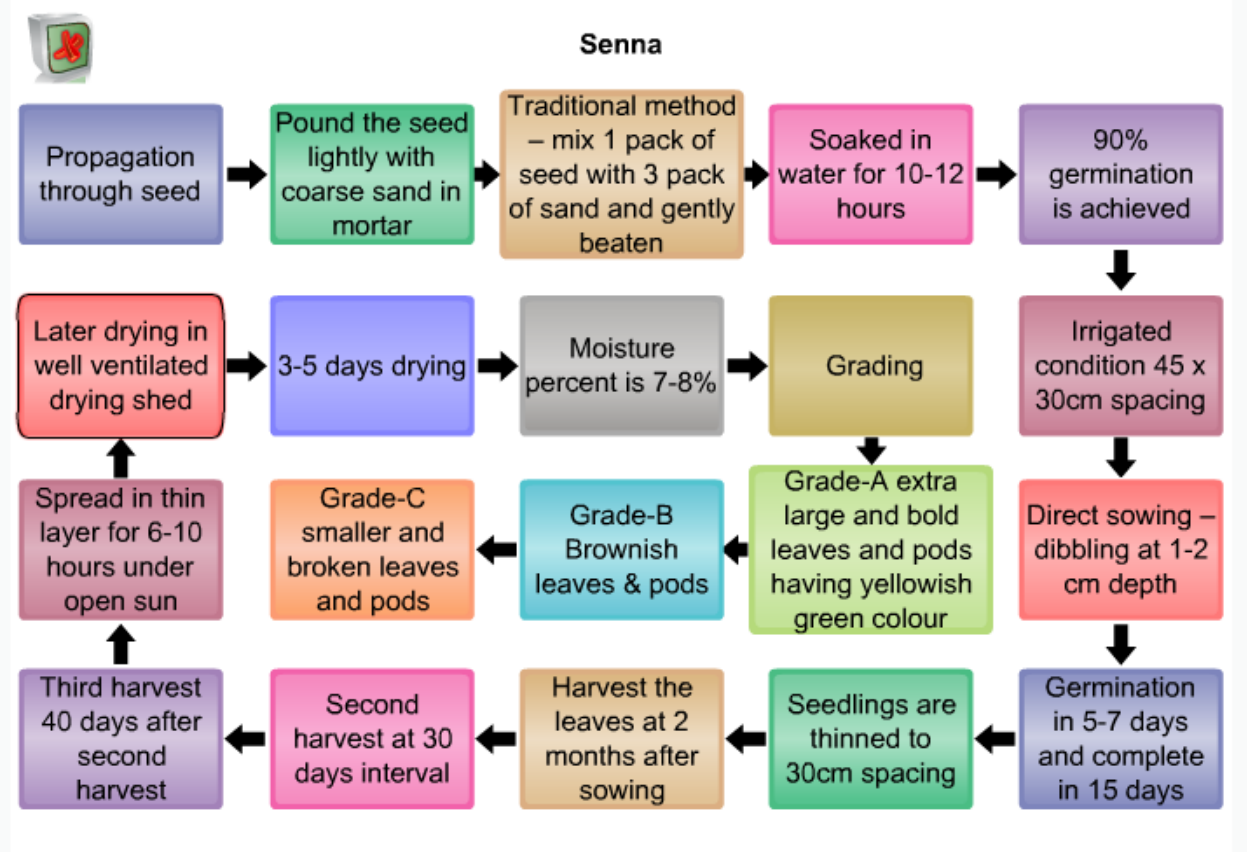
A basal dose of 25 tonnes of FYM, 50 kg N, 25 kg P2O5 and 40 kg of K2O/ha can be applied. Top dressing of 25 kg of N can be applied 40 days after sowing and another 25 kg N after 80 days of sowing. 4-6 irrigations can be given during the cropping period. Continuous rain, water stagnation and excess moisture are not suitable for senna growing.

Crop rotation and intercropping

Senna is grown after the paddy and grown as intercrop between rows of cotton, sesamum, chillies, brinjal, okra, mustard and coriander.

Irrigation

Senna can be economically grown under rainfed conditions. However, when it is grown as semi irrigated crop, the yield increases considerably and excess irrigation is injurious to the crop.



Pests and diseases

Pest

The leaf eating caterpillar feed on the green senna leaves and spraying of carbaryl (4g/l) controls the infestation. The pod borer is also reported to attack the pods and can be controlled by spraying chlorpyriphos 1000 ml/ha

Diseases

1. **Leaf spot and leaf blight:** The crop is sprayed with 0.1% benlate at about 70-80 days after sowing.
2. **Damping off:** Drenching with 0.2% brassicol or 0.5-0.15% rhizoctol.
3. **Seedling blight:** Spraying with 0.2% Mancozeb at forthnightly intervals.

Harvest and Yield

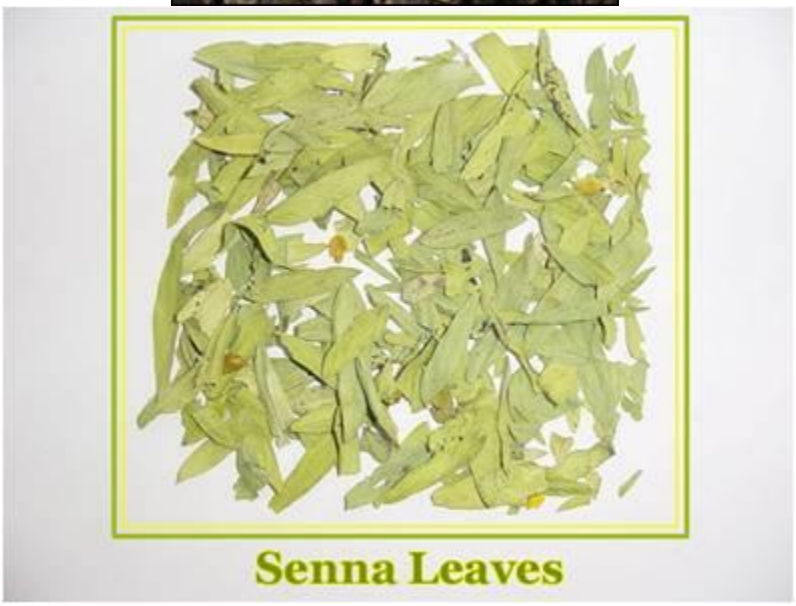
The leaves can be harvested in 2 months period. The second harvest is made at 30 days interval and the third harvest 40 days after second harvest.The harvested leaves should be shade dried for 7 to 10 days.

Yield

Yield/ha	Leaves (kg)	Pods (kg)
Rainfed	1000	150-200
Irrigated	2000	400

It has been shown that young leaves and pods contain more sennosides than the mature ones; however, bluish green, matured leaves are preferred in the market and they also fetch better price. Even though, the produce are sold by weight, leaves containing about 2.0-2.5 % and pods having 2.5-3.0 % of total sennosides are acceptable in the industry.

Post harvest handling and storage



The harvested leaves should be spread in a thin layer under open sun for 6-10 hours to reduce the moisture content. Further drying of the produce is done in well ventilated drying sheds. It takes 3-5 days to dry the produce in the sheds by frequently turning them all over. A well dried produce should have 7-8 percent moisture and should maintain light green to greenish yellow colour.

Grading

One of the serious limiting factors in senna trading is lack of grading. High degree of variation in sennoside is experienced due to mixing of small, medium, large and extra large leaves. In the market, three or four grades of senna are recognised based upon size of leaf and colour.

- Grade A / first grade:The extra large and bold leaves and pods having yellowish green colour
- Grade B /second grade: Produce having brownish leaves and pods
- Grade C /third grade: Smaller and broken leaves and pods

*****☺*****

Lesson 5

Periwinkle - Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, types and varieties, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Periwinkle (*Catharanthus roseus*) belonging to the family *Apocynaceae,* is one of the few medicinal plants which have found mention in the folk medicinal literature as early as 2nd BC.
- Modern investigations have shown that periwinkle contains more than 100 alkaloids, distributed through out the plant.
- It has medicinal importance owing to the presence of alkaloids like ajmalicine (raubasin), serpentine and reserpine in roots, which is well known for their hypotensive and antispasmodic properties.
- It gained further importance after the isolation of vincristine and vinblastine alkaloids from leaves, which have importance in cancer therapy.
- 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.

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.
- Farmers prefer it because of its wide adaptability and its ability to grow in marginal lands and its drought tolerance.
- The presence of alkaloids all over the plant confers immunity to cattle – browsing and crop loss due to pilferage.
- 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.

Description of plant

It is a perennial herb which grows up to 90-120 cm tall. It is a diploid with the chromosome number 2n = 16.

Types and varieties



three variants in periwinkle, those with (i) rose purple flowers, (ii) white flowers and (iii) white flowers with a rose purple spot in the centre. 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.

Cultivation

Soil

The crop is hardy and grows well on a wide variety of soils, except those which are alkaline or water-logged. 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.

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.

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.

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 over night 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.

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 weedings 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.

Pests and diseases

- Plant is hardy hence devoid of pest and diseases. Occasionally they suffer from little leaf due to infection by mycoplasma resulting in stunted growth. This can be effectively checked by uprooting and destroying the affected plants.
- Die back / Twig blight/top rot is reported during monsoon. Control measure is spraying Mancozeb at an interval of 10 -15 days.

Harvest, processing and yield

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 rainfed 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%

*****☺*****

Lesson 6

Phyllanthus -Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- The WHO puts that, about 400 million of Hepatitis – B carriers are present all over the world.
- In India alone, 42 million people are Hepatitits –B carriers.
- As most of the carriers in the developing countries are dependent of traditional system of medicine which rely on plants mainly Phyllanthus amarus, which is known popularly known as "Bhumyamalaki" in the Indian system of medicine.
- t is traditionally being used in the treatment of variety of ailments including Hepatic disorder.
- This fascinating plant belongs to the family Euphorbiaceae possess various group of organic compounds.
- Out of these, the main components are lignans like Phyllanthin and hypophyllanthin.
- The name phyllanthus means 'leaf and flower' because the flowers, as well as the fruits are borne on the same axil.
- The genus Phyllanthus has a long history of use in the treatment of liver, kidney and bladder problems, diabetes and intestinal parasites.

Origin and Distribution

- Plants in the genus Phyllanthus can be found around all tropical regions of the world; from Africa to Asia, South America and the West Indies.
- Phyllanthus contains about 550 to 750 species in 10-11 subgenera.
- *P. amarus* can be found in all the tropical regions of the world; roadsides, valleys, on the riverbanks and periphery of lakes. This plant is a common arable weed of southern Florida, the Bahamas, the West Indies and tropical America and is naturalized in the Old World tropics.
- *Phyllanthus amarus* is usually misidentified with the closely related *P. niruri* L. in appearance, phytochemical structure and history of use. *P. niruri* reaches a length of 60 cm, the fruits are larger, and the seeds are dark brown and warty.

Uses

- It has been reported to exhibit a marked anti hepatitis-B virus antigen activity both in in-vitro studies.
- Further more, the plant has been reported to possess anti bacterial, anti crustacean, anti fungal and anti viral activities.
- Besides this property, it also has shown to possess anticarcinogenic and antimutagenic activity both in vivo and in vitro condition.
- *P. amarus* increased the activity of various antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), glutathione-S-transferase (GSC) glutathione peroxidase (GPX) and glutathione reductase (GR), both in blood and tissue.
- *P. amarus* has therapeutic potential for treating Hepatitis B virus by inhibiting the polymerase activity and decreased episomal DNA content. *P. amarus* suppressed the mRNA transcription in Hepatitis B virus (HBV) and exhibited therapeutic potential in chronic HBV carriers.

Cultivation

Soil and climate

The species is adapted to varied types of soil starting from red loam to lateritic, calcareous, and black clay soils. It can tolerate a pH of 6.5 to 7.5. However for commercial cultivation, well drained red loam soils are preferred. Being a short duration crop, the soil stratum should be ideal for root and vegetative growth within a short period and all desired nutrients should be available.

Being a weed, it tolerance a wide range of climatic condition ranging from the dry and water starved regions to regions having high rainfall. The crop does not like water logging but at the same time, assured irrigation is required throughout its life time to get the economic returns.

Season

Both the monsoons are suitable for its growth. Winter season is not ideal as the crop is susceptible to powdery mildew disease.

Propagation

The species is propagated by seeds. Seed extraction is a complicated effort and care has to be taken to extract healthy seeds alone for sowing. The seeds lose germination very quickly and

therefore freshly harvested seeds are used for sowing.

The seeds have to be sown in nursery beds to get the desired yield. Seeds treated with carbendazim (1 g/l) and mixed with the fine sand and sown on raised nursery beds applied with plenty of organic manure. The seeds germinate in about a week and are maintained up to 20 days. Soaking the seeds in fresh water for 20-30 min before sowing would help in increased germination. About 2.5 kg of seeds is required for nursery raising and for planting in one hectare.

Field preparation

The land is well ploughed and brought to a fine tilth by adding 10 t of farm yard manure/ha.

Transplanting

The plants are propagated by seeds. The months of April- May have been found excellent for raising the nursery. Approximately 1 kg of seeds is enough to get sufficient seedlings for transplanting an area of 1 ha.

Healthy vigorous seedlings of 35-40 old or 15 cm height are pulled out from the nursery and transplanted to the main field. Beds of convenient sizes are prepared and the seedlings are transplanted in the ridges at 20x15 cm.

Manures and fertilizers

At the time of last ploughing 10t/ha FYM is applied. A dose of 100 :50:50 kg of NPK is optimum to obtain better growth and herbage yield. Half the dose of N and full dose of P & K should be applied at the time of transplanting and the remaining half of N is applied when plants attain 40-45 cm height.

Irrigation

The field should be irrigated before and after transplanting of the seedlings. Life irrigation should be given three days after the planting. The crop requires adequate irrigation through out its life period. Irrigation once in a week is required. Phyllanthus will not tolerate water logged condition.

Interculture

Weed infestation would pose a problem in the initial stages. Weeds carried on through the FYM should be removed and the young seedlings should be encouraged to grow. Chemical weeding is not allowed in *P. amarus* field as it is harmful to this plant.

Plant protection

A green coloured semilooper is only the pest in this crop in the early stages of plant growth and the loss due to this pest is below the economic loss.

Regarding disease, powdery mildew is the only major diseases in the winter months. To control powdery mildew, rational use of fungicides like sulphur is used (2g/l). Stem blight is also a disease found in Phyllanthus. This can be controlled by the bio control agent *Pseudomonas fluorescens.*

Harvesting and yield

- The plant becomes ready for harvest in 90 days after planting. The leaves, fruits and stem are cut at ground level and transported to the drying yard (under shade) for drying. Care should be taken to harvest the leaves along with the fruits which otherwise tends to shatter.

- The herbage is dried under shade to retain the chlorophyll and hypophyllanthin. It takes 4-6 days for complete drying (at 10 per cent moisture). Frequent raking of the herbage is a must as otherwise, moulds and fungus may develop.
- An average yield of 5 ton fresh herbage/ha or 400 to 500 kg dry herbage/ha is obtained.

*****☺*****

Lesson 7

Pyrethrum and Cinchona -Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, types and varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and processing

PYRETHRUM

Importance and chemical composition

- The term pyrethrum is applied to the dried flower–heads of *Chrysanthemum cinerariaefolium* Vis. Family- Asteraceae).
- 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.
- 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.

Origin and distribution

- ***C. cinerariaefolium*** is a native of Dalmatia, Herzegovina and Montenegro and is cultivated on a commercial scale in Algeria, Yugoslavia (Dalmatia), Brazil, Bulgaria, Japan, Kenya, New Guinea, Congo, Tanzania, Ecuador, Australia, USA, China, France, Italy, Persia, Russia, Spain, Switzerland, England and India.
- Kenya and its neighbours Tanzania and Rwanda produce over 80% of the total pyrethrum produced in the world.
- The experimental cultivation of pyrethrum in India was under-taken in Kashmir in 1931 and in the Nilgiri hills in the early years of World War II (1942).
- At present, it is successfully grown in several parts of India (Kashmir, Kodaikanal, Lucknow) on a commercial scale.

Description of the plant

- *C. cinerariaefolium* Vis. (2n=18) is a glaucous, perennial herb which grows up to 60 cm tall. It has an unbranched stem with short, scattered hairs below the flower.
- The leaves are petiolate, long finely cut and silky beneath, with distinct segments.
- Numerous flower-heads are borne which measure 6-9 mm when closed, and 9-12 mm, when open.

- The cream-colored floret looks like that of the field daisy (*C. leucanthemum* Linn.), but differs from the latter in having the central teeth of ray-floret shorter than the adjacent ones.

Types and varieties

- *C. cinerariaefolium,* grown on the Eastern Coast of the Adriatic sea, is called Dalmatian pyrethrum. While, the Japanese pyrethrum also derived from *C. cinerariaefium,* is similar to the Dalmatian pyrethrum in appearance. The concentration of active principles (pyrethrin) in the Dalmatian and Japanese type of pyrethrum flowers range from 0.38 to 0.58 and 0.58 to 1.21%, respectively. The pyrethrum grown in Kenya and other African countries, known as the Kenya pyrethrum, has a higher pyrethrin content of 1.43 to 1.89%.
- 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.

Cultivation

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

Pyrethrum is a temperate crop. 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.

Season

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 rides 45-50 cm apart if the land is flat. In undulating land, the area should be terraced.

Propagation

Pyrethrum is propagated by seeds. However, it can also be raised vegetative by splits. 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.

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
Experiments conducted at the CIMAP field station in Kodaikanal have established that the application of liquid phosphorus (3-% P) @ 120 kg/ha increased the flower-yield by 28%. Liming the soil @ 1 t/ha and foliar application of P, resulted in 20% increase in the flower-yield over the control.

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.

Pests and diseases

- **Root-rot** - caused by ***Fusarium solani,*** can be controlled by drenching the nursery with 0.15% Benlate solution or Mancozeb.
- **Damping-off** is caused by *Sclerotinia sclerotiorum*. The application of a solution of copper fungicide to the base of the plants can control this disease.
- **Bud disease** is reported to be caused by *Rannularia belluniensis* and this can be controlled by spraying Bordeaux mixture and pereneox.

Harvesting, processing and yield

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 t the end of June or in the 1st week of July.
- The flowers should be picked when ⅔rd of the disc-florets are pen 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.

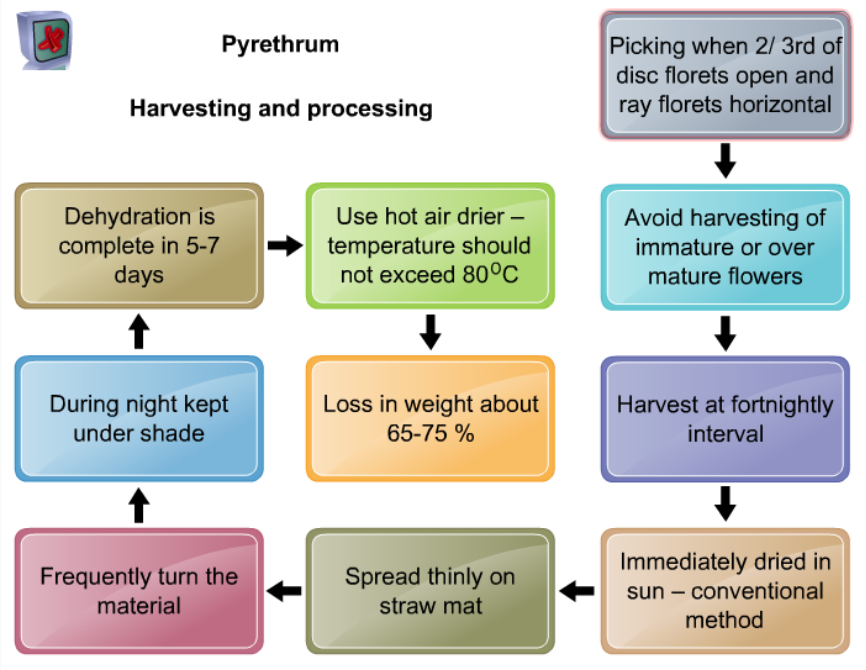
- There is a gradual fall in the pyrethrin content of harvested flowers after the third year of planting.
- The yields tend to become uneconomical after 3-4 years and replanting is necessary.
- Light pruning at the beginning of the dry season, after picking the flowers, is required to keep the plant 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 800C.
- 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%.



CINCHONA

Importance and chemical composition

- Cinchona belongs to the family, Rubiaceae which 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 cinchonine** are 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.
- In addition to the alkaloids, the bark also contains the bitter g**lycoside, a-quinovin, cinchofulvic, cinchotannic and quinic acids**, a bitterish essential oil possessing the odour of the bark, and a red colouring matter.
- Quinovin, on hydrolysis, yields **quinonic acid, and mannitan.**
- The alkaloids are formed during the descent of the sap, and their concentration is low in twigs and increases down the stem to a maximum in the root-bark.
- In *C.ledgerina*, almost 90% of the total alkaloids of the stem-bark is quinine, while of the total alkaloids of the root-bark, only 60% is quinine.
- 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.**
- Salts of quinine are employed in beverages, as an addition to hair-oils, as a vulcanization accelerator in the rubber industry, for making polarized lenses and have various other uses in photography and optics.

Origin and distribution

- Cinchona is indigenous to South America, and occurs in the Andes, Colombia, Eucador, Costa Rica, Peru and Bolivia between 100 N and 190S at attitudes ranging from 750-2725 m.
- Some species are also cultivated in Java, Sri lanka, India, Myanmar, Bohemia, Panama, Indonesia, Guatemala, Uganda, Philippines, Tanzania, Kenya and Zaire.
- In India, it is confined to some parts West Bengal, Tamil Nadu (the Annamalai Naduvattam, Shevaroy Hills, Palani and parts of Tirunelveli) and Karnataka (Dakshin Kannada and Kodagu) in an area of about 6000 to 8000 ha.

Description of the plant

Cinchona spp (x =17) are evergreen shrubs or trees. The leaves are opposite, simple entire; the stipules are interpetiolar and deciduous. The inflorescence is a terminal panicle. The flowers are small and fragrant the calyx is small united and has pointed lobes; the corolla is tubular with 5 spreading lobes and a frill of hairs along the margins, it is heterostylous. In microstyled plants, 5 exerted anthers alternate with corolla lobes while the bifid stigma reaches half the length of the corolla tube. In

macrostyled plants, the stamens are half the length of the corolla tube and the stigma is exerted. The fruit is a capsule, dehiscing from the base upwards with 40-50 small. Seeds are flat and winged.

The following are the commercial species.

a. *C. succirubra* Pav.ex kl.

It attains a height of 40-50 ft or more. This species has a red bark. The quinine content in the bark of this species is very poor (0.5 to 1.5%). The species is vigorous and grows well between 660 to 1800 m (2000 and 6000 ft) altitude. The species is possibly a variety of *C.pubescens.*

b. *C. officinalis* L.

This species is well suited for the higher altitudes of South India and flourishes well at elevations of 1800 to 2420 m (6000-8000 ft). It is a slender tree, 20-30 ft high. It is the source of Crown or 'Loxa bark'. The quinine content of the bark ranges from 1.5 to 2.0%. The species is indigenous to the mountains of Colombia and Peru.

c. *C. ledgeriana* Moens and Tremen

This is a weak but fast growing species, attaining a maximum height of about 20 ft. and it can be grown between 900 to 1800 m (3000-6000 ft) elevations. It is a source of 'Ledger bark' or 'Yellow bark which is the richest in quinine (4 to 5%) the quinine content is occasionally as high as 14%. This species is considered either a hybrid between high-yielding varieties like *C.calisaya* and *C.succirubra* or a complex hybrid between *C.calisaya, C.succirubra and C.lancifolia.*

d. *C.robusta*

The origin of this species is uncertain, but it is presumed to be a hybrid between *C.succirubra* and *C.officinalis*. In India, it is grown in the Darjeeling Hills, West Bengal, and can be grown in places with an elevation of up to 1510 m (5000 ft). The average quinine content of the bark is about 2%.

e. *C. hybrida*

This vigorous growing hybrid is a cross between *C. succirubra* and *C. ledgeriana*. The yield of bark is high and the quinine content varies from 2 to 2.5%.

Varieties

- Cinchona 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.

Cultivation

Soil

Cinchona 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

C. ledgeriana grows best in tropical climates at altitudes of 1800 m (6000 ft). However, the other species grow well in areas with an average minimum temperature of 13.50C and a maximum of 210C with a mean relative humidity of 83%. The growth is very poor at temperatures below 70C or above 260C. 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

Cinchona 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 it is comparatively less expensive.

Seeds propagation

Cinchona 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. Even the budding on coppices has given a better growth of budded plants. The cuttings are made to root by cincturing and etiolating. During May-June, the shoots are treated, from which cuttings are taken after 50-65 days and planted in the nursery.

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.

Manures and fertilizers

Application of a fertilizer mixture containing N, P and K gives marked results. Liming (dolomite or limestone) is done for the soil if the pH is 5 or lower. Nutrients are supplied @ 115 kg N, 105 kg P2O5 and 115 kg K2O/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.

Cover cropping

Besides the native cover, *Crotalaria usaramoenis* or *Leucaena glauca* are grown as cover crops in cinchona plantations. When the plantation becomes older, the ground is shaded more heavily, hence the original cover crop must be replaced with shade-tolerant species. The plants should be staked properly in the first three years to prevent their swaying or leaning.

Pests and diseases

Pests

- The grubs of cockchafer beetles (*Holotrichia repetita, Rhizotrogus refus, Serica nilgiriensis, Popilla chlorion, etc.*) cause serious damage to the seedlings in South Indian plantations. The adults of these beetles come to the surface during summer and should be flushed by irrigating the seed-beds with water mixed with crude oil emulsion. The beetles must be then hand-picked and killed.
- Crickets also cut the young seedlings and drag them to their haunts in the seed-beds. The haunts must be searched and the insect killed. The application of tobacco decoction with kerosene or phenyl wards off these insects.
- The tea-fly *(Helopeltis antonii and H.cinchoniii)* infest the leaves in nurseries and also in the main field. These insects cause leaf-curl by sucking the juice form the tender leaves. If heavy damage is noticed, sodium arsenate mixed @ 28 g with 113 g of molasses in 9 litres of water may be sprayed on the plants for controlling these insects. The leaf bug, (*Disphinctus humeralis*), is occasionally found on tender foliage.

Diseases

- **Stem blight** caused by Sporotrichium and Verticillium spp., seedling blight due to *Phytophthora parasitica,* root-rot due to P*hytophthora cinnamomi,* and *Sclerotium rolfsii* and **damping-off** due to *Pythium dexans* and *Rhizoctonia solani* are some transplant bed-diseases affecting cinchona seedlings.
- The spread of these diseases can be checked by scooping out the soil in the diseased patches all around, to a depth of 10 cm and throwing it away.
- The cavity, so formed, may be filled with sterilized, dry soil.
- The nursery-beds should also be drenched with mercurial fungicide to check the spread of the diseases.
- Die-back or pink disease is caused by *Pellicularia salmnicolor*.
- This organism attacks the tender tips of the stems and branches and gradually spreads. The branches should be pruned to prevent the spread of the disease.

- Besides, the fungus *Armillaria mellea* causes root rot and *Rosellinia spp.* causes leaf spot diseases.

Harvesting and yield

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 leftover 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.

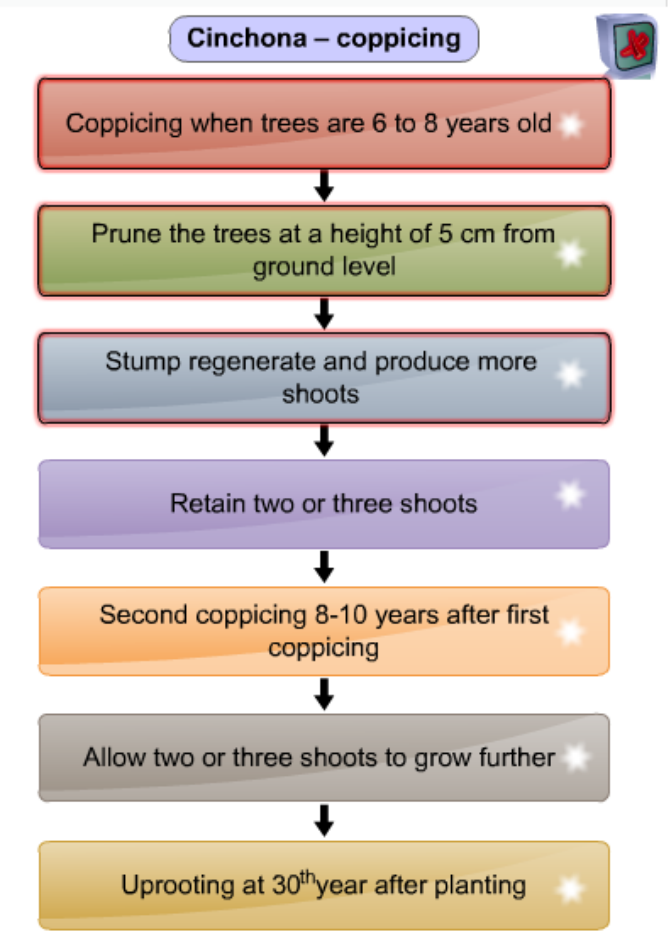
The plants are uprooted in the 30th year when their vigor declines.

The major harvest are 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 700C, 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.
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.

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 recrystallizaiton to constant specific rotation.
The crystalline, efflorescent trihydrate is a white, odourless, intenselybitter, micro-crystalline powder.



*****☺*****

Lesson - 8

Rauvolfia and Belladona -Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, intercropping, nutritional requirements, plant protection, harvesting and processing

RAUVOLFIA

Importance and chemical composition

- Importance and chemical composition
- Sarpagandha (Rauvolfia serpentina) commonly referred to as serpent wood, belongs to the family Apocynaceae
- It is also known as Candrabhaga, Chota chand, Serpentina root & Chandrika and is one of the most important native medicinal plants of India.
- The roots of sarpagandha have a 400 years history of use in treatment of snake bite, insect stings, nervous disorders and psoriasis.
- About 30 alkaloids are known to exist in this plant.
- The most important are rescinamine, deserpidine, reserpine, serpentine, ajmaline, ajmalicine and rauvolfinine.
- 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.

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.
- **Area & production:** There is no commercial cultivation of Rauvolfia in India, and the entire demand is met by import.

Description of the plant

- 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 40 to 60 cm deep into soil.
- The root bark constitutes 40-60% of the whole root, is rich in alkaloid.

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.

Cultivation

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 10-30oC seems to be well suited for this plant. It grows well in frost-free tropical to sub-tropical situations under irrigation.

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. 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 sq m 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. Keep the beds just 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 30 cm 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 wooded 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.

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 of 10kg/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.

Pests and diseases

Pests

Nematode: Root knot appears as galls of various sizes, covering the root system. Application of 25 kg of 3G carbofuran or 20kg of 10G phorate granules per hectare will control the nematode.

Pyralid caterpillar: It feeds on tender leaves, causing defoliation of the plant. It can be controlled by spraying 0.2% Rogar.

Grub: Attacks the seedlings about 2cm below the hypocotyl resulting in their drying up. To control the attack of grubs, mix phorate granules with the soil at the time of nursery preparation.

Diseases

Leaf spot: Dark brown coloured spots on the upper surface of the leaves and yellowish brown on the lower surface. Spray Mancozb @ 0.2%.

The other diseases are mosaic and die back.

Harvesting , processing and yield

The roots are harvested at 2-3 years after planting i.e., from 18 months onwards. The roots are dug out 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.
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 and 3300kg per hectare from 3 year old plantation, under irrigated conditions on sandy, clay loam soil.

BELLADONNA

Importance and chemical composition

- Belladonna (*Atropa belladonna* Linn.) belongs to the family **Solanaceae**.
- It comprises of four species, the commercial drug is obtained from the leaves, flowering tops and roots of A. belladonna Linn., commonly called as **'Deadly Night Shade'** and *A. acuminata* Royle, often referred as' Indian Belladonna'.
- The commercial drug is obtained from the leaves, flowering tops and roots of *A. belladonna.*
- Leaves and roots of belladonna contain tropane alkaloids whose concentration varies from 0.13 to 0.70 per cent (average 0.45%).
- 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.

Origin and distribution

- *A. belladona* is indigenous to southern and central Europe and naturalized in south England.
- It is cultivated for its drug in Central Europe, England, USSR, United States and North India.
- A. accuminata is found in a natural state in the western Himalayas extending from Kashmir to Shimla.

Description of plant and varieties

A. belladonna is an erect, herbaceous plant. The plant is shrub like with spreading slender often purplish branches. The flowers borne singly in the leaf axils, are large bell shaped, the upper part is brownish violet or purple or golden brown with violet brown veins. The fruit is a berry. ***A. acuminata*** is a tall, perennial herb, 70-150cm in height with a dichotomously branched stem. It closely resembles A. belladonna.

Varieties

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

Cultivation

Soil

Belladonna 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.

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.

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 1m surrounded by drainage and irrigation channels to be made and apply well decomposed FYM to the soil. Seeds pretreated with fungicides like Mancozeb (10 g per kg of seeds) may be mixed with fine

soil (1:4 ratio) and broadcasting in the nursery beds. Cover the seed beds with a layer of FYM and then with straw. Watering of beds should be done immediately after sowing with a rose can. The seeds germinate in 3 weeks 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 like Agallol. 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.

Manures and fertilizers

Belladonna is an exhausting crop, hence a basal dose of 25-40kg N, 40-60 kg P205 and 30-50kg K2O per hectare. 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.

Interculture and weeding

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

Pests and diseases

Pest

Cut worms cause considerable damage to young plants. The other insects noticed in this crop are potato beetle and flea beetle. They can be controlled by treating the seed bed with aldrin just before planting and treating the soil with the solution of chlordane two weeks after germination of seed.

Diseases

Root rot: Plants at every stage of growth are affected. This can be controlled by fumigation of soil with Methyl bromide and treating the seeds with agallol or captan.
Leaf spot: The disease can be controlled by spraying blitox @ 3g/l of water.

Harvesting, processing and yield

- The first harvest of the leaves is available three month 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.

- 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.

*****  *****

Lesson 9

Dioscorea -Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, species and varieties, propagation techniques, planting and after care, provision of support, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Diosgenin, a steroidal sapogenin obtained from the rhizomes of various species of Dioscorea (Family: Diascoreaceae), is the major base chemical for several steroid hormones including sex hormones, cortisones, 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 and of other precursors is 1200 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.

Description of the plant

- Plants of the genus Dioscorea, commonly called medicinal yams, 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.

Species and varieties

D. deltoidea Wall (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 Mart. And Gal. (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 leaves are petiolate and spirally disposed on the stem. The male flowers are solitary or in groups of 2-3, dark-brown or green and sessile with 6 stamens. The male spike is short and solitary, with 6 staminodes and a hypogymous stigma with a bifid apex (divided into two). 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.

Three varieties of *D. floribunda* have been released for cultivation. The varieties **FBC-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 (ICAR), 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 20 000-25 000 kg/yr (1 kg/plant) or 60 000 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 6000 kg (in a 2-year-old crop) and the diosegenin content ranges from 3.5 to 4.0%.

Pusa-1

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

D composita Hemsl.

This species is also a native of Mexico and has been domesticated in several tropical countries. It is a robust climber, twining to the left, which produce large, thick leaves. The underground portion comprises of thick, fleshy, branching tubers which are long, white in colour and grows deep. This species is mostly propagated from seeds rather than from tubers, as the rotting of tubers is pronounced.

Other important sapogenin-bearing species are *D.friedrichshali* R.Kunth, *D.spiculiflora* Hemsl, and *D.prazeri*. Prain and Burk.

Cultivation

Soil

Dioscorea 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 water-logging. The bet 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, a recommended 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 and 30 x 70 cm, respectively.

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) and (3) Tips (distal ends). Crowns produce new shoots within 30 days of planting, while the others take nearly 100 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.

Seed production

Since dioscorea is a dioecious plant, female and male plants should be grown close to obtain the seeds. Under South Indian conditions. Excellent seed set is noticed. Flowering starts from August and the seeds mature from December to February. The pods turn brown and dehisce along with the upper margin. The harvested seeds should be stored in airtight plastic bags where they will remain viable for 3-5 years.

c)Propagation by stem-cuttings

D. floribunda can be propagated by stem cuttings with 80% success. The vines should be raised from 50-100 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 4 hours. 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 100 ppm 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

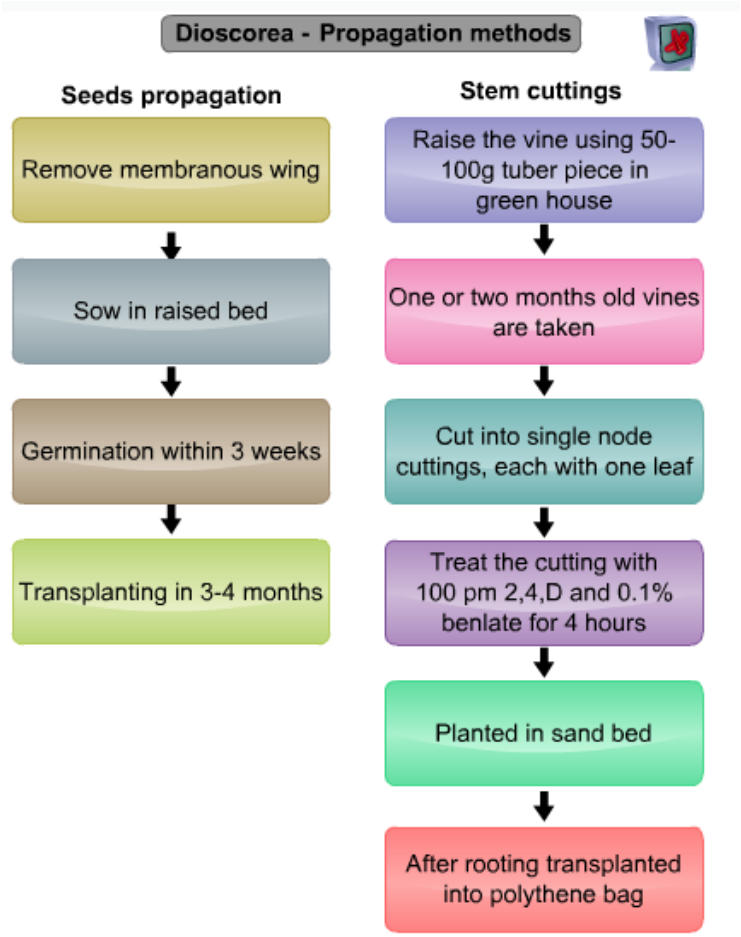
A well decomposed FYM of 20-25t/ha is applied while preparing the land. Yams respond very well to fertilizer application. A fertilizer dose of 300 kg N, 150 kg P2O5 and 150 kg K2O/ha, has been found to be optimum for a one-year-old crop of *D. floribunda.* The entire quantity of P should be applied as 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.



Pests and diseases

Pests

The two important pests affecting this crop are aphids and red spider mites which can easily be controlled by spraying 0.5-1.0% of Kelthane (1 ml/1). Cut-worms are also reported to damage this crop.

Diseases

No major disease has been reported to affect this crop. The only disease which affects the crop is the rotting of *D.floribunda* tuber pieces during storage in sand-beds. This can be controlled by treating the tubers with 0.3% benlate solution. Leaf spot disease, caused by Drechelera sorokiniana, is also reported to occur in *D. composita,* resulting in defoliation and death of the seedlings. The disease can be effectively controlled by spraying Benlate (0.1%). Besides, Cercospora, Remularia and late blight caused by Phytophthora infestans are reported from Tamil Nadu and can be controlled by Dithane Z-78 (0.3%) or any other copper fungicide. Collar rot of seedlings, which is a nursery disease, can be effectively controlled by spraying Brassicol (0.5%).

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, from 2.5-3.0% 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.

Lesson 10

Isabgol Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Isabgol or Blonde psyllium *(Plantago ovata)* belonging to the family Plantaginaceae, is important for its seeds and husks which 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.

Origin and distribution

- It is indigenous to the Persia and West Asia, extending upto the Sutlej, Sind and West Pakistan.
- The plant is also acclimatized well in Mexico and in the Mediterranean regions.
- It has been introduced in India and cultivated specially in Gujarat and some parts of Rajasthan.
- At present Isbgol has acquired the place of 'dollar earner' crop of North Gujarat.

Area and production

- Isabgol 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.

Description of the plant

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

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.

Cultivation

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 300C.

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 of 1015tonnes /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.

Weeding and interculture

Periodical weeding and hoeing is required. The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, farm yard manure (FYM), vermi compost, green manure, etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds & leaves), Chitrakmool, Dhatura, Cow urine, etc.

Pests and diseases

Pests

White grubs and termites damage the crop by cutting off the root which can be controlled by broad casting phorate 10G @10kg/ha. Aphids also attack the crop and can be controlled by spraying 0.2% Dimethoate.

Disease

Downy mildew is the major disease caused by *Peronospora plantaginis*. The disease appears at the time of spike initiation. The first symptom is small patches on the leaves, completely destroying it and thus affecting the yield. To control it, Bordeaux mixture or Dithane M-45 or any copper fungicide at the rate of 2-2.5g/l can be sprayed.

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 turn yellowish and the spikes turn brownish. The seeds are shed when the spikes are pressed even slightly. At the time of harvest, the atmosphere must be dry and there should be no moisture on the plant, harvesting will lead to considerable seed shattering. Hence, the crop should be harvested after 10 am only.

After two days, they are threshed with the help of tractor during early morning. Water is sprinkled over the heap for easy thrashing 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.

*****☺*****

Lesson 11

Aloe - Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting, grading and processing

Importance and chemical composition

- Aloe species, perennial succulent belonging to the family Liliaceae and has long been employed in medicinal preparation and for flavouring liquors and a source of the drug 'aloe'.
- Out of 275 species, three are commercially important species.
- They are: *A. barbadensis, A. ferox* and other species (*A. Africana* and *A. spicata*).
- Two of the major products derived from the leaves are the yellow bitter juice consisting of aloin and the gel consisting of polysaccharides.
- Apart from these products, several other products like dehydrated aloe powder, concentrates are also prepared.
- The Aloe contains cathartic anthrax-glycosides as its active principle ranging from 4.5 to 25 per cent of aloin.
- These are extensively used as active ingredients in laxative and anti-obesity preparation, as moisturizer, emollient or wound healer in various cosmetic and pharmaceutical formulations.

Origin and distribution

- Plants of the genus Aloe belong to the old world and are indigenous to Eastern and Southern Africa, the Canary Islands and Spain.
- The species spread to the Mediterranean basin and reached the West Indies, India, china and other countries in the 16th century and certain species are now cultivated for commercial purpose, especially in some of the West Indian Islands of the North Coast of South America .
- It is also cultivated in India.

Description of the plant

- Aloe is a coarse looking, perennial, shallow rooted plant with a short stem, 30-60 cm high.
- The plants have multiple tuberous roots and many supporting roots penetrating into the soil.
- Aloe does not have a true stem but produces bloom stalks.
- The plants generally grow slow close to the ground in a typical rosette shape.
- The fleshly leaves are densely crowded, strongly, cuticularized and have a spiny margin with thin walled tubular cells.
- The flowers vary from yellow to rich orange in colour and are arranged in axillary spikes.
- The ovary is superior, triocular with axile placentation. The plant does not produce many viable seeds.

Species and varieties

- In India, 2 or 3 easily recognizable varieties are found, but their exact delimitations are not clear.

- In *A.vera var.chinensis* Baker, common all over the Deccan, the leaves have a distinct purple colour towards the base and the spies are not sharp.

- The leaves of *A.vera var.littoralis* Koenig ex Baker, found on the beach shingles in Madras right up to Rameswaram are smaller in size and have a dentate margin.

- Another variety which thrives on the Kathiawar coast, also called *A.abyssinica*, is the source of the Jaffarabad aloes.

- *A. variegata* called *A.varigata* Linn. A near kin of *A.vera* is found in parts of Maharastra.
- It has large, fleshy, green leaves with sharp spines and white specks at the base of the leaves.

Cultivation

Soil

Because of its hardy nature, the plant can be grown on a variety of soils. It can be seen growing successfully from sandy coastal soils to loamy soils of plains with a pH of up to 8.5. However, water logged conditions and problematic soils do not suit its cultivation.

Climate

It has wide adaptability and can grow in various climatic conditions. It can be seen growing equally good in warm humid or dry climate with even 150-200 cm to about 35-40 cm of rainfall per annum. It is usually cultivated between March and June. However, in dry regions, the crop should be provided with protective irrigation.

Propagation

It is generally propagated by root suckers or rhizome cuttings, for this purpose, medium sized root suckers are chosen and carefully dug out without damaging the parent plant at the base and directly planted in the main field. It can also be propagated through rhizome cuttings. In this case, after the harvest of the crop, the underground rhizome is also dug out and made in to 5-6 cm length cuttings which should have minimum 2-3 nodes on them. It is rooted in specially prepared sand beds or containers and after it has started sprouting, it is ready for transplanting.

Planting

The field should be prepared well before the onset of monsoon and small furrows opened. About 15-18 cm long root suckers or rhizome cuttings are planted at a spacing of 60x45 cm in such a way that two third portion of the planting material should be under the ground.

Manuring

It is a newly domesticated crop and its full production technology including manurial requirement is yet to be worked out. Application of a mixture of 150kg/ha of nitrogen, potassium and phosphorus is recommended. The fertilizers are applied in the soil near the root system, after the plants are established.

Irrigation and weeding

Soon after planting, the land is irrigated. During the crop period, irrigation must be given according to the moisture status of the soil. Generally, 4 to 5 irrigations per year are sufficient. However, water should not be allowed to stagnate near plant. The land is kept weed free by weeding the plot as and when necessary.

Pests and diseases

Major insect **:** Mealy bug
Major diseases **:** Leaf spot, Leaf rot and Anthracnose

Control measures

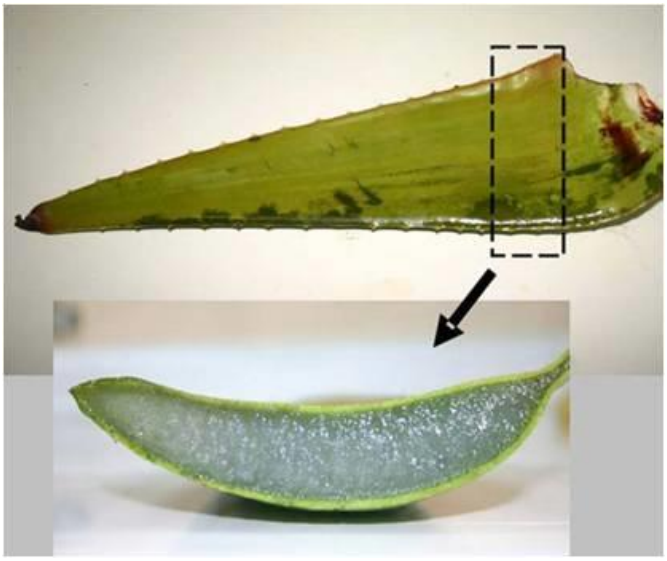
1. For controlling mealy bugs spray Chlorpyriphos 2 ml in 1 litre of water.

2. Spray the crop with Bavistin 10 g with Carbendazim 2g per litre and repeat at 10 days interval for controlling leaf rot and anthracnose.
3. Leaf spot can be controlled by spraying the crop with 0.2% Mancozeb at weekly intervals

Harvesting, yield and processing

After about 8 months, the leaves are ready for harvest. While harvesting, the plants can be removed manually. The broken rhizome parts left in this soil throws new sprouts to raise the succeeding crop. Aloe plantation gives commercial yield from second year and upto 5 years. Thereafter, it needs replantation for economic yields. An average crop yield of about 10,000 to 12,000 kg on fresh weight basis may be obtained from on hectare.

Processing

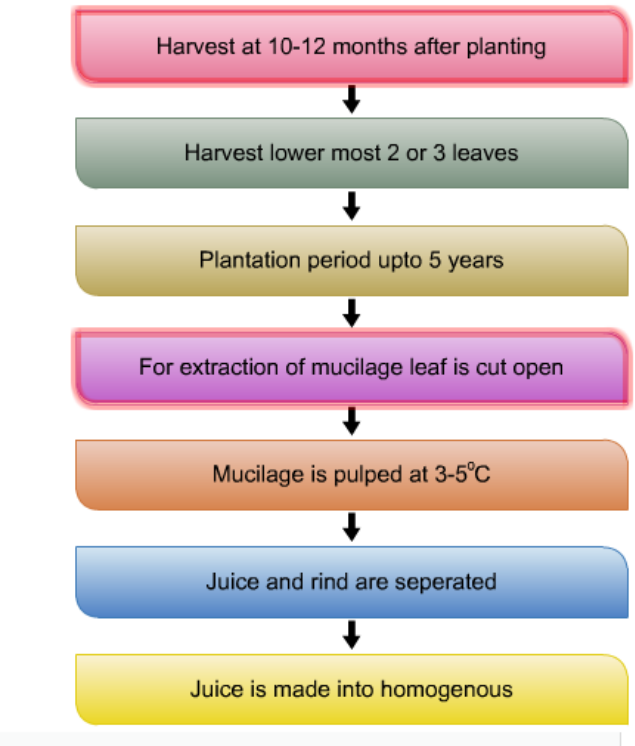


The mucilaginous pulp from the leaf parenchyma, which is mainly carbohydrate in nature, is used in skin disorders. For the purpose of isolation of aloe gel, the portion of leaves remaining after the removal of their exudates is cut open and their mucilage is scraped out with a blunt edged knife. This mucilage is stirred vigorously in a blender to make it into a uniform solution and is strained through a muslin cloth and filtered. The gel is precipitated from the extract by slowly adding acetone. The gel is obtained by centrifuging and re-dissolved in slightly warm water. It is dried at high temperature and weighed.

RollOver to see the images

Aloe vera

Harvest and processing



*****☺*****

Lesson 12

Solanum viarum -Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Among the various plants which are being used as raw materials for the production of steroidal drugs, steroid-bearing solanum (S*olanum viarum* Dunal.) belonging to the family Solanaceae, holds an important place due to its shorter crop duration and low initial investment in its commercial cultivation.
- It is also known as 'Tropical soda applae'.It yields a glyco-alkaloid, solasodine, a nitrogen analogue of diosgenine. Solasodine through 16-dehydro-pregnenolone (16 DPA) is converted to a group of compounds like testosterone and methyl¬testosterone and corticosteroids like predinisolone and hydrocortisone.
- These steroidal compounds have anti-inflammatory, anabolic and antifertility properties, due to which they find large-scale use in health and family planning programmes all over the world.

Origin and Distribution

- It is widely distributed in the subcontinent, extending from sea-level up to 2 000 m and is reported from Khasi, Jaintia and the Naga Hills of Assam and Manipur.
- It occurs in Sikkim, West Bengal, Orissa, the Upper Gangetic Plains and in the Nilgiris, ascending to an altitude of 1 600 m.
- It is reported from North-east, North-west, southern as well as Central India, and extends into Burma and China.
- Its com¬mercial cultivation is mainly confined to the Akola-Jalgoan tract of Maharashtra in an area of about 3 000 ha.

Description of the plant



S. viarum, is a stout, branched, woody shrub attaining a height of 0.75 to 1.5 m. The stem has spines, the leaves are ovate to lobed with spines on both the' surfaces, the flowers are hermophrodite, borne on axillary clusters, white; the berries are yellowish when ripe or greenish; the seeds are small, brown in colour and abundant, embedded in a sticky mucilage.

Varieties

Some of the promising, less spiny strains developed in this crop are the Glaxo strain, BARC Strain, Pusa-1, RRL 20-2 RRL-G and L-6 which is said to be less-spiny. 'Arka Sanjeevini' and 'Arka Mahima' are the two varieties developed at the Indian Institute of Horticultural Research, Bangalore and released for cultivation as high yielding types. ‘Arka Mahima’ is tetraploid variety with solasodine content of 2.5%.

Cultivation

Soil

Solanum is a hardy plant and can be cultivated on a wide range of soils under various agroclimatic conditions, but it cannot withstand water-logging. Though it can be grown in all types of soils, the best soil for its successful cultivation is red lateritic soil with a moderate quantity of organic matter. The plant does not perform well in very clayey soils.

Climate

It is found growing under different kinds of climates throughout the length and breadth of the country, but prefers a moderate climate for its successful growth. The growth as well as development of the plants and, finally, the yield of fruits depends significantly on the climatic conditions. Depending upon the temperature, dry period length, rainfall and irrigation facilities, the sowing time

may vary from June to September or October. The plants sown in late October to February are more susceptible to virus diseases, and sowing in March is not practicable as harvesting and drying will be hindered by the rainy season. Under rain fed conditions, the crop should be sown from mid-June to the first week of July. Under irrigated conditions, the sowing in September results in profuse flowering and berry formation during the winter months.

Propagation

Nursery raising and transplanting

The seeds are raised in nursery beds of 10m X 1m size. To each strip 10kg of FYM, 1kg of Calcium ammonium nitrate are applied. Seeds are presoaked in water for 24 hours and sown in lines of 1 to 1.5 cm-deep furrows, 10 cm apart and covered with a thin layer of soil. About 1.25 kg seeds sown in 5 nursery beds of the above size will provide enough seedlings for planting 1 ha of land. Their germination is completed in 7-10 days. Within 4-5 weeks, when the seedlings are 10-12 cm high and develop 6 leaves, they are ready for transplanting into the main field at a spacing of 90cm x 90 cm. A closer spacing of 45 x 30 cm is also recommended for tetraploid variety.

Manures and fertilizers

S. viarum responds well to the application of manures and fertilizers. Green manuring before planting has been found to increase the yield by 20%. For better yields, an application of 100:60:40 kg of N, P2O5 and K2O/ha, depending upon the soil condition, is recom¬mended. The entire quantity of phosphorus, potassium and half of the nitrogen are applied at the time of land preparation. While the remaining half of the nitrogen is applied when the plants start flowering.

Irrigation

In the absence of sufficient moisture in the soil, the field should be immediately irrigated after transplanting. The crop is further irri¬gated at weekly intervals during the first month and then the interval is increased to once in fortnight, and later as and when required.

Weeding

After 2-3 weeks of transplanting the first weeding is done, and later when the crop is 2-3 months old. Afterwards, the crop puts on enough canopies to smother the surface and, hence, no growth of weeds takes place.

Pests and diseases

Pests

The plant is hardy and, therefore, free from any of the serious pests. However, it is sometimes attacked by leaf-eating cater¬pillars and wingless hoppers. In case of severe attack, the crop may be sprayed with Endosulphan (3 ml/l) to control them. The fruit borer (Leucinodes orbonalis) and root-grubs are the other pests reported. Ekalux (2 ml/l) can be sprayed to control the fruit borer. Chloropyriphos may used to control grubs.

Diseases

Powdery mildew is noticed during prolonged dry and warm period, Bavistin (1 g/l) may be sprayed to control this disease.

Collar rot or Fusarium wilt can be overcome by keeping the field clean and planting the crop in a well drained soil. Dipping the roots of the seedlings in a 0.1 % solution of Bavistin for 1 hour and drenching the seed-beds with 0.25% of copper oxychloride or 0.1 % of Bavistin solution can control the disease.

Sometimes the plants are attacked by mosaic, caused by three different viruses, which leads to stunted growth and chloratic leave Such plants are better removed and destroyed.

Nematodes

The occurrence of the chlorotic stunt disease and its association with the root-knot nematode (Meloidogyne javanica), and the wilting of plants due to *M. incognita* have also been reported.

Harvesting, processing and yield

- Generally, the accumulation of glyco-alkaloid increases with the physiological age of the fruit and attains its peak value in the fruits of 50-60 days.
- This state of fruit growth coincides with the change in fruit colour from green to just yellow with streaks of green still present, after which the glyco-alkaloid content falls gradually with the maturity of fruits.
- The alkaloid is distributed throughout the fruit.
- It is, however, established that about 60% of this is present in the seeds and the remaining 40% in the pericarp.

- The crop takes about 6 months to be ready for harvesting.
- Harvest¬ing is one of the labour-intensive operations.
- The spiny nature of the plant hampers plucking the berries at the right stage of maturity, which is very important. During the first part of the harvesting season, when the fruit is big, on an average, one person with gloves can pluck about 50 kg of berries, while working 8 hours a day. However, some good workers in the peak season when most of the berries are ready for harvest can pick even 80 kg of berries per day.
- The figure is reduced to 40 kg towards the closing season when the fruits become smaller in size. The picking operation spreads over 3 months, because the fruits mature at different times. The processing of berries for marketing requires a lot of care. Fresh fruits contain about 80% moisture.

- The pharmaceutical firms need berries containing about 10% moisture. Hence, the berries must be dried in the sun.

Yield

- When the crop is grown by adopting proper cultivation practices, it may yield nearly 10,000 kg/ha of fresh berries which, in turn, will give about 2,500 kg/ha of dried berries.

*****  *****

Lesson 13

Mints (Mentha sp.) -Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and processing

Importance

Mints are a group of perennial herbaceous plants, belonging to the family Lamiaceae; which yield essential oil on distillation. The various species of mints which are commer¬cially cultivated in different parts of the world are: Japanese mint or corn mint or field mint (*Mentha arvensis)* peppermint (*M. piperita* L.), spearmint or lamb mint (*M. spicata* L.) and bergamot mint or orange mint (*M. citrata* Ehrh.).

Origin and distribution

- Mint is believed to have originated in the Mediterranean basin and, from there, spread to the rest of the world by both natural and artifi¬cial means.
- USA is the major producer of peppermint and spearmint.
- Bergamot mint is a native of Europe and has been naturalized in eastern USA.
- It grows successfully in the temperate and subtropical region of India.
- In India, Japanese mint is grown mainly in the Terai region, extending to parts of the Indo-Gangetic Plains and parts of Punjab in North-western India.
- The total area under mint cultivation, which is mostly confined to Uttar Pradesh and the Punjab, is around 10 000 ha.

Area and production

- M. arvensis is cultivated in about one lakh hectares in India predominantly in UP, Terai region and the annual production of menthol from India is 8000 ton.

Description of the Species of Mint

M. arvensis (Japanese mint) is a downy, perennial herb, spreading by root-stocks which creep along the ground or just under the surface and root at the nodes. There are three horticultural varieties in this species.

M. piperita spreads by a system of branching, underground rootstocks and grows to a height of 45 to 90 cm (l.5 to 3 ft).

M. citrata grows up to 30-60 cm height, with decumbent branches and erect ends. The leaves are 1.25-5.0 cm long, thin, bronzy-green, petiolate; smooth. ***M. citrata*** is a hybrid between ***M .aquatica*** and ***M.viridis***.

M. spicata propagates by stolons, from which 30-60 cm erect, ascending branches arise. The leaves are sessile, smooth above and glandular below, the apex is acute and up to 6.5 cm long.

Another variety of spearmint known as scotch spearmint (M. cardiaca . (S.F. Gray Baker)) is cultivated in the USA to a limited extent.

Varieties

A) Japanese Mint

Himalaya (MAS-I): It is a selection released by the CIMAP Lucknow. The yield of oil is around 290-293 kg/ha. This variety is highly resistant to rust, leaf-spot and powdery mildew diseases.
Kalka (Hyb-77): It is a tall, vigorous variety evolved by the ClMAP Lucknow, It is highly resistant to leaf-spot, powdery mildew and rust diseases.
Shivalik: It was introduced from China and released by the CIMAP, Lucknow. The plant has a compact, bushy growth with thick, leathery leaves.
EC-41911: It is less affected by rain, root ¬rot and aphids and is reported to yield 236.5 g/ha of herbage and 12.2 kg/ha of oil, with a menthol contented 70%.
Kosi: A leading high yielding variety and cultivated in maximum acarage.

B) Peppermint

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

C) Bergamot Mint

Kiran: This is a mutant selection developed by the CIMAP, Lucknow. It has a high oil content and quality. Yield 239 kg/ha of oil with 48% linalool.

D) Spearmint

MSS-l: This is a selection from the spearmint cultivars introduced from USA. This variety was released by the CIMAP, Lucknow.
MSS-5: It is a selection from MSS-1 made at the CIMAP, Lucknow.
Punjab spearmint-l: This variety is a clonal selection made at the CIMAP, Lucknow.

Chemical composition and uses

Japanese mint *(M. arvensis)*

Japanese mint is a primary source of menthol. The fresh leaves con¬tain 0.4-6.0% oil. The main constituents of the oil are menthol (65-75%), menthane (7-10%) and menthyl acetate (12-15%) and terpenes (pipene, limonene and camphene). The menthol content of the oil varies, depending on the climatic conditions. Generally, it is higher in tropical regions.

Menthol is used in the flavouring of a large number of pharma¬ceutical and oral preparations like toothpastes, dental creams, confectionery, beverages and other items like tobacco, cigarettes and paan masala. Medicinally, it is an' excellent carminative and gastric stimulant. When applied externally, it acts as a mild analgesic.

Peppermint *(M. piperita)*

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%. The other constituents are menthyl acetate (14-15%), menthone (9-25%) menthofuran and terpenes like pinene and limonene.

Bergamot mint *(M. citrata)*

Linalool and linalyl acetate are the main constituents of Bergamot mint oil. The oil is used directly in perfumes. Cosmetic preparations like scents, soaps, after-shave lotions and colognes also contain this oil.

Spearmint *(M. spicata)*

The principal constituent of spearmint oil is carvone (57.71%) and the other minor constituents are phellandrene, limonene, L-pinene and cineole. The oil is used mostly as a flavouring in toothpastes and as a food flavouring in pickles and spices, chewing gum and confec¬tionery, soaps and sauces.

Cultivation

Seasons

In the plains, planting is done during the winter months, whereas in temperate climates, 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.

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.

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 subtropical 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 sub¬tropical areas. However, the yield is higher in temperate climates.

Land preparation

Mints require thoroughly ploughed, harrowed, fine soil. All the stubble of weeds should be removed before the crop is planted. Manuring may be done at the time of land preparation by adding FYM @ 25 to 30 t/ha. Green manuring may also be done before the mint is planted. Sun-hemp (Crotalaria juncea L.) is an ideal green manure crop. Mints are planted on flat land or ridges. Hence, flat beds of convenient sizes or ridges are made according to the spacing recommended.

Propagation

Mints are propagated through the creeping stolons or suckers. In the case of peppermint and bergamot mint, even runners are planted. Stolons are obtained from the previous years planting. A hectare of well-established mint, on an average, provides enough planting material for ten hectares. About 400 kg stolons are required for plant¬ing one hectare of land. The best time for obtaining stolons is during the months of December and January.

Planting

The stolons are cut into small pieces (7-10 cm) and planted in shallow furrows about 7-10 cm deep with a row-to-row distance of 45-60 cm, manually or mechanically. 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.

Fertilizer application

Mint responds very well to a heavy application of nitrogenous fertiliz¬ers. The increase in herbage by the application of phosphorus is not as remarkable as in case of nitrogen. Generally, nitrogenous fertilizers @ 80-120 kg; P and K at 50 kg are required for a good crop of mint. However, in M. arvensis an increase of up to 160 kg N/ha and, in M. piperita, 125 kg N/ha has given increased fresh herbage and essential oil-yield. Potassium application has no significant effect on herb and oil-yield. In M. spicata, the maximum herb-yield is obtained with the application of 100-120 kg N/ha. Nitrogen may be applied in three split doses at 1 and 3 months after planting and the third dose after the first harvest of the crop. Boron deficiency reduces both the yield of green herb and the essential oil in peppermint. Increased yields of herb, menthol content and essential oil content in peppermint have been obtained by using a combination of boron and zinc fertilizers.

Irrigation

The water requirement of mint is very high. Depending upon the soil and climatic conditions, the crop is irrigated 6-9 times before the first monsoon. The crop requires three irrigations after the monsoons during September, October and November. Sometimes irrigation is required during winter, if the plant is dormant and there are no winter rains to encourage proper growth of the under¬ground stems.

Intercultural and weed control

Uninterrupted weed growth causes about 60% reduction in herb and oil-yields. Hence, mints require weeding and hoeing at regular inter¬vals in the early stages of crop growth. One hand-weeding is required after the first harvest. Combining organic mulch with a combi¬nation of 0.5 kg/ha of Oxyfluorfen herbicide and weeding give excellent weed control throughout the crop growth.
In low temperature areas, the plant becomes dormant in Novem¬ber. In order to give a perennial crop (of 3 years only) in peppermint, replanting is done either in autumn (November-December) or in spring (March-April).

Crop rotation

The following crop rotations are in practice in Uttar Pradesh (a) Mint-maize-potato (b) Mint early paddy and potato and (c) Mint-late paddy and sweet pea. Whereas, in Punjab, the farmers practice mint-maize and rape seed/mustard and mint-maize and 'potato or mint and paddy rotation. The recommendation for the Terai region of Uttar Pradesh is a 2-year rotation of mint-summer fallowing or millet (fodder) followed by mint on poor fertility lands and mint-wheat-paddy and mint on medium-fertile lands.

Pests and diseases

Pests

A large number of insect pests attack mints. Among them, the impor¬tant ones are the leaf-roller, pyralid, the hairy caterpillar and termites.
The attack of the hairy caterpillar (*Diacrisia obliqua* Walk) during the months of April-May causes rapid defoliation. This can be controlled by spraying 5% Dipterex. During the dry months, termite

attacks are often observed. These can be effectively con-trolled by the application of 3% Heptafan @ 50 kg/ha to the soil before planting. Other pests like cut-worm (*Aulucophora favicollis*) also cause damage to the crop. They can be controlled by spraying Thiodon.
Nematodes severely damage the foliage yield of mints. The nematodes can be effectively controlled by the application of neem cake @ 250 kg/ha to the soil.

Diseases

Rust, powdery mildew, wilt, leaf-blight and stolon-rot are the five fungal diseases which have been reported to affect mint to a signifi¬cant extent under Indian conditions.

Harvesting

- 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.
- A good crop of Japanese mint can give as high a yield as 48 t/ha of fresh herb. However, the average yield of mints from three cuttings is 20-25 t/ha. The fresh herb contains 0.4 % oil.

Distillation and storage of oil

Mint oil is obtained by distilling either the fresh or the dry 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 latter 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.

The average yield of oil is 50-70 kg/ha. Although bergamot mint as well as Japanese mint gives an average yield of 70-100 kg/ha, the yield of peppermint oil is lower with an average of 50 kg/ha.

Storage of oil

Mint oil is a light and golden-coloured, motile liquid and it should be completely free from moisture before storage. It is stored in large steel, galvanized steel or aluminum containers, filled up to the brim to protect against any air remaining inside and placed in a cool storage godown, away from light and humidity.

*****☺*****

Lesson 14

Piper longum -Importance, chemical composition-origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and processing

Importance and chemical composition

- Long pepper is a slender aromatic climber whose spike is widely used in ayurvedic and unani systems of medicine particularly for diseases of respiratory tract.
- Pipalarishta, Pippalyasava, Panchakola, Pippalayadilauha, and Lavana bhaskar churan are common ayurvedic preparations made out of the dry spikes of female types.
- Ittrifal fauladi, Angaruya-i-kabir and Majun Khadar are well known Unani preparations of long pepper. Its roots also have several medicinal uses.
- The root is useful in bronchitis, stomach ache, diseases of spleen and tumors.
- Fruit is useful in bronchitis, stomach ache, diseases of spleen and tumors.
- The spikes of this plant contain piperine and piplartine alkaloids.
- The roots and fruits are used in palsy, gout and lumbago. Long pepper acts as a general tonic and hematinic and widely used in Ayurveda as good rejuvenator (Rasayana).

Area and production

Piper longum is cultivated in a small extent in Kerala, Assam and Tamil Nadu (Nagercoil) however, no precise data is available on area and production. To meet the Indian requirement, about 70 ton of long pepper dry spikes are imported from Indonesia.

Cultivation

Soil and climate

It flourishes well in rich, well-drained loamy soil. Laterite soils rich inorganic matter content with good moisture holding capacities are also suitable.

The plant requires a hot moist climate and an elevation between 100 and 1000 m for its cultivation. It can be grown successfully even in areas which receive heavy rainfall with high relative humidity. In its natural habitat, the plant is found growing as an under shrub. Hence it is specially suited as a under crop in coconut and areca nut gardens with 20-25 per cent shade intensity.

Propagation

Long pepper can be propagated through seeds, suckers or cuttings or layering of mature branches at the beginning of rainy season. However, it can be easily propagated through the terminal stem cutting obtained from one year old growth and 3-5 internodes. To plant one hectare, about 25000 cuttings will be required. Vine cuttings can be rooted in polythene bags filled with the common pot mixture. The nursery can be raised during March and April. The cuttings planted in March-April will be ready for planting in the main field by the end of May.

Planting

Before planting, the land should be ploughed 2 to 3 times and leveled properly. Then the field is divided into plots of convenient in which the pits are dug at a spacing of 60 cm x 60 cm. These pits are filled with soil mixed with well decomposed FYM or compost. In heavy rainfall areas, channels are made to drain excess water. Afterwards, with the onset of monsoon the rooted cuttings are planted in the pits at the rate of 2 per pit. The pits are gap filled one month after planting. Long pepper is planted as an inter crop in Subabul, Eucalyptus and under coconut in different parts of the country.

Manures and fertilizers

The crop needs heavy manuring. About 20 tons FYM along with 50 kg N, 20 kg P205 and 70 kg K20 per ha/ year is required for optimum growth and yield. OF this 50% of N and entire dose of P205 and K20 is given as basal doses and the remaining N is given as top dressing. Since the crop will give economic yield for 3 years, the manuring has to be done each year. In the subsequent year's manures and fertilizer application is done by spreading it in beds and covering with soil.

Irrigation

The crop should be irrigated once in a week if it is grown as a pure crop. In case the crop is grown as an inter crop with other crops, the irrigation provided to the main crop is sufficient. Sprinkler system of irrigation may be adopted for economizing the irrigation water.

Interculture

During the first year of planting, weeding is done when weed growth is noticed in the beds. After application of FYM, earthing up is done. During summer, to prevent the moisture less or losses from the soil surface, the beds are mulched with dry leaves or straw.

Plant Protection

- Crop losses can be heavy due to pests and diseases.
- Mainly bugs and root grubs, attack the plant particularly during summer.
- Infested plants show yellowing and stunted growth.
- Application of systemic insecticides like nuvacron or dimecron will control the pests. Adults and nymphs of Helopeltis theivora severely feeds on the foliage which can be controlled by 0.25% neem kernel suspension.
- Rotting of leaves and vines during monsoon season is caused by Colletotrichum glorosporiodes and necrotic lesions and blights on the leaves during summer is caused by Colletotrichum and Cercospora spp.
- These diseases can be controlled by spraying of 1% Bordeaux mixture repeatedly.
- A virus like disease characterized by yellowing and crinkling of leaves, stunted growth and production of spikes of smaller size and inferior quality was also recently reported.

Harvesting and yield

The first harvest can be done after six months of planting. The spikes are ready for harvest 2 months after their formation on the plants. Spikes are picked when they are blackish green and most pungent. The harvested spikes are dried in the sun for 4 to 5 days until they are perfectly dry. The green/to dry spike ratio is around 10:1.5. The dried spikes are then stored in the moisture proof containers.

During the first year, the dry spike yield is around 200 kg per hectare. The yield increases thereafter up to 3 years and it will be about 500 kg per hectare during the third year. After three years, the productivity of the vines decreases and should be replanted. Besides the spike, the thick parts of stems and roots which have medicinal value may also be harvested from 18 months after planting. While harvesting the stems are cut close to ground, the roots are dug up, cleaned and heaped in shade for a day, after which they are cut close to ground, the roots are dug up, cleaned and heaped in shade for a day, after which they are cut into 2.5 to 5 cm long pieces. The average yield of dried roots is 500 kg per hectare.

*****☺*****

Lesson 15

Ashwgandha -Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting, grading and processing

Importance and chemical composition

- Aswagandha (Withania somnifera) is commonly known as 'winter cherry' and Indian Ginseng in English. Several types of alkaloids are found in this plant, out of which, withanine and somniferine are important. In addition the leaves are important to contain five unidentified alkaloids. The total alkaloid content in Ashwagandathe roots of Indian types has been reported to vary between 0.13 -0.31. The drug is mainly used in Ayurvedic and Unanic preparations.

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

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

Origin and distribution

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

Area and production

Aswagandha is cultivated in 5000 hectares in India predominantly in Madhya Pradesh. The estimated annual production is 2500 metric tones of dry roots.

Varieties

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

Cultivation

Soil and climate

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

Land preparation

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

Nursery raising and planting

The crop can be sown either by broad casting or in lines. Line to line method should be preferred increased root production and also helps in performing intercultural practices in required by farmers. The seeds are usually sown about 1-3 cm deep during June- July in nursery. A light shower after sowing ensures good germination. About 5-12 kg seeds are sufficient for one hectare field. The seedling of 25-35 days old can be transplanted in the fields marinating 30 x 30 cm. spacing between the plants & the rows. As Ashwagnadha is a rainy season Kharif crop, the time of its sowing should be decided by date of arrival of monsoon in area of cultivation.

Thinning and weeding

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

Manures and fertilizers

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

Irrigation

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

Pest and disease management

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

Harvesting, processing and grading

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

Processing

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

Grading

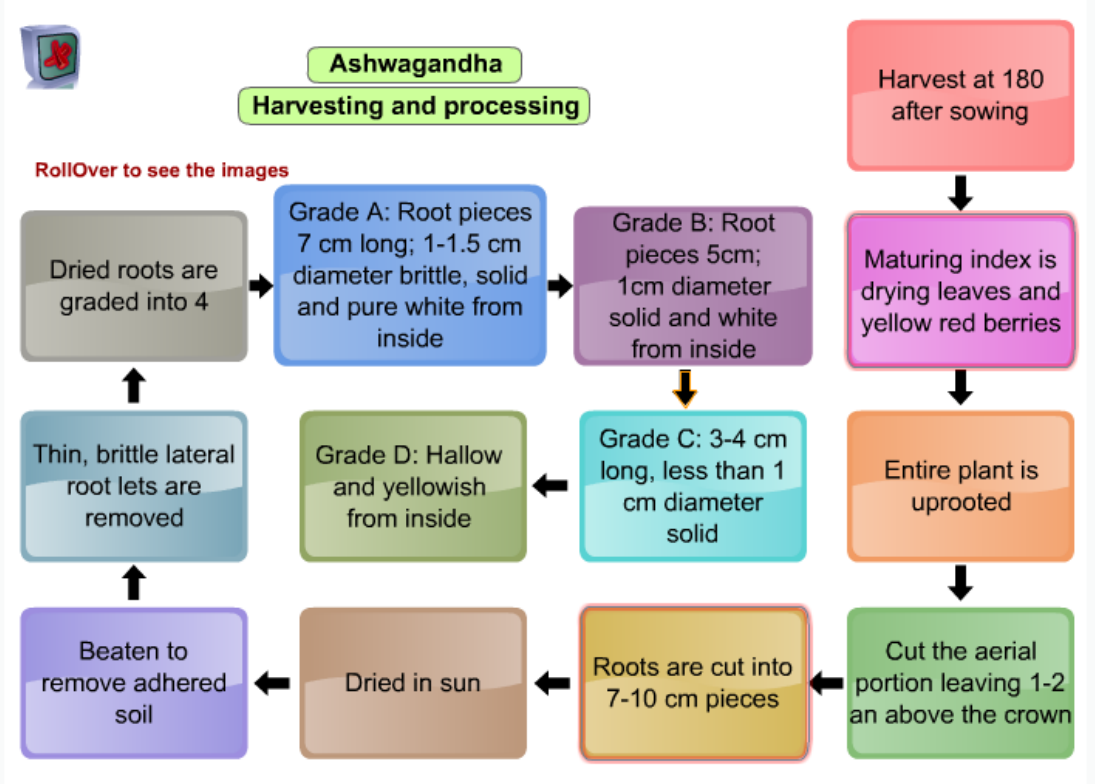
The entire produce (dried roots) is then carefully hand sorted into following 4 grades.

Grade A: Root piece 7 cm long, diameter 1 to 1.5 cm. Roots should be brittle, solid and pure white from inside.

Grade B: Root pieces 5 cm, diameter 1 cm, roots brittle, solid and white from inside.

Grade C: Root pieces should be solid, 3 - 4 cm long, diameter less than 1 cm.

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



Lesson 16

Guggul - Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting, grading and processing

Importance and chemical composition

The *Commiphora mukul* tree

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

Origin and distribution

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

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

Cultivation

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

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

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

Planting
The land is prepared well in advance of rainy seasons by 2.3 ploughing and laid out into plots of convenient sizes. Pits of size 0.5 x 0.5 m (0.5 m2) are dug at the spacing of 3x3 m. They are filled with FYM and top soil. The rooted cuttings are planted in the pits during the rainy season. As the plant grows they are trained properly by cutting the side branches.

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

Irrigation
Light irrigation during summer season is required.

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

Pests and diseases

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

Harvesting and processing

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

Processing (Gum tapping)

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

Yield

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

*****☺*****

Lesson 17

Opium Poppy - Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting, grading and processing.

Importance and chemical composition

- Opium poppy (*Papaver somniferum*) is an annual herb belonging to the family, Papavaraceae.
- It 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 commer¬cial 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**.
- Other minor alkaloids include **aporeine, codamine, cryp¬topine, guoscopine, hydrocotarnine, laudanine, narcotoline, neopine, oxynarcotine and papayeramine.**
- 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.
- It should be used in very limited quantities and under the strict supervision of a physician.
- In India, this plant is mainly cultivated for its latex (opium) and the seeds come as a by-product.
- 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.
- Its cultivation has to be done under the strict control of the Central Excise Department and it cannot be cultivated everywhere.
- It can be grown only in those areas specified by the Government of India.

Origin and distribution

Opium poppy is supposed to have 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. First, it was cultivated along the sea coast and later penetrated into the interior of the peninsula.

Area and production

The 1953, the United Nation's Opium Conference Protocol (still in effect) for limiting and regulating the cultivation of opium poppy plants asserts that Bulgaria, Greece, India, Iran, Turkey, the USSR, Egypt, Czechoslovakia, Poland, Germany, Holland, China, Japan, Argentina, Spain, Hungary, Portugal and Yugoslavia are the countries that may legally produce opium. The only country where substantial amount of opium is now produced for export is, India which amounts to 1,465 t 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.

The control and regulation of all aspects of the cultivation of poppy and wholesale trade has been under the purview of the Government of the India since 1773. After the partitioning of the Indian subcontinent in 1947, the essentials of the present system of narcotics control, which derived from the system instituted by the British in the 1857 Opium Act, were retained with few changes.
The Government of India is able to effectively license farmers to grow opium. This is highly organized so as to allow elimination of those growers whose yield of opium is poor.

Description of the plant

The poppy is a small, erect, scarcely branched (towards the top) 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, whitish-yellow, grey-brown, reddish-brown or black, and richin oil.

Varieties

The most popular varieties grown in the country remain in the field from 140 to 160 days. The following are some of the important varieties of which Talia, Ranghatak and Dhola Chota Gothia are

popular varieties recommended for heavy black soils.

(i) Talia

It is sown early and it remains in the field for 140 days. Its flowers are pink and have large petals. The capsule is oblong, ovate, light-green and shiny (waxy).

(ii) Ranghatak

It is a medium-tall variety, maturing for lancing in 125-130 days after sowing. It bears white and light-pink flowers. It produces medium-sized capsules (7.6 cm x 5.0 cm), which are slightly flat-tened on the top. It yields opium of a comparatively thin consistency that changes to a dark-brown colour on exposure.

(iii) Dhola Chota Gotia

It is a dwarf cultivar (85-90 cm), bearing pure white flowers and light¬ green capsules which are oblong-ovate in shape. It is ready for lancing after 105-115 days of sowing and matures for seed in 140 days.

(iv) MOP-3

This variety has been developed at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Mandsaur, recently. It bears pinkish-white flowers comprising of large non-serrated petals. Its capsules are ready for lancing 120 days after sowing and the variety is recommended where adequate irrigation facilities exist in the later part of the season.

(v) MOP-16

This is another promising selection made at the Jawaharalal Nehru Krishi Vishwa Vidyalaya, Mandsaur. The plant bears white flowers with serrated petals and round, flat-topped capsules. This is comparatively drought tolerant and is ready for lancing 105-110 days after sowing. It is recommended where an early maturing crop is preferred.

(vi) Shama

This variety was released by the CIMAP, Lucknow during the year 1983. The main alkaloids like Morphine (14.51-16.75%), Codeine (2.05-3/24%), Thebaine (1.84-2.16%), Papaverine (0.82%) and Narcotine (5.89-6.32%) in this variety are reported to be on higher side than the existing commercially cultivated variety. It yields 39.5 kg of latex and 8.8 kg/ha of seeds.

(vii) Shweta

This variety was also released by the CIMAP, Lucknow, along with Shama. However, it is reported to be superior to Shama in the content of the main alkaloids-morphine (15.75-22.38%), codeine (2.15-2.76%), thebaine (2.04-2.5%), papaverine (0.94-1.1%) and Narcotine (5.94-6.5%). It gives an average yield of 42.5 kg of latex and 7.8 kg/ha of seeds.

(viii) BROP 1 (Botanical Research Opium Poppy-l) (NBRI-3)

It is a synthetic variety developed at the National Botanical Research Institute, Lucknow, by crossing selections from Kali Dandi, Suyapankhi and Safaid Dandi. This variety is highly adaptable to varied agroc1imatic conditions and gives a higher yield than national checks. It is moderately resistant to diseases. It yields about 54 kg/ha of opium and 10-13 q/ha of seeds. The morphine content is 13% and above pose a problem, since they remain wet during the rains and are too difficult to cultivate in the dry period.

(ix) Kirtiman (NOP-4)

It was developed at the Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, through selection from local races. The variety is moderately resistant to downy mildew. It yields 35-45 kg/ha of latex and 9-10 q/ha of seeds. The morphine content is up to 12%. .

(x) Chetak (U.O.285)

This variety was developed at the Rajasthan Agriculture University, Udaipur. It is moderately

resistant to diseases. The opium yield is up to 54 kg/ha and the seed-yield is 10-12 q/ha and contains up to 12% morphine.
In general, the 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.

(xii) Jawahar Aphim 16 (JA-16)

It is a pure line selection of 10CaIIandraces developed at the Jawaha¬ralal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Mandsaur (Madhya Pradesh). It is moderately resistant to downy mildew. It gives 45-54 kg/ha of latex, 8-10 q/ha of seeds and contains up to 12% morphine.
Recently, another three varieties:'NBRI-3' of opium, 'Sujatha' an opium-free poppy for the production of oil and seed and 'Shubhra' for high morphine and seed yield have been released from the NBRI, Lucknow, RRL, Jammu and ClMAP, Lucknow.

Cultivation 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. Heavy clay or fine sandy soils generally sowing for correcting zinc deficiency 12-30 kg/ha of zinc sulphate should be added.

Sowing

Poppy seeds should be sown in a well prepared soil. The file dshould 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 (405 g/kg of seed) to protect the seeds against soil borne pathogens. The seeds are sown between late October to mid November. After sowing, seeds are covered by a thin layer of soil followed by a light irrigation.

Fertilizer application

The crop requires nutrients required for flowering and capsule formation. A fertilizer recommendation of 90:50:30 kg NPK/hectare is followed.

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.

Pest and diseases

Insects

1. Cutworms *(Agrotis suffuse)*: This insect can be controlled by flooding the field water and dusting the crop with 2% Carbaryl.
2. Weevils (*Stenocarus fulginosus*-root weevil and *Cautorhynchus maculalba* – capsule weevil).

Diseases

- **Downey mildew and powdery mildew :** This disease can be controlled by the application of Dithane Z-78 (0.4%)
- **Other diseases :** Root rot ,leaf blight, cabbage ring spot virus, beet yellow virus and bean yellow mosaic virus

Lancing and latex collection

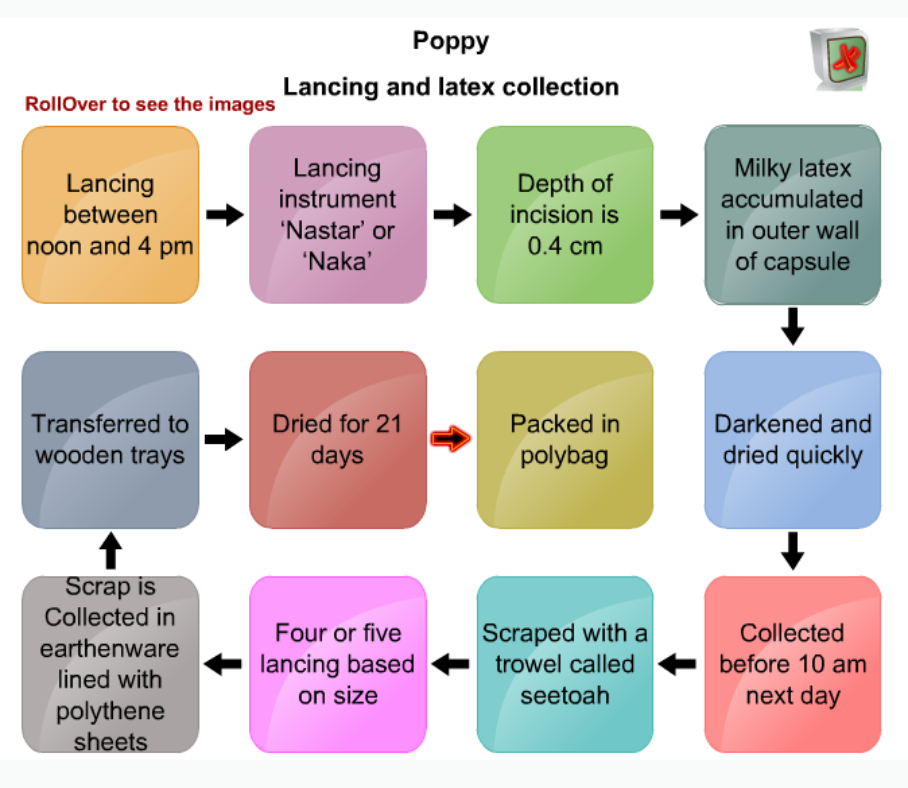
The lancing operation is performed by skilled labour (an average of 6 persons to a plot), usually on bright sunny days between noon and 4 p.m. The hottest part of the day is chosen, since the pellicle is said to form on the surface of the freshly exuded latex due to the hot sun, resulting in a greater degree of evaporation and quicker thickening. This also helps prevent the latex from falling off the capsule. The lancing operation is started at the edge of the field and the person works backward to avoid contact with the exuding latex. The hand is quickly passed over a capsule with the exuding latex. The hand is quickly passed over a capsule and a subjective decision is made as to whether it is ready for incision or not.

The lancing instrument, called "Nastar" or "Naka", comprises of four lines about the dimension of ordinary needles spaced at 1.5 to 2mm apart and affixed to a holder about 18cm long. The nester is held carefully, as one holds a pencil while writing and the incision is made by a swift downward stroke starting just below the stigmatic rays. The depth of the incision is controlled by the affixation of the lines to the holder, for if incisions are too deep the latex is exuded to the interior of the capsules and is thus lost. If the cut is too shallow the yield of latex will be low, usually, an incision with a depth of 0.4 cm is considered ideal. About 150-200 capsules can be lanced per hour by an experienced worker.

Immediately on lancing, the latex exudes; it is initially milky and gets accumulated in the outer wall of the capsule. It quickly darkens and dries during the course of the day and is generally collected the next day before 10a.m. by scraping with a trowel called the Seetoah. The collection may also be delayed for one or two days, depending upon the 'appearance' of the capsules and the vigor after the latex flow. In other words the interval is subjectively determined by the collator. The lancing process is usually repeated twice, making a total of series of vertical incisions. The spacing of the incisions on the capsule is generally even. If the capsules are exceptionally, large, four to five lancing can be done. The air dried latex, which has now become blackish in colour, is scraped from the capsules into small earthenware pots which are lined with polythene sheets. Scraping is carried out by grasping the capsule between the thumb and forefinger of the left hand and including it gently, the scraper is then drawn upwards. The capsule is finally 'cleaned' with the thumb.

The semi-dry, blackish latex is then transferred to wooden trays and dried further, upon arrival at the

factory, appropriate samples are drawn from each grower's produce and their quality is determined in the laboratory of the Chief Opium Chemist. The material is graded according to morphine content as follows:
A = With morphine content more than 12%.
D1 = With morphine between 11 an 12%.
B2 = With morphine between 10 and 11%
B3 = With morphine between 8 and 10%



Processing, Harvesting of seeds and Yield of crude opium and seed

The crude opium is transferred to the appropriate storage vats capable of holding 3 to 30t. The opium of variable consistency contained in these tubs is removed as require and is carefully air-dried in the sun to 70˚ consistency. The drying generally takes 21 days and is carried out in wooden trays, by turning the latex 3-4 times a day. Sun drying is considered a critical process, since artificial drying causes a substantial loss in alkaloid content. Each processed tray comprises of 36kg of opium with 70˚consistency. The opium is then packed in polythene bags, each containing 5 kg of the product, which is then shipped in wooden chests; 60 kg chest for sir-freight and 50 kg/chest for surface shipment.
In addition to export, a small amount of 90˚consistency opium is prepared for domestic quasi-medical purposes. This is called 'Government Excise Opium' and is available in cubical cakes. These are wrapped in 'butter paper' tied and stamped and shipped to various states where the opium is taxed and sold to those who are duly registered as addicts and consumers.

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 15 days after the lancing is completed. In India, the capsules are plucked by hand and the seeds are separated after breaking the capsules. Are plucked by

hand and the seeds are separated after breaking the capsules.
A dry capsule weighs about 7g and it contains 11 to 12 thousand weighing about 3.5 to 4g.

Yield of crude opium and seed

On an average 25-30 kg/ha of crude opium and 400-500 kg/ha of seeds are obtained in India.

*****☺*****

Lesson 18

Java Citronella -Importance, chemical composition origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of essential oil.

Importance and chemical composition

Java Citronella (Cymbopogon winterianus) is an aromatic grass belonging family Poaceae, which upon as the steam distillation gives an essential oil known to the trade as the oil of Java citronella. This is used extensively as a source of imported perfumery chemicals like citronellal, citronellol and geraniol, which finds use in soap, toiletries, mosquito repellents, perfumery, cosmetic and flavouring industries throughout the world. 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%). Citronella is used as a starting material for further derivatives.

Origin and distribution

- Both the Ceylon and Java types of citronella have probably originated from Managrass of Ceylon, which occurs today in two wild forms: *C. nardus* var. linnael (typicus) and *C. nardus var. confertiflorus.*
- The Java citronella which is called **Mahapengeri** in Ceylon is the result of a selection from the Ceylon citronella.
- It is distributed in tropical and subtropical countries like India, Taiwan, Guatemala, Honduras, Malaysia and Brazil.
- The NBRI, Lucknow introduced citronella into India.

Area and Production

At present, the world production of citronella oil is approximately 2000- 2500 t, the bulk of which is produced in Taiwan, Guatemala, the Honduras, Malaysia and Brazil. India produces about 120t oil annually. The important states in our country growing this crop are Assam, Gujarat, Jammu, Kashmir, Karnataka, Maharastra, Tamil Nadu, West Bengal and Uttar Pradesh.

Varieties

- Jorhat- C2, Java -2, and CIMAP- Bio-13 are the high yielding varieties of this crop for Southern and Eastern India.
- Whereas Manjusha and Mandakini are the varieties released by the CIMAP, Lucknow for the North Indian plains.
- An elite mutant clone of Manjusha M3-8 named 'Manjari' which has been found to possess 50-90% more oil, high citronellol and low elemol content on an average, over the other varieties.
- Manjari is an erect growing herb with yellowish green leaves and a dark purple stem.
- It is profuse tillering and rapid growing ability hence produces a high herb yield.

Cultivation

Soil

The plant has been found to grown well under varying soil conditions but sandy loam soil with abundant organic matter is the most suitable. Heavy clay and sandy soils are not conducive to the good growth of this plant. Citronella thrives well in a wide range of soil pH ranging from 5.8 to 8.0. However, a pH of around 6.0 is the most suitable. The plants are reported to grow well at altitudes between 1000-1500m.

Climate

Citronella thrives best under tropical and subtropical conditions. It requires abundant moisture and sunshine for its good growth. However the distribution of rainfall is important rather than the total amount. Well distributed rainfall ranging from 200- 250cm and high atmospheric humidity appears to influence the plant's growth, yield and quality of oil favourably. In areas where the rainfall is low the plant can be grown with supplementary irrigation.

Land Preparation

The land is brought to a fine tilth by ploughing and harrowing and the field is laid out in 6m x 6m size beds, providing irrigation channels. Ridges and furrows are made at 60cm intervals.

Propagation

Citronella flowers profusely in South India at higher altitudes and sporadically in the plains of the North and North – eastern regions. Viable seeds, however, are not formed because of irregularities in meiosis and therefore the species can be propagated only by vegetatively. The slips are taken from healthy, vigorously growing young bushes. The bush is gently dug out and separated into a number of slips and each slip contains 1-3 tillers. The fibrous roots and leaves should be trimmed off the slips before planting. It is observed that one year old clump on an average gives about 50 slips.

Planting

The slips are planted in May- June when they establish well in this region. Late planting, particularly after July, sometimes results in heavy casualty. The slips are planted at a distance of 60cm x 60cm apart. However in areas where the soil is very fertile and the climatic conditions support luxurious growth spacing of 90cm x 90cm may be followed. It is better if the slips are planted on ridges to avoid water –logging. The field should be irrigated immediately after planting, if there are no rains within the next 24 hours.

Manures and Fertilizers

In the red laterite soil of Karnataka and other Southern States where the plant grows through out the year 10t of FYM is applied. A fertilizer dose of 80-120 kg N, 80 kg P2O5 and 40kg K2O is given. Nitrogen is applied in 4 equal split doses, the first about a month after planting and then after each harvest at an interval of about 4 months. The CIMAP, Lucknow, has recommended a spray of 0.5% Fe through ferrous sulphate + Citric acid to check the spread of chlorosis.

Irrigation

Citronella requires sufficient moisture for good growth and yield of leaves. In the areas where the annual rainfall is about 200-250cm, well distributed over the year and humidity is high, supplementary irrigation is not necessary. In the drier months, however, irrigation may be provided and this increases the yield. Under Karnataka conditions about 8-10 irrigations are required in the dry period.

Interculture

Citronella plantations should be kept weed –free. When the plants have established themselves and grown into bushes the problem is not that severe. However in newly established plantations and after each harvest, weeds spring up in the inter-row spaces and weeding is essential.

Pests and Diseases

Pests:

Termites, mites and thrips are minor pests occurring in the crop. These are controlled by spraying chlorpyriphos termite control formulation (TC)(5 ml/litre).

Diseases:

Leaf blight caused by *Curvularia sp* can be controlled by spraying Mancozeb at intervals of 10-15 days.

Sheath rot disease caused by *Rhizoctonia solani* is controlled by spraying Hexaconazole 5% Among the insects termites are reported to cause the most damage to the plants. The termite menace can be controlled by the application of 25kg/ha Aldrin to the soil at the time of planting.

Harvesting, distillation and Yield

The crop is ready for the first harvest after about 9 months of planting. Harvesting is done by using an ordinary sickle at about 20-45 cm above the ground. Under Karnataka conditions, the crop is harvested in the month of March, June and September. The crop flowers during October – November and the flowering stalks should be nipped off to discourage flowering. If the flowering stalks are allowed to grow, the plants will tend to age very soon and their life span may be reduced. Generally the crop once planted yields a profitable income for about 3-4 years and should be replanted after this period. Well maintained plantations may thrive longer.

The yield of leaves may range from 15-20t/ha in the first year and 20-25t/ha in the second and third years. The yield of oil obtained during the first year is about 100-150 kg/ha and in subsequent years about 200-250 kg/ha oil may be obtained.

*****☺*****

Lesson 19

Lemon Grass- Importance, chemical composition origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of essential oil

Importance and chemical composition

- Lemon grass ***(Cymbopogon flexuosus)***, belonging to family Poacea, is the source of lemon grass oil obtained from the leaves and shoots of the plant.
- Lemon grass oil is mainly used in the manufacture of perfumes for soaps, hair oils, scents and medicines. It also has antibacterial properties.
- Ionone prepared from the citral present in lemon grass oil was one of the most important raw materials for the preparation of Vitamin A.
- In addition to its use in perfumery, Ionone is used in certain kinds of confectionary and liquors.
- The oil can be used to improve the flavour of some fish and can be used to flavour wines and sauces. It can be used for headache, tooth aches, baths, and as a diuretic agent for fever.

Origin and distribution

- The species is considered to have originated in India.
- It grows wild in many tropical and subtropical parts of Asia, Africa and America.
- The plant is grown for its oil in the West Indian Islands and also in Central America, South America, Thailand, Bangladesh, the Comoros Islands, Madagascar and China.
- Although the oil has been known since very early times in India, the systematic cultivation and distillation of the grass were started in Kerala only about 90 years ago. At present, it is grown commercially in the Nothern district of Travancore and Cochin (Kerala), Assam, Maharashtra and parts of Uttar Pradesh.

Area and production

- Traditionally, India has been the largest supplier of lemon grass oil to the world market but has ceased to be so any longer.
- The crop is under cultivation in India in an area of about 2000ha.
- The production of oil which was 1800t in 1961 -62 has declined to about 400t at present.
- The Indian monopoly in the lemon grass trade in the world market has been broken due to the entry of Guatemala and a few other Latin American states including Brazil and Mexico, Puerto Rico, Dominica, and China.

Description, types and varieties of the plant

Lemon grass grows to a height of about 3m. The leaves of the plant are linear, lanceolate, 125cm long and 1.7 cm broad. The plant is spreading, 100 -135 cm tall, slightly hairy.

There are two main types of lemon grass namely,

- The East Indian or true lemon grass (*C. flexuosus*) and
- The West Indian lemon grass *(C. citratus)*

The oil obtained by the distillation of the grass of *C. flexuosus* called the East Indian oil, is the genuine oil of commercial importance. It is produced in Kerala and is popularly called the Cochin oil, since it is shipped mainly from the port of Cochin. A small quantity of oil is also obtained from *C. pendulus*, popularly known as North Indian lemon grass or Jammu lemon grass, since it is grown mainly in Jammu and other North Indian States. The West Indian (South American) oil of *C. citratus* is extracted in Indo- China, Madagascar, Guatemala, Brazil, Congo and West Indies. It is found that the East Indian oil produced in South India is readily soluble in alcohol. Both the type have practically the same citral content (75-86%), but the West Indian oil along with citral contains other aldehydes which lower the quantity of the oil. In *C. flexuosus* the red stemmed plant with chocolate to purple coloured stems, yields the genuine oil, while the white stemmed grass does not. Recently a new species C. khasianus has been discovered which is important for its geraniol content. Some lemon grass varieties released for cultivation are given below.

Sugandhi (OD-19):

It was released from the Aromatic and Medicinal Plant Research Station (AMPRS) Odakkali, Kerala. This variety is red in colour and is adapted to a wide range of soil and climatic conditions. The plant grows from 1- 1.75 m height and with profuse tillering yields 80-199 kg/ha of oil with 80-88% citral under rain-fed conditions.

Pragathi:

It is a clonal selection from OD-19, evolved at CIMAP, Lucknow. The variety is tall with a dark purple leaf-sheath and is adapted to the North Indian plains and Terai belts of subtropical and tropical climates. The average oil content is 0.63% with 86% being the citral content.

Praman:

Evolved through clonal selection from C.pendulus at the CIMAP, Lucknow, it is a tetraploid plant with a profuse tillering habit. The leaves are erect and medium in size. The variety is reported to yield 227kg/ha/annum of oil with 82% citral content.

RRL- 16:
It is evolved from C. pendulus and released for cultivation from the RRL, Jammu as Jammu lemon grass. The average yield of the herb is 15-20t/ha/annum, giving 100-110 kg of oil. The oil content varies from 0.6 -0.8% with 80% citral content.
CKP- 25:
It is interspecific hybrid between C. khasianus and C. pendulus, developed by the RRL, Jammu. The strain gives herb yield of 80-85 t and 350-400 kg/ha/annum of oil. The citral content in the oil ranges from 80-85%

In addition to the above, OD-408 from the AMPRS, Odakkali, RRL-39 from RRL, Jammu and Kaveri and Krishna from the CIMAP, Regional Station, Bangalore, have been recently released as high yielding varieties for cultivation. The other varieties under cultivation are SD-68 and GRL-

Cultivation

Soil
It flourishes on a wide variety of soils ranging from rich loam to poor laterite. In sandy loam and red soils, it requires good manuring. Calcareous and water logged soils should be avoided as they are unsuitable for its cultivation.

Climate
It requires a warm, humid climate with plenty of sunshine and a rainfall ranging from about 200-250cm, well distributed over the year. In areas where the rainfall is poor, it can be grown with supplemental irrigations. It grows well at altitudes between 1000 -1200 m.

Propagation
Lemon grass is generally propagated through seeds, vegetative propagation and rooted slips. It is reported that both the seedlings and rooted slips performed equally well, with respect to growth and yield. But due to high cost of transplanting, direct seeding is widely practiced, especially over the plains and the terraced lands in Kerala. For raising the crop by direct seeding a seed rate of 20 to 25 kg/ha is recommended. While sowing, the seeds must be thoroughly mixed with dry river sand in a ratio of 1:3, to ensure the uniform distribution of seeds during storage.

Nursery raising
For raising the seedlings required for planting 1ha of land, a 1000m area is required. The area is well prepared and raised beds of 1 to 1.5m width and convenient length are made. The recommended seed rate is 3 to 4 kg/ha. The seeds are uniformly broadcasted on the beds and are covered with a thin layer of soil, followed by watering at regular intervals.
The seeds collected during the month of January – February are usually sown in the nursery during April – May.

Transplanting
The land is prepared by repeated ploughing and harrowing, and beds of 1 to 1.5 m width and convenient length are made with a spacing of 30 to 50 cm between beds. The beds are made along the contour of the land slopes. Three to four leaved, 50 to 70 days old seedlings are planted during the monsoon season (May- June) in Kerala. A spacing of 30cm x 30cm with a plant density of 1,11,000/ha is recommended. A wider spacing of 60cm x 45cm for seedlings and 90 cm x 60 cm for slips has been

recommended for fertile, irrigated land under North Indian conditions.

Manures and fertilizers

Lemon grass is an exhaustive crop and it requires 275 kg N, 25 kg P2O5 and 175 kg K2O/ha/annum. In order to promote growth and to obtain a higher oil yield the crop is applied with 2t/ha of compost made from spent grass and 2t/ha of wood ash at the time of bed formation. In addition, it has to be supplied with chemical fertilizers. Under Odakkali conditions, it was found that an application of 100kg N in 3 to 4 split doses was found to be optimum, though a response up to 200kg was recorded. The response to P and K was found to be erratic. The application of 50kg ha each P2O5 and K2O as a basal dose gave encouraging results in West Bengal. It is recommended to apply 60:45:35 kg/ha N, P2O5 and K2O as a basal dose and 60kg N in 3 to 4 splits/annum as top dressing during the growing season as an optimum dose. Lemon grass is also reported to respond well to the application of copper, iron, calcium and sulphur.

It is reported from the CIMAP, Lucknow, that a lower dose of boron (2.5ppm) in combination with chloride salts can be beneficial for the crop.

Interculture

The earthing up of the plant after about 4 months of planting and again after every harvest is beneficial, as the root region of lemon grass has a tendency to grow above the soil. The field is kept stubble free. Generally 2-3 weedings are necessary during the year. Among the herbicides Diuran @ 1.5 kg a.i./ha and Oxyfluorfen @ 1.5 kg a.i./ha are effective for weed control. Intercultivation can be done by a tractor drawn cultivator or a handheld hoe in row planted crops. Under rainfed conditions, burning the dry grass and stubble of the standing crop prior to the onset of monsoon is practiced in Kerala to prevent white ant attack and also to rejuvenate the old clump.

Irrigation

After planting if there are no rains, the crop should be irrigated every alternate day for about a month. It is recommended that 4 to 6 irrigations are given during the period February to June under North Indian conditions for an optimum yield.

Pests and diseases

Pest infestation is very low for this crop. Several diseases are reported on lemon grass, but none are serious enough to cause major reduction in oil yield.

The leaf diseases can be controlled by prophylactic sprays of Dithane M-45 and Dithane Z-78 @ 3 g/l thrice at intervals of 15 days.

Harvesting and yield

The crop is perennial in nature and gives good yields for 5 years. Harvesting is done by cutting the grass 10cm above the ground level. During the first year of planting 3 cuttings are obtained and subsequently, 5-6 cuttings per year are taken subject to weather conditions. The harvesting season begins in May and continues till the end of January. The first harvest is done about 90 days after planting. The interval from sowing to harvest exerts a considerable influence on the yield and the quality of oil. Both immature and over mature grass gives a lower quantity of oil. For the local type of lemon grass, the optimum interval is 40-50 days. The optimum period of harvesting, when grown on hill tops and low lying areas are 60 and 55 days, respectively. Herbage yield 15t/harvest and oil recovery about 0.3 – 0.5% from fresh grass can be expected. The oil is obtained by steam distillation. Oil yield of about 350- 400 kg/ha from the second year onwards is considered satisfactory.

Factors influencing the oil –yield:

The factors influencing the oil production during distillation are:

i)Storage of the plant material

ii) Treatment of the material

iii) The method of distillation.

The cut grass is kept in a dry atmosphere with limited air circulation. The grass when stored in the shade can increase the oil recovery up to 96 hours and storage for a further period will only decrease the oil yields. The essential oils are enclosed in the oil glands, oil sacks and glandular hairs of the plant. Therefore before distillation, the plant material must be cut into small pieces to enable them to directly expose as many oil glands as is practically possible. Once the plant material has been reduced in size it must be distilled immediately. Otherwise, the essential oil being volatile will be lost by evaporation. Dipping the chopped lemon grass in sodium chloride solution for 24 hr at 1-2 % concentration before distillation has been found to increase the citral content.

*****  *****

Lesson 20

Palmarosa- Importance, chemical composition origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of essential oil

Importance and chemical composition

- The oil of palmarosa (Cymbopogon martinii) (Family: Poaceae) is obtained from the floral shoots and the above ground parts of the variety motia. This variety is also referred as "Rosha grass" or "Russa grass" and yields oil with a high geraniol content (75.90%), which is also called East Indian Geranium Oil or Russa Oil. Another variety, sofia, called ginger grass is also grown wildly in India and it yields oil of lower geraniol content. The oil known as Ginger Grass oil is of an inferior grade and fetches a much lower price than the palmoarosa oil. Oil of palmarosa is one of the most important essential oils.

- Oil of palmarosa chiefly contains 70-80 % geraniol. Java oils also have almost the same geraniol content, but their ester content is higher. Oil of palmarosa is used in perfumery, particularly for flavouring tobacco and for the blending of soap, due to the lasting rose note it imparts to the blend. In soap perfumes it has a special importance by virtue of geraniol being stable in contact with alkali. It also serves as a source of very high grade geraniol.

Origin and Distribution

- Rosha grass is a native of most parts of subtropical India and it grows in warm humid areas.

- It occurs in patches, in open scrub forests, in part of Madhya Pradesh, Maharastra, Tamil Nadu and parts of Uttar Pradesh.

- Out side India, the crop is grown commercially in Indonesia, the East African countries, Cuba and Brazil.

Description of the plant

Palmarosa is an aromatic, perennial grass, which attains a height of 300 cm. The aerial parts die in the winter. Being very susceptible to frost, its leaves and shoots may dry up even in November when there is early frost, but usually withering starts in December, and by the end of January the plant dries up completely.

Area and production

Palmarosa is cultivated in Madhya Pradesh, Maharastra and Tamil Nadu in an estimated area of 1000 ha with an annual production of 150 ton essential oil

Varieties

- Some of the high yielding varieties under this crop are Sel. IW-31243 and IW-31245, released under the All India Co-ordinated project on the improvement of Medicinal and Aromatic Plants, and Trishna and Tripta from the CIMAP Lucknow.
- PRC-1 is another important variety recommended for cultivation.

Cultivation

Soil

A well drained loamy soil with a pH of 6 to 7 with irrigation facilities is ideal for the cultivation of palmarosa. A rise in pH above 8.5 is found to decrease the growth and consequently the oil yield, but has no adverse influence on the quality of oil produced. It also grows well in well-drained clayey loam soils, free from water-logging. If the soil is not well drained or if after heavy irrigation, the water remains standing in the hot weather, the growth of the grass is badly affected.

Climate

Palmarosa is a crop which grows well in a warm tropical climate with an elevation of up to 300m. Locations with an annual variation in temperature between 10 to 36° C and the rainfall around 150cm, with ample sunshine are the best suited for its cultivation. Areas which are affected by severe frost are not suitable, as the frost kills the grass and reduces the oil content.

Land Preparation

The field is prepared well before the onset of the monsoon. It is ploughed and harrowed to a fine tilth. All the stubble and roots of weeds are removed. At the time of the last ploughing, FYM @ 10t/ha is incorporated into the soil.

Healthy and established seedlings which are 15cm high are carefully removed from the nursery and planted in rows at 60 cm x 60cm apart. In fertile areas, the spacing should be increased. It has been demonstrated at the CIMAP, Lucknow, that a closer plant spacing of 30 x 30 cm improves the palmarosa oil production by 44% over the planting at 60 x 30cm.

Propagation

It is best raised by

i) transplanting the nursery raised seedlings
ii) by root cuttings of healthy plants and
iii) through slips.

For commercial planting the crop is propagated through seeds.

Nursery raising

The nursery beds are prepared in May. Raised beds are preferable as the seeds are not washed off by irrigation. Liberal amounts of FYM should be added to the seed bed. As the seeds are small and light, they are mixed with fine soil in the ratio of 1:10 for even distribution and ease in sowing. They are sown in lines at 15-20cm apart. The seeds should not be sown densely as this will lead to crowding of seedlings, resulting in poor growth of the plants. About 2.5 kg of seeds are adequate to give enough seedlings for planting one hectare. The beds are watered lightly and regularly. Germination starts within two weeks. Later on a weak solution of urea (0.2 -0.5%) may be given for their good growth. In about 3 to 4 weeks the seedlings are ready for transplanting.

Slips

Plants that give yield and high quality oil should be used for taking slips. In this way it is possible to raise plantations yielding high quality oil, which is not possible when the plantation is raised from seeds as the seeds give rise to many morphologically indistinguishable but different varieties. However, the rate of establishment of rooted slips is very poor as compared to nursery transplants. Slips can be planted in June- July during the rainy season.

Planting

The seedlings are transplanted into the prepared fields as soon as the rainy season sets in (June-July).They can be transplanted even earlier, if the weather is not very warm and irrigation is available.

Manures and fertilizers

As the grass is perennial it is necessary to replenish the soil. In rich soils, manuring may not be required for the first two years. By manuring already rich soils, the vegetative growth is increased and the oil content is reduced. However for deficient soils a mixture consisting of 20kg N, 50kg P2O5 and 40kg K2O/ha is used as a basal dose at the planting. About 40kg/ha of N is applied in three split doses after each harvest. The mixture of N, P and K should be repeated at the time of the appearance of fresh leaves each year.

A foliar spray of FeSO4 and MnSO4 has been found to improve the plant growth, herbage and oil yield of palmarosa. The CIMAP, Lucknow, has also recommended an application of 10kg/ha of Zn which is reported to significantly increase the number of tillers, herbage and oil yield without affecting the oil content and quality. Similar results were obtained by the application of 20kg/ha of sulphur in the form of elemental sulphur or ammonium sulphate.

Irrigation

The irrigation required depends upon the climatic conditions. The grass requires irrigation after about 8-10 days during the growing season. With an ample supply of water, growth is luxuriant, but if drought prevails the growth is arrested, the leaves wither and the oil content is reduced. However, before harvesting irrigation should be discontinued.

Weeding

Odour is an important factor of the oil quality and it is essential to keep the fields clean of other growing plants, particularly those which impart their own odour. Therefore, the plantation should be kept free from weeds by regular weeding and hoeing. Particular care is required in the initial stage of growth, so that the weeds do not over power the grass. Diuron (1.5kg a.i./ha), Isoproturon 90.25kg a.i./ha) and oxyfluofen (1.5kga.i./ha) are the weedicides recommended to control weeds in palmarosa.

Pests and diseases

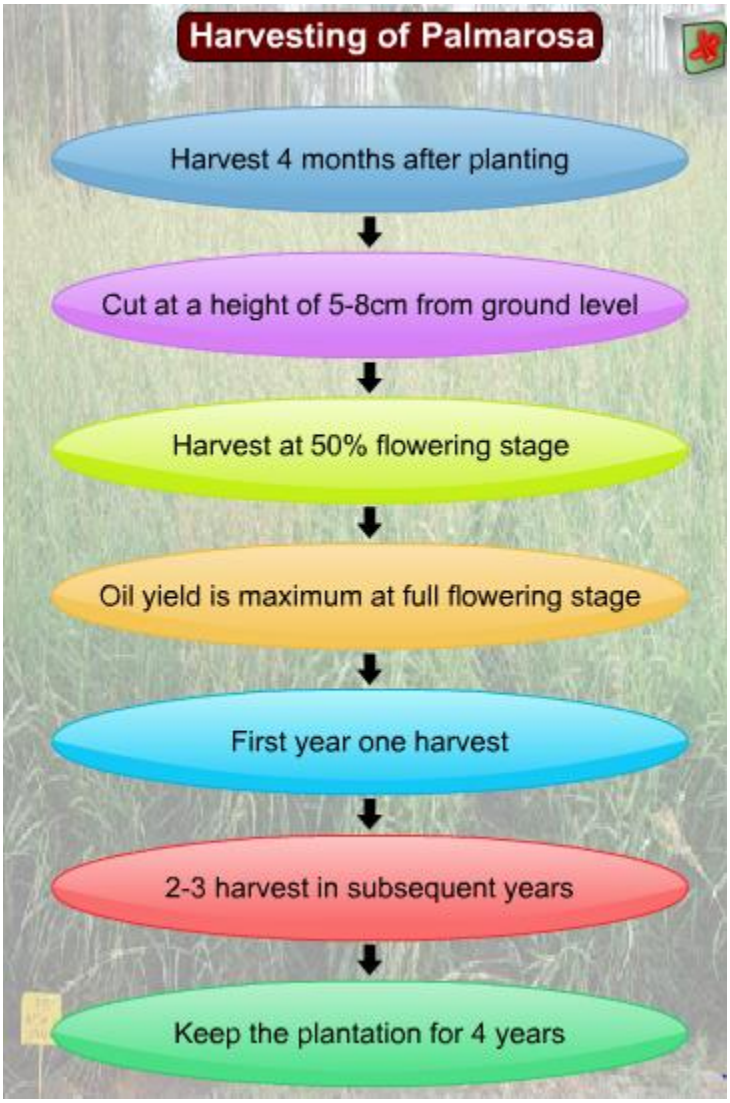
The crop is not attacked by any pest or disease of a serious nature. Leaf blight and the symptoms of yellowing of leaves and necrosis and leaf spot are reported in the crop.

Harvesting and yield

The essential oil is distributed in all the parts of the grass, viz. the flower heads, leaves and stems. The flower heads containing the major portion. The grass is harvested when it is 4 months old and in full bloom. Usually the grass is cut at a height of 5-8 cm from the ground level and the whole plant is used for distillation. The maximum yield of oil is obtained when the entire plant is at full flowering stage.

The number of harvests depends upon the climatic conditions. During the first year, usually one crop is obtained during October- November, whereas 2-3 crops are obtained in the subsequent years. An oil yield of 250-300kg can be expected per ha. per year.

Palmarosa plantations remain productive for about 8 years. However the yield of grass and oil starts decreasing from the fourth year onwards. It is therefore recommended that the plantation is kept only for 4 years.



*****☺*****

Lesson 21

Vetiver- Importance, chemical composition origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of essential oil

Importance and chemical composition

- Vetiver or khus (***Vetiveria zizanioides)*** (syn. ***Chrysopogon zizanioides***) belonging to family Poaceae, is a grass found growing on various types of soils.
- The underground part of the plant consists of numerous fine rootlets of light- yellow or grey to reddish in colour, which contains a viscous essential oil with a pleasant and persistent odour.
- The commercial oil of vetiver is obtained by the distillation of the root. In India, the plant is known as 'khus khus'. Khus meaning **'aromatic root'**.
- The major constituents are **vetivone, vetiverols, vetiverenyl, vetivernate, benzoic acid** and **palmitic acid.**
- The economic part of the plant is the root, which possesses a most agreeable aroma and is employed to scent clothes, either by itself or in the form of sachets.
- From time immemorial, vetiver roots have been employed to make baskets, hand fans and mats which when sprinkled with water and hung like curtains in houses, cool the air and emanate a pleasant odour.
- The oil of vetiver is one of the most valuable and most important perfumer's raw materials, widely used in perfumeries, cosmetics and for the scenting of soaps. It also acts as a natural fixative.
- The oil of vetiver blends well with other oils particularly with those of sandalwood, patchouli and rose.
- Medicinally it is reported to be used as a carminative in flatulence and as anthelminthic and possesses stimulant and refrigerant properties.
- It is locally applied to relive pains on the body.

Photo courtesy: L.Hegde

- Young leaves are used as fodder and bedding for horses and cattle, the leaves are also used for thatching purposes; while the stem and inflorescence peduncles are used for making brooms and ornamental baskets.
- The plant has also gained recognition as one of the best soil-binders and is being used extensively in arid zones to check soil erosion.

Origin and distribution

- Vetiver is indigenous to the Indian subcontinent and is widely distributed in tropical Asia, Africa and Australia. It flourishes on the slopes of the Himalayan Mountains and in many parts of India, Sri Lanka and Malaysia.

- It is cultivated extensively in Java, Reunion Island, Indonesia, Haiti, Jamaica, Zaire, Vietnam, Brazil and in the Seychelles Islands. In India it is found growing wild in the forests of Rajasthan and Uttar Pradesh.
- It is also found in some parts of Assam, Jammu, Bihar, Orissa, Andhra Pradesh and Karnataka. However it is systematically cultivated as a crop in Kerala and Karnataka.
- It is found in a semi-wild state in the East Godavari and Kurnool districts of Andhra Pradesh and its cultivation is picking up in parts of Madhya Pradesh, Uttar Pradesh and Haryana.

Area and production

- Vetiver is mainly cultivated in Nilambur and Malapuram districts in Kerala in an estimated area of 100 hectares. There is no data on production of vetiver on commercial basis.

Types and varieties

The grass growing wild in North India and that cultivated in South India are two different types. Thus there are two main types namely, flowering or seeding and non-flowering or non-seeding. The one that grows in North India is mainly the flowering type, while that which is cultivated in south India is the non-flowering type.

The North Indian type is poor in oil yield, but its oil quality is superior, whereas the south Indian type yields more oil, but the quality is inferior.

The CIMAP has developed two superior clones, KS-1 and KS-2 from a collection from Bharatpur. These have a yield which is almost comparable to the existing high yielding material. However the quality of oil from both the clones was rated the best among the clones evaluated.

An improved tetraploid strain “Sugandha” has also been released by the CIMAP and is reported to be superior in terms of oil-yield over the corresponding diploid parent. This is attained by an enhancement in the root biomass and an increase in the percentage of oil content in the roots. The new strain can yield 1.4% oil content in fresh roots and 21.2q/ha of roots, against 1.15% oil and 18.5q/ha of roots in the control.

Pusa hybrid numbers (1-30) have been evolved by NBPGR, New Delhi. Of these F1 hybrids Hyb-26 gives higher yield of roots (14.5q/ha) with an oil content of 1.50%. Whereas hybrids 26, 7 and 16 perform better in saline and alkaline soils with high root and oil yield. Under Bangalore conditions, hybrid -8 has been found to be better. Its roots yield 1% essential oil and possess 70-85% vetiverol content. The yield of root ranged from 12-15q/ha when harvested at 15 months age. A vetiver clone ODV-3 developed at Aromatic and Medicinal Plants Research Station, Odakkali is reported to give god root and oil yield in Kerala. The CIMAP, Lucknow has released few new varieties based on the oil odour value. They are Kesari, Gulabi and Dharini.

Cultivation

Soil

Vetiver can be grown on almost every kind of soil. Light soils, however, should be avoided as the roots obtained produce a very low percentage of oil. Well drained, sandy loam and red lateritic soil rich in organic matter are considered to be ideal as the roots produced in such soils are thick and contain more essential oil. It can be grown even in saline and alkaline soils, with a pH range of 8.5 to 10.0.

Climate

The crop prefers tropical and subtropical climate for its proper growth, development and essential oil yield. It grows luxuriantly in places with an annual rainfall of about 1000 to 2000 mm, the temperature ranging from 21-44° C and with a moderately humid climate. In the places which are otherwise suitable but have scanty rainfall, it can be grown as an irrigated crop.

Land Preparation

The land is ploughed to a depth of 20-25cm repeatedly and the soil is mixed with the recommended dose of manure and fertilizers and made ready for planting.

Propagation

Vetiver is propagated from seeds or slips. Seeding is found to be profuse in the crop, in areas where it occurs in the wild and regeneration takes place from self sown seeds and the rains received. In south India where the crop is cultivated on a large scale, the non seeding type is grown. This is propagated from slips obtained from the uprooted clumps of the previous crop. These clumps, when broken, give a number of slips. Slips that are separated from the clump and have 15-20 cm of the shoot portion, constitute the material for planting.

Planting

Vetiver is planted in rows 45cm apart with a plant to plant distance of 30cm. The planting is usually done during the months of June- July, at the advent of the rainy season. If irrigation facilities are available, it is better to plant during March- April. However in that case, frequent irrigation will be required. Two or three slips are planted in each hole of 5-8 cm depth and the soil is pressed around the hole. Late planted crop yields coarse roots which in turn, yield inferior quality oil. A spacing of 60 x 25 cm is also recommended to allow 60 000 plants/ha.

Manures and fertilizers

In order to obtain economic yields, the vetiver crop may be supported with 10t FYM, 25kg/ha each of N, P and K. While the entire quantity of FYM, half N and a full dose of P and K are applied at the time of planting, the remaining half of N is given after about 6 months of planting. A fertilizer dose of 60kg N, 22.5 each of P2O5 and K2O is recommended in Kerala.

Irrigation

In areas where rainfall is good and well distributed throughout the year and humidity is high, supplemental irrigation is not necessary. However, in drier areas, about 8-10 irrigations will be required in order to obtain the optimum yield.

Interculture

Once the plants have established and grown into bushes, the weed problem is not severe because of the nature of the bushes. However, in the newly established plantations, 3-4 weedings are necessary until the bushes are formed.

Pests and diseases

Pests

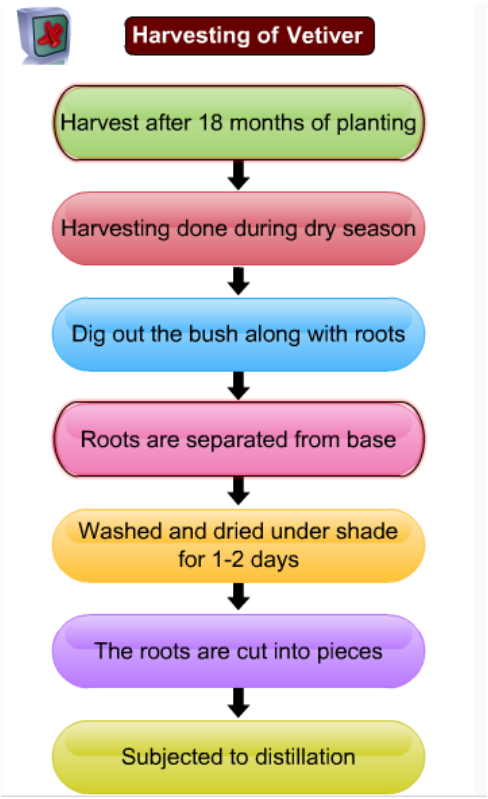
There are no serious insect pests except for the ants attack the roots.

Diseases

Very few diseases have been reported on vetiver. During the rainy season the plant is attacked by *Fusarium spp.* It can be effectively controlled by drenching the soil with Bordeaux mixture (1%).

Harvesting and yield

- The time of harvesting is very important as the yield of roots and oil percentage vary with changes in environmental conditions.
- The crop planted in July should be harvested after 18 months to get the maximum oil yield.
- Harvesting is usually done during the dry season from December to February, by manually digging out the bush along with its roots.
- The roots are then separated from the base, washed and dried under shade for 1-2days before distillation.
- This improves the quality of the essential oil, while prolonged drying in the sun reduces the yield.
- The yield of the roots may range from 3-4t/ha. A recovery of about 1% of essential oil is considered satisfactory.
- A root yield of up to 14-18 q/ha has been obtained in North India.



Lesson 22

Rosemary and Thyme -Importance, chemical composition ,origin, distribution, area, production, climate and soil requirements, types and varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of oil

ROSEMARY

Importance and chemical composition

- Rosemary (*Rosmarinus officinalis* L.) belonging to family Lamiaceae.
- The leaves and flowering tops, on steam-distillation, yields the essential oil.
- The oil is valued for its use in culinary, medicine, perfumery and cosmetic industries.
- It is an excellent fixative material and the oil also contributes a strong fresh odour, which blends well with various other oil odours and also serves to mask the unpleasant smell of certain other ingredients in any preparation.
- Rosemary oil is known to have antimicrobial activity against certain gram-positive and gram-negative organisms.
- It is also used in formulations of compounded oils for flavouring meat, sauces, condiments and other food products.
- The leaves are used in cooking. Distilled water is obtained from the flowers which are used as a soothing eye-wash.
- The oil has 1, 8 cineole (20-50%), borneol (20%), camphor, linalool, α-pinene, camphene, β-pinene, sabinene, myrcene, α-phellandrene, α-terpinene, limonene, α-terpinene, p-cymene, terpinolene, thujone, copaene, terpinen-4-ol, caryophyllene, methyl chavicol, α-terpineol, thymol and carvacrol.

Origin and distribution

- It is a native of the Mediterranean regions of Europe, Asia Minor and North Africa. Rosemary is grown in Spain, Italy, France, Algeria, Morocco and Portugal for its essential oil.
- Spain has traditionally been the largest supplier of the oil, but it appears to be rapidly losing ground to Tunisia.
- The annual world production of the oil has been increasing gradually over the years and now 200-300 t of oil is being produced annually.
- In India, a negligible quality of oil is produced.

- Rosemary is cultivated to a limited extent in the Nilgiris in South India. Its cultivation in the plains is of recent origin and now it is being cultivated in and around Bangalore on a small scale.

- The oil is comparable to the Spanish oil in quality and has been well received by the trade.

Description of the plant

The plant is a hardy, dense, evergreen shrub, growing up to 1 m in height with an erect stem divided into numerous long, slender branches bearing many sessile, opposite leaves which are smooth and green, woody, whitish and glandular beneath. The leaves are 2 to 4 cm long and cylindrical, leathery and green on top, white and hairy below and sticky to touch. The flowers are situated in little clusters towards the end of the branches. The calyx is two-lipped, the upper one with a single broad oval lobe, the lower one with two segmented triangular lobes. The corolla is also two-lipped with two violet stamens and a long style projecting from it. The fruit is an oval, four-sectioned cremocarp.

Types and varieties

There are two types of rosemary under cultivation. They are the **'French rosemary'** and the **'Italian rosemary'**.

The French type produces white-coloured flowers and its oil is superior in quality to that of the Italian type whose flowers are purple coloured.

Cultivation

Soil

It is a very hardy plant and is found growing on rocky terrains in the temperate parts of the world. In India, the plant comes up well on the light, loamy soils of the Nilgiris and the sandy loam soils of Bangalore. The crop requires a soil pH ranging from 6.5 – 7.0 for its successful growth.

Climate

Rosemary prefers a Mediterranean type of climate with low humidity, warm winters and mild summers for its successful growth. However, any place where frost occurs frequently should be avoided as the plant is susceptible to it. The climate of the Nilgiris and Bangalore, in India, has been found suitable for its cultivation.

Land preparation

The land is prepared well by repeated ploughing and harrowing. About 20 t of well decomposed FYM is incorporated into the soil at the time of the final ploughing.

Propagation

Vegetative propagation

It is best propagated by vegetative method by stem-cuttings. Cuttings from healthy mother-plants, 10-15 cm in length, are taken. All leaves about half of the length from bottom should be removed. The cuttings are then planted in nursery beds of sandy soil under partial shade at a depth of about 6 to 10 cm. Thereafter, regular watering and weeding is provided to the nursery for about a month. After about 6-8 weeks, the cuttings are ready for transplanting into the main field. They can also be raised in small polybags or seed-pans. This helps in easy transportation of the rooted cuttings.

Seed propagation

The crop can be propagated by seeds also. The ideal season for raising the nursery is between September and November. The seeds are very small and about 0.2 to 2.5 g seeds are required to cover 1 sq. m area and are sown to a depth of 1-2 cm.
After they are sown in well-prepared nursery beds, regular watering and weeding of the nursery is continued. The seeds germinate best at a soil temperature ranging from 14-15°C. When the seedlings are about 8 to 10 weeks old, they are ready for transplanting into the main field.

Transplanting

Eight to ten weeks-old rooted cuttings or seedlings are planted in the main field at a spacing of 45 x 120 cm. About 20,000 plants/ha give the highest yield of oil. It is reported from the CIMAP, Lucknow, that a spacing of 45 cm x 45 cm between plants is optimum and gives the best yield.

Manures and fertilizers

Prior to transplanting, 20 t of FYM, along with 40 kg of P_2O_5, 40 kg of K_2O and 20 kg of N is applied to the soil as a basal dose. After each harvest, 80 kg/ha of N is applied in 4 equal split doses as a side-dressing to promote vegetative growth. For obtaining the highest yield, the CIMAP, Lucknow has recommended the application of 300 kg N/ha/year.

Irrigation

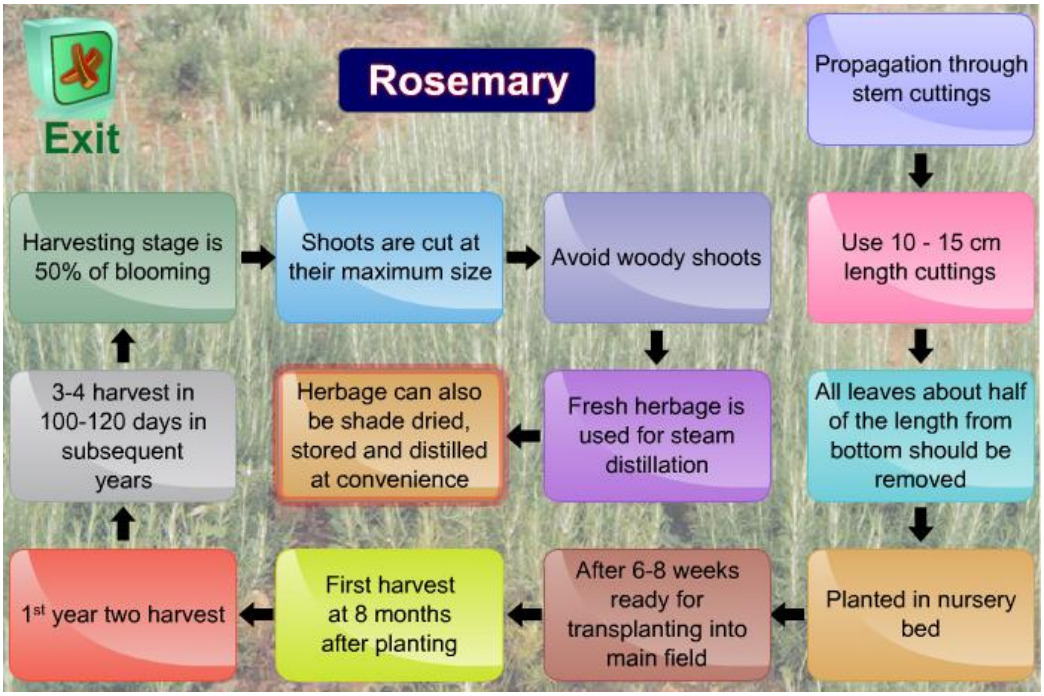
Initially the crop is irrigated twice a week till the plants establish. Afterwards, once a week is enough. By nature, this crop is drought-resistant and can withstand long drought periods.

Inter-cultivation

About 5-6 cultivations between the rows and an equal number of weedings within the rows are required to keep the weeds under control.

Pruning

After 2 to 3 years, the bushes are cut frequently to keep them from becoming leggy and to promote the formation of numerous shoots, which can be harvested for the oil.



Pests and diseases

When the crop was introduced, there were no major pest and disease problems for this plant. But of late, blight caused by *Rhizoctonia spp*. a soil borne fungus, *Phytocoris rosmarini* and *Orthotylus ribesi* have been reported. Mancozeb (1%) can be sprayed on the crop and drenching may be done at an interval of 8-10 days to keep these diseases under control.

Harvesting and yield

During the first year, the crop is ready for harvest 8 months after planting and only 2 harvests are obtained. In subsequent years, 3 to 4 harvests at 100 to 120 days intervals can be taken. Depending upon the exposure of the plantation, the plants start flowering earlier in warmer and low altitude areas and later on the high slopes.

Harvesting should begin at the time of 50% blossoming and continue till 75-90% inflorescence emerges and must end when the flowers have finished blossoming. The shoots are cut for distillation when they have reached their maximum size, but have not become woody. The hardwood should not be distilled as it imparts an odour of turpentine.

Essential oil is obtained by steam-distillation of the freshly harvested herbage. The herbage can also be shade-dried, stored and distilled at convenience without any loss of oil.

The time required to distil one charge is 3 hours. Recently, the CIMAP, Bangalore, has recommended that rosemary be distilled for 2 hours for the maximum recovery of oil.

In the laboratory, the fresh rosemary leaves yield 1% and shade-dried leaves yield 3% oil. However, in field-distillation units a yield of 0.7% is considered satisfactory. About 12 to 15 t/ha/year of herbage, yielding about 85 to 100 kg of oil is obtained.

THYME

Importance and chemical composition

Thyme **(*Thymus vulgaris* Linn)** commonly called **'Common Thyme'** of **'Garden Thyme'**, belonging to the family Lamiaceae, is an important herb used by man since ancient times On distillation, the herb yields the Red Thyme oil of commerce. Apart from the oil the other constituents of thyme are tritepinoid saponins, flavones, ursolic acid (1.5% in the tops), coffeic acid, bitter principle, tannins and resins. Besides, there are several other wild species which yield volatile oil. They are *T.serpyllum* L., *T. zygus* L. and *T.satureioides* Coss and Bal. Thymol. Linalool and linalyl acetate are the major compounds present in *T.zygus* and *T.serpyllum*, *T.zygus* and its var. *gracitis* are also a source for genuine thyme oil, while thymol, burneol and α-terpineol are the major compounds in *T.satureioides*. The oil called the **'oil of thyme'** in commerce is a colourless, yellow or red liquid with a characteristic pleasant odour, and a pungent taste. The composition and also the quality of the oil are reported to vary in different geographical areas. The concentration of the active principle (Thymol) is high (60%) in the Spanish oil and is low (20-35%) in the French and Moroccan oils, whereas, carvacrol is present in minor amounts. The seeds yield 37% of a drying oil which contains mainly linolenic, lindeic and oleic acids.

The leaves and flowers find use as food flavourants and seasoning for various food items, especially fish and meat preparations and for garnishing. Medicinally, the leaves are said to possess laxative, stomachic and tonic properties, good for the kidney and eye and are blood purifiers. The herb also has insect-repellent property. It is used in perfumery and in liquor distillery as well. The dried leaves and floral tops constituting the thyme of commerce are known as **Thymi Herba** in pharmacy and contain not more than 3% of stems over 1 mm in diameter and 2% of other organic matter and yields 4% acid insoluble ash. The shoot-extracts of flowering thyme plants have antibacterial action against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. The herb which has a pun get taste is reported to possess antiseptic, antihelmentic, expectorant, carminative, diuretic, alexiteric, emmenagogue and sedative properties.

Thyme oil has antiseptic, antispasmodic and carminative properties. It is used in mouthwashes and gargles. Formulations containing thyme oil are available for the treatment of whooping cough and bronchitis, the oil is used in soaps, perfumes and for flavouring food products such as a meat, sausages, sauces and canned food.

Origin and distribution

It is distributed in India, Asia, Australia, Canada, Europe, France, Germany, Greece, Italy, Morocco , Spain,USA Thyme grows wild in almost all the countries bordering the Mediteranean and also over much of Asia and in parts of Central Europe and it grows best in the hills. It is found in the western temperate Himalayas, from Kashmir to Kumaon between altitudes of 1525 m and 4000 m. Thyme is grown in Europe Australia and North Africa, Canada and the USA as well.
Among the countries producing thyme oil, Spain stands first followed by France, Morocco and the Mediterranean countries. The bulk of the world demand for thyme oil is met by Spain and Turkey.

Area and production

Thyme is cultivated in high altitudes of Nilgris of Tamil Nadu in an estimated area of 20 hectares. The exact data on production of this crop is not known.

Description of the plant

Thyme is a low, evergreen perennial under-shrub reaching a height of 20-30cm whereas, wild thyme (*T.serpyllum* L.) creeps on the soil surface and has broad leaves with a weaker odour. The roots are fairly robust and the stems are branched. The former has oblong lancelolate, sessile leaves 10 mm x 3mm in size with orange-brown, glandular dots and is coriaceous. The young leaves are slightly woolly. The flowers are small purplish or bluish to almost white, united in spikes at the tips of the branches and have a bilabiate, tube-like calyx and a bilabiate, tubular corolla with a 3-lobed lower lip. The fruit is a nutlet brown 4-sectioned, smooth and is found in the remains of the calyx. The entire plant is aromatic.

Cultivation

Soil

The plant prefers a light but fertile and calcareous soil for good growth and oil content. On heavy, wet soils the aroma of the leaves will be less and there are chances that the plants may soon dry up.

Climate

A warm climate is best suited for this crop. It can be grown both in the hills and on the plains. Hilly regions are best suited for its cultivation. However, the plants are susceptible to frost. The seeds may be sown in the nursery in April. Late summer is the time for transplanting the seedlings or for planting the rooted cuttings.

Land preparation

The land is prepared well by repeated ploughing and brought to a fine tilth and divided into plots of convenient size.

Propagation

Thyme can be propagated by seeds and vegetatively by the division of old plants or by cuttings, or by the layering of side-shoots in March or April. The seeds are sown directly in rows or in well-prepared nursery beds in good soils. Fine soil is preferred for the nursery, because the seedlings are very small and remain inconspicuous for several weeks after germination.

Planting

When the seeds are sown directly, they can be sown in rows 90 cm apart and, later, when the seeds germinate, the seedlings may be thinned out to 30-45 cm within the rows. While planting the seedlings or rooted cuttings or layers, they are planted 30-45 cm apart in rows, 60 cm apart. A light irrigation is provided after planting.

Manures and fertilizers

A light dressing of FYM in the autumn and an additional dressing of nitrogen in the spring can be applied. This promotes the formation of numerous leafy shoots. A fertilizer dose of N 75kg, P2O5 and K2O each at 40kg/ha is recommended for higher yield.

Irrigation

Since the crop is planted late in summer, it requires frequent irrigations during the dry period.

Interculture

Inter culture operations and weeding are done at regular intervals to encourage the good growth of plants. In the hills, mulching helps to avoid frost injury to the plants during the winter.

Pests and diseases

The plant is not damaged by any pests of serious nature, but wilt disease is a major problem in this crop. The disease can be controlled by improving the phytosanitation and by drenching the soil with a suitable fungicide like Blitox or Dithane M-45 at 0.3% concentration.

Harvesting and yield

- The leaves and flowers which are used for culinary and medicinal purposes are harvested five months after sowing/planting.
- The leaves and flowers are plucked from the plants or shoots of about 15 cm are cut off from the plants, dried in the shade or in a dryer immediately after harvest and stored in airtight containers to prevent the loss of flavor.
- The dried leaves are curled, brownish-green in colour, usually not longer than 6-7 mm. The dried shoots may also be powdered and packed.
- Under favourable conditions the yield of dry herb is around 1,100-2,200 kg/ha. The yield is comparatively low during the first year.
- The plants become woody which necessitates their replanting after three or four years.
- For extracting the oil, the fresh herb is collected, on dry days, at the stage when it just starts flowering. At the time of collection, the lower portions of the stem, along with any yellow or brown leaves, should be rejected.
- The oil is distilled from the fresh flowering-tops by steam-distillation. The herb contains about 2% essential oil and the total oil recovered by distillation is about 21 kg/ha.

*****  *****

Lesson 23

Scented geranium -Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and distillation of oil

Importance and chemical composition

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

Origin and distribution

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

Area and production

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

Description of the plant

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

Types/varieties

1.Algerian or Tunisian

This type of Scented geranium is slender with flowers of a dark pink colour. It is being grown in the Nilgiris and is unsuitable for wet conditions. This variety yields 50-60% more oil with a more delicate odour than that of the Reunion type.

2.Reunion or Bourbon

Grown in the Nilgiris and Anamalai hills, the plant is sturdier with light-pink flowers and more suitable for wet conditions. The oil content is higher during the summer months from April to June. The terminal portion with 6 to 12 leaves contains more oil than the middle and basal portions.

KKL-1

In the evaluation trial of the Algerian and Reunion types, PG-7 and PG-20, respectively at the Horticultural Research Station, Kodaikanal, the clone PG-7 recorded 0.3% essential oil has been released under the name 'KKL-1'.

Sel-8

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

Cultivation

Soil

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

Climate

Scented geranium can be grown in temperate, subtropical and tropical climates at various altitudes from 1 000 to 2 200 m. It thrives best in subtropical climates with a temperature ranging from 5°C to 23°C. However, temperatures below 3°C will kill the plant. Warm winters coupled with mild summer

temperatures and, well-distributed annual rainfall ranging from 100-150 cm is ideal. However, heavy rainfall results in water-logging, causes root-rot and stunted growth. It has been observed that it grows equally well at much lower altitudes and tolerates higher temperatures up to 43° C in the plains when grown under irrigated conditions.

Propagation

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

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

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

Planting

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

Irrigation

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

Weeding

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

Intercropping

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

Manures and fertilizers

Prior to transplanting the cuttings, 10 t of FYM, 35 kg N, 35 kg P2O5 and 35 kg K2O/ha are incorporated into the soil. A second dose of nitrogen at 35 kg/ha is applied about 2 months after the first application, Further, nitrogen is given in two equal split doses for each harvest-the first dose being just after the crop is harvested and the second two months later. Altogether, 210 kg/ha/yr of N is applied to the crop in six equal doses to cover three harvests. Application of 30 kg N/ha (15 kg/ha as basal and 15 kg as a foliar spray with 1% urea solution, 45 and 90 days after basal application) is reported to increase herbage yield and oil yield by 447% and 140%, respectively, over the control. 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%.

Pests and diseases

Wilt

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

Control measures:

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

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

Harvesting, processing and yield

Scented geranium is harvested 4 months after transplanting, when the leaves begin to turn light-green and exhibit a change from a lemon-like odour to that of rose. However, this requires careful observation and experience. The crop should be harvested using a sharp sickle and sent for distillation 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 of 25,000 plants should be maintained in a hectare in a year which, in turn, may yield 15 kg of oil on steam-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 scented geranium crop.

*****  *****

Lesson 24

Patchouli- Importance, chemical composition , origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, nutritional requirements, growth regulators, intercropping, plant protection, harvesting and distillation of oil

Importance and chemical composition

Patchouli (*Pogostemon patchouli* Pellet) (syn. *P. cablin* Benth.) (2n=34) belonging to the family Lamiaceae. It is often confused with *Pogostemon heyneanus* Benth which is indigenous to India and is grown in gardens, but has no commercial importance. More than hundred years ago, India used to export fabrics heavily perfumed with dry patchouli leaves, a technique which was later adopted by the French manufacturers to create a typical oriental aroma for their homespun shawls.

Patchouli oil is extensively used as a flavouring ingredient in major food products, including alcoholic and non-alcoholic beverages, frozen dairy desserts, candy, baked goods, gelatin, meat and meat products. It is one of the most important essential oils of the perfumery industry because the oil blends well with other essential oils like vetiver, sandalwood, geranium, lavender, cedar wood derivatives and clove oil. There is no synthetic chemical to replace the oil of patchouli, which further enhances its value and unique position in the perfumery market, and there is great demand for it in soaps, scents, body lotions, pre-shave and after-shave lotions, detergents, tobacco and incense manufacturing factories. The oil also gives one of the finest attars when blended with sandalwood oil. The oil of patchouli is used as an ingredient in insect repellent preparations and is said to have antibacterial properties as well.

Origin and distribution

It is native of the Philippines. The patchouli plant grows wild in Malaysia, Indonesia and Singapore. Its natural habitat extends across Paruguay, Penang, East and West Indies, the subtropical Himalayas and the Deccan peninsula. This crop was introduced in to India by Tata Oil Mills as early as 1942. However, systematic cultivation was started by the ClMAP regional centre at Bangalore in 1962. Now, it is cultivated in Bangalore and the coastal areas of South India, Bengal, Orissa and Assam.

Area and production:

The production of patchouli oil in India is very negligible (about 100-150 kg/year). India is importing over 20 t of oil annually from Indonesia, Malaysia and Singapore. The total annual world production is around 700-800 t.

Description of the plant

Patcholi Patchouli is an erect, branched, pubescent herb, 0.5 to 1.0 m high and aromatic when crushed. The leaves are ovate to oblong-ovate, coarse, simple or doubly crenate-serrate, on both surfaces more or less densely tomentose, the glands are dotted beneath, up to 12 cm by 10 cm. The petiole is 6-8 cm; the stem is densely tomentose and swollen on the nodes; the spikes are terminal and axillary, panicled, dense, sometime interrupted, 2.5-14 cm long. The calyx is 5-6.5 mm; the corolla lobes are obtuse, 6-9 mm, pink, purple or white-violet blotched on all segments: The filaments are violet, with the bracts as long as the calyx. Flowering takes place from January to February in India, Malaya and Philippines. In Java, it is never found flowering.

Types and varieties

Johore, Singapore and **Indonesia** are the commonly cultivated types of patchouli. Of these, Johore yields the best quality oil in terms of chemical composition and odour value whereas, the other two have high herbage and oil-yield potential, but their oils are of inferior quality. The **CIM-Shresta** is the recently released variety of patchouli.

Cultivation

Soil

The plant is hardy and grows on a wide range of soils and under varied climatic conditions. However, partially shaded, well-drained fertile soils with evenly distributed rainfall or places with assured irri¬gation are ideal. A deep, loamy soil rich in humus and nutrients, in the tropics, is said to be the best for optimum oil production. The crop requires a soil pH of 5.5-6.2.

Climate

Patchouli prefers a warm and humid climate and flourishes well in places with fairly heavy and evenly distributed rainfall, ranging from 150-300 cm/year. A temperature of 24-28°C and 75% average atmospheric humidity is reported to be ideal. It grows successfully up to an altitude of 800 to 1050 m above MSL.

Land preparation

The main field is thoroughly by using harrow and disc. Nematicides like Furadan at the rate of 20 kg/ha (3% a. i.) is mixed well into the soil a few days before transplanting. The plot is then laid out into ridges and furrows. The ridges should be 20-25 cm high and 18-22 cm broad, with 60cm row-to-row distance. The beds should be irrigated a day before transplanting.

Propagation

Patchouli is propagated through cuttings. The leaves can also root under intermittent mist and adventitious plantlets can be obtained from these leaves.

Nursery raising

Since the crop is highly susceptible to nematode attack, it is advisable to adopt phyto-sanitary measures at the nursery stage itself. Polythene bags are filled with well-heated sand which can be made by passing steam through it for about one hour. If this is not practicable for a grower, the sand should be treated with a suitable nematicide like Furadan (3% a.i) at the rate of 20 kg/ha.
Shade is essential for raising a nursery and it can be raised at any time of the year. Stem cuttings from

9-month-old branches of 10-12 cm length, consisting of 4-5 nodes especially with the terminal bud and a crown of 2-3 leaves are quite suitable. The basal end of the cutting should be neatly cut in oblique from just about 1 cm below the node. Treatment with 1500 ppm IBA to the basal end encour¬ages rooting. The cuttings should then be planted in seed-pans, nursery-beds or in polythene bags with the help of a dibbler at a spacing of about 10 cm. Aeration, partial shade and regular watering are essential for early rooting. The plants should be removed from the shade about 10 days before transplanting. The cuttings take about 30-35 days for rooting in the nursery and, in about 8-10 weeks, they are ready for transplanting.

Transplanting

The rooted cuttings are transplanted to the main field at a spacing of 60 cm x 60 cm transplanting in August-October gives about 90% establishment. Crops can also be raised by direct planting of the cuttings in the main field. For this, 15-20 cm long cuttings are required. In order to have better establishment, 2-3 cuttings are planted per planting point. During the early stages, partial shade and sufficient moisture are essential. Cuttings planted at an angle give better results com¬pared to those planted erect. When there is a scarcity of cuttings, single-node cuttings can also be raised, but the initial rate of growth of these cuttings is slow and the percentage of success is lower.

Manures and fertilizers

Patchouli requires rich soil. If the soil is of low fertility it should be supplemented with suitable doses of fertilizers. About 12 t/ha of FYM is added while preparing the main field and is mixed well. At the time of transplanting, normally a basal dose of 25 kg N, 50 kg P205 and 50 kg K2O/ ha, is given in the form of urea, super phosphate and muriate of potash. Thereafter nitrogen is applied in 5 split doses after every harvest, in such a way that the crop receives the first dose just after the harvest and another about 2 months later. In total150 kg/ha/yr of N is applied to the crop.

Irrigation

After transplanting, the plants should be watered every day for 3-4 days and subsequently on alternate days for 10-15 days. By this time, the seedlings will have established well and thereafter irrigation once in every 3 days will be sufficient. Patchouli needs evenly distributed rainfall and, hence, artificial irrigation is necessary in areas where rainfall is scanty, to obtain good yields.

Inter culture

The crop may require weeding after about six weeks of transplanting and one hoeing after each harvest. During the first 2 to 3 months, the field should be kept weed-free. Pre-emergence spray of herbi¬cides, Diuron (2 or 3 kg/ha), Simazine, effectively control weeds with low phytotoxity.

Growth regulators

Foliar sprays of Triacontanol (0.05%), auxin (0.25%) + cytokinin or phenol compound (3 ppm) at 2-weekly intervals or 2,4-D (0.5%) at 4-weekly intervals were found to enhance plant growth and yield with the auxin/cytokinin mixture being the most effective. It is reported that Kinetin treatment (0.5 x 10¬-4) was effective in improving growth and increasing oil-yield.

Intercropping

Patchouli is a shade loving plant. It can be grown as an intercrop with coconut, areca nut, rubber, coffee, banana and other plantation crops.

Pests and diseases

Pests

Root-knot Nematode (*Meloidogyne incognita* and *M. hapla*): It is commonly found in tropical and subtropical regions. The nema¬tode which enters into the root by thrusting with the mouth spear, they reach the cortex, multiply and cause galls which are commonly called root-knots. Heavily infected plants show stunting of top growth and wilting symptoms. Typical symptoms of an infested plant become apparent only after 8 months. The nursery should be raised from healthy mother-stock under nematode¬ free conditions. The plot should be treated with a proper nematicide like Furadan @ of 20 kg/ha (3% a.i.) or Dasanit @ 150 kg/ha (5% a.i).

Disease

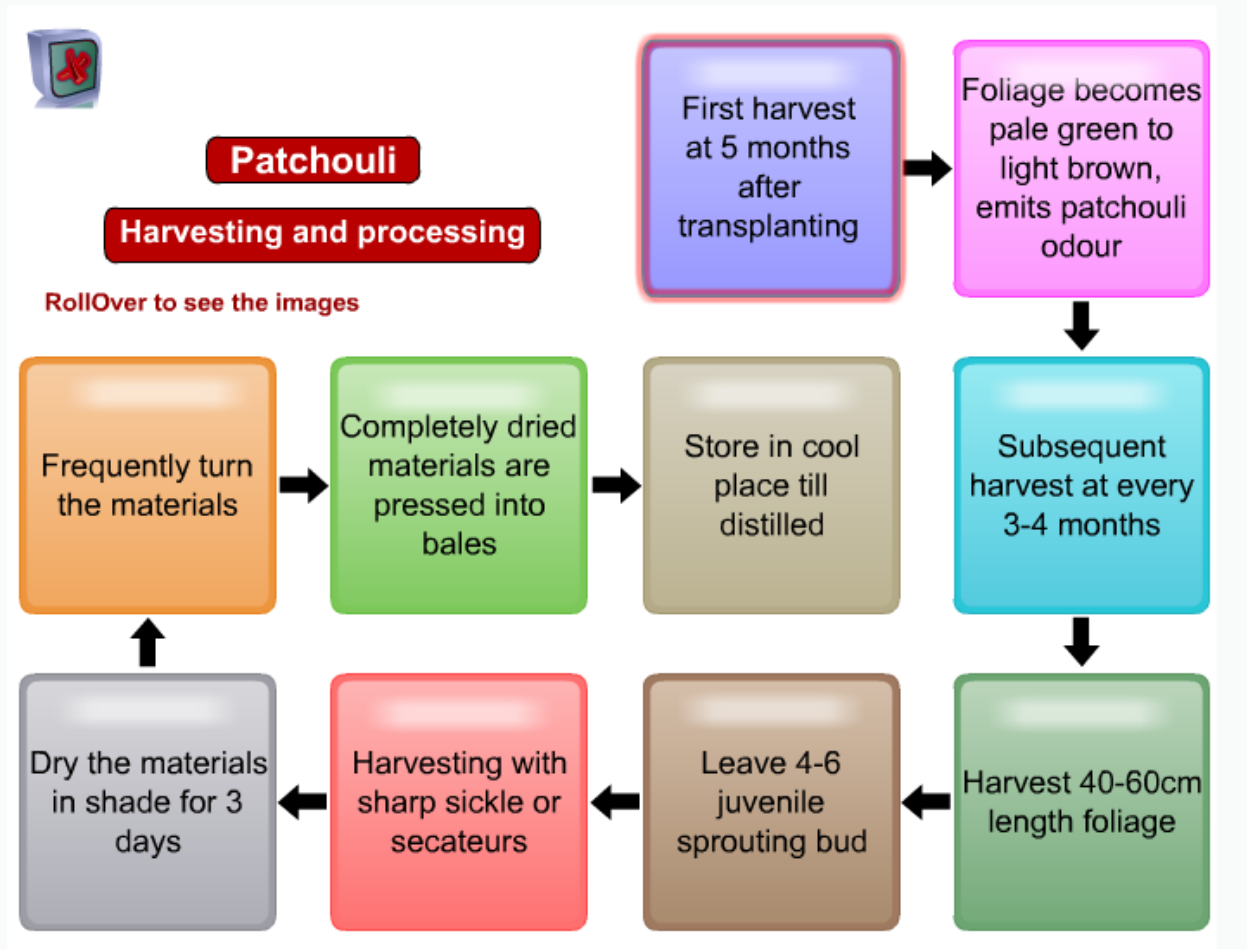
Leaf-blight (***Cercospora spp.***): The disease is characterized by the appearance of brown spots near the margin or at the apical region of leaves which enlarge irregularly, coalesce, cover the entire lamina and starts drying. It is seen in one ¬year-old plants and is less serious than the root-knot nematode. It can be controlled with two sprays of Dithane 2-78, (0.5%) at a one month interval.
The other diseases reported on this crop include wilt caused by *Rhizoctonia solani, Fusarium solani* and *Pythium aphanidermatum* and virus diseases of which pogostemon virus-I, yellow mosaic virus and tobacco necrosis virus (TNV) are important. Yellow mosaic virus is transmitted by white fly *(Bemisia tabaci)*.

Harvesting and processing

The stage at which crop has to be harvested is very important for a good yield and better quality of oil. The first harvest of the crop is obtained after about 5 months of transplanting. It is harvested when the foliage becomes pale-green to light-brown, when the stand emits the characteristic patchouli odour which can be easily smelt by a passer-by, especially in the morning hours. Subsequent harvests can be done after every 3-4 months, depending much upon the local conditions and management practices. The length of cut ¬tops ranges from 40-60 cm. It is necessary to leave 4-6 juvenile sprouting buds at the basal region for rapid regeneration. Harvesting is done with the help of a small, sharp sickle or secateur. The first 2 or 3 harvests of the new plantation give good yield and high-quality oil.

The crop can be maintained for about 3 years. The harvested material is spread out under the shade in thin layers and is turned periodically to ensure proper drying, which is of great importance for obtaining maximum yield and oil of good quality. Drying normally takes about 3 days. During the process, the material should be frequently turned over in order to promote even and thorough drying and to prevent fermentation. Later, completely dried material is pressed into bales and stored in a cool, dry place till distilled.

A good crop yields about 2 t/annum of dry leaves and about 50 - ¬60 kg/ha of oil.



*****☺*****

Lesson 25

Ocimum -Importance, chemical composition origin, distribution, area, production, climate and soil requirements, types and varieties, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting and distillation of oil

Importance and chemical composition

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

The plant contains mainly phenols, aldehydes, tannin, saponin and fats. The essential oil components are eugenol (about 71%, eugenol methyl ether (20%), nerol caryophyllene, selinene, α-pinene, β-pinene, camphorcineole, linalool and carvacrol (3%). A terpeneurobsolic acid possessing anticancer properties has also been isolated. The seeds of this plant give a greenish-yellow fixed oil and also contain antistaphlocoagulase which can be extracted with water and alcohol.
The plant is also used as a pot herb. Its leaves are used as a condiment in salads, and other dishes. The leaves, seed and root are medicinally useful. The leaves also contain ascorbic acid (83 mg 100 g) and carotene (2.5 mg/100 g). The juice of the leaves possesses disphoretic, antiperiodic, stimulating, expectorant and antipyretic properties. It is used in catarrh and bronchitis, applied to the skin in ringworm and other cutaneous diseases and as drops to relieve earache. An infusion of the leaves is used as a stomachic in gastric disorders of children. If taken internally, it strengthens the liver and heart and is a good appetizer. It cures amenorrhoea and promotes the secretion of milk in lactating women. The leaves, if chewed, give relief from toothache. The leaf-juice is applied to reduce inflammations. A decoction of the root is given as a disphoretic in malarial fevers. The powdered root, if taken twice daily for seven days cures spermatorrhoea.

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

Origin and distribution

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

Area and production

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

Description of the plant

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

Types and varieties

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

Cultivation

Soil

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

Climate
The plant can be grown under partially shaded conditions but it yields less oil. It flourishes well under fairly high rainfall and humid conditions. Long days and high temperatures have been found favourable for the plant growth and oil production. Tropical and subtropical climate (at altitudes up to 900 m) are suited for its cultivation. The plant is moderately tolerant to drought and frost.
The nursery can be raised in the third week of February and transplanting is generally started in the middle of April. This can be undertaken in the month of March, if the seedlings are raised in beds.

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

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

Nursery raising
Raised seed-beds of 15′ x 4′x 9″ size should be thoroughly prepared and well manured by the addition of FYM. About 200-300 g seeds are enough to raise seedlings for planting one hectare of land. The seeds should be sown 2 cm deep in the 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 x 40 cm, 40 x 50 cm and 50 x 30 cm to get high herbage and oil-yield per hectare at Lucknow, New Delhi and Indore, respectively. The plots are irrigated immediately after transplanting. 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.

Fertilizer application
The application of 120 kg/ha, 105 kg/ha of P2O5 and K2O is recommended for saline and alkaline soils at Lucknow. The optimum fertilizer dose recommended for this crop is 120 kg N and 60 kg P2O5/ha. Half the dose of N and the entire dose of P2O5 are given as a basal dose. Whereas, the remaining N is applied in two split doses, after the first and second cuttings. The application of the micronutrients Co and Mn at 50 and 100 ppm concentrations, respectively, is reported to increase the oil-yield significantly.

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

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

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

Diseases and pests

Diseases
The plant is susceptible to powdery mildew caused by *Oidium spp.*, seedling blight caused by *Rhizoctonia solani* and roor-rot caused by *Rhizoctonia bataticola*. Powdery mildew can be controlled by spraying wettable sulphur (4 g/I of water), and the latter two diseases are managed by improved phyto-sanitary measures and by drenching the nursery-beds with a solution of mercurial fungicide.

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

Harvesting, yield and processing

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 5 t/ha of fresh herbage can be obtained twice or thrice a year.

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

*****☺*****

Lesson 26

Artemisia -Importance, chemical composition origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, nutritional requirements, Growth regulator application, plant protection, harvesting and extraction of oil

Artimisia annua

Importance and chemical composition

Artimisia annua Linn., commonly known as **'Sweet worm wood'** or **'Annual worm wood'** is a strongly scented annual belonging to the family Astraceae. It is traditionally grown in China as a medicinal plant with pronounced anti-malarial activity. The medicinal property of the herb is attributed to the active constituent 'artimisinin'. The essential oil called 'Artemisia oil,' is used in perfumery, cosmetics and in dermatology. The artimisia oil has some specific antimycotic and antimicrobial action. The main constituent of the plant is artemisinin, artimisilene, arteannuin and artemusinic acid.

Origin and Distribution

The plant is indigenous to China and is also found growing in India in Punjab from Peshawar to Waziristan of Pakistan, Afghanistan, USA, UK, and France. In India it is cultivated in temperate as well as sub tropical conditions in Kashmir valley and Himachal Pradesh.

Description of the plant

Photo courtesy: L.Hegde

A annua is an annual, determinate, erect herb with a very slender and glabrous stem. The branches are deeply grooved, the leaves are broad. The heads are 2 mm in diameter, subglobose, secured in very slender panicle racemes, pedicle is pendulous, the inner orbicular is green and shiny with a scarious margin.

Varieties

A. annua is a highly cross pollinated crop. Hence, the crop exhibits a large variation. The CIMAP, Lucknow, has developed a variety called 'Asha' through mass selection and this variety is recommended for cultivation. Jeevanraksha and Suraksha are the other two varieties recently released from CIMAP, Lucknow.

Cultivation

Soil

The crop is adapted to wide range of soil types from sandy loam to loam, which are free from water logging, but a well drained, light loam, rich in organic matter, is reported to be the best suited.

Climate

A, annua is a short day, temperate plant, which requires a cold winter and a moderate summer. The critical photoperiod lies between 12 and 16 hours. It can also be cultivated in sub tropical areas as a winter crop. The extreme s of too much shade or high temperature reduces the artimisinin content.

Propagation

The crop is propagated by seeds. The seeds are very small in size; therefore direct sowing in the main field does not give good results. Hence, the seedlings are raised in nursery beds and then planted in main field. Two crops can be grown under Indian conditions. The first crop during the late rainy season and the second during summer. The seeds can be sown in the nursery during September October for late rainy season crop and during December for summer crop.

Nursery raising

Nursery beds of convenient sizes are prepared and well decomposed FYM at the rate of 10 kg/bed is applied and 250-500 g of seeds mixed with sand are spread uniformly over nursery beds and covered with thin layers of soil or sand. The beds are kept moist frequently and the seeds germinate in about 5-8 days. The seedlings could be ready for transplanting after 6 -8 weeks.

Transplanting

The beds are irrigated a day prior to transplanting. Transplanting is done at as pacing of 30-40 cm between rows and 45-60 cm between the plants. Gap filling should be done within 8-10 days of planting. It is advisable to plant two seedlings per hill at the time of transplanting.

Manures and Fertilizers

About 10tonnes of FYM and inorganic fertilizer dose of 60-80 kg N, 40-60 kg P2O5 and 60 kg K2O/ha may be applied for a good yield. The full dose of P2O5 and K2O and two third of N is incorporated into the soil at the time of land preparation. The remaining one third of N is applied in two equal split doses at 30 and 60 days after transplanting. A basal application of Borax at the rate of 8kg/ha is recommended.

Interculture

The crop requires 2-3 weeding and hoeing during the growth period. The herbicides, Metachlor and Chloramben (2.2 kg/ha) as pre emergent and Trifluralin as post emergent treatment have been found useful for chemical weed control.

Irrigation
The field is irrigated frequently for establishment of the crop. Once established, only 3 -4 irrigations are required in all.

Pests and diseases
The ant menace can be minimized by mixing about 10 kg/ha of carbaryl dust into the soil at the time of land preparation. Damping off disease can be overcome by adjusting the planting time, so that the bright weather prevails during the first few days in the early stages of establishment.

Harvesting, processing and Yield

The crop is harvested in about 4-5 month as soon as the flower initiation takes place. The crop is cut 15-30cm above the ground level and dried in shade. The fresh herbage yield is about 10-15t/ha which in turn gives 30-40kg/ha of essential oil. The essential oil percentage varies from 0.2-0.4%. The essential oil content is highest in inflorescence. The yellow flowers are reported to contain 2-4 fold higher concentration of artemisinin as compared to the leaves.

Distillation of oil
The essential oil from the fresh or dried leaves and flowers can be extracted by steam distillation or by solvent extraction method using hexane.

Artemisia pallens

Importance and chemical composition

Davana *(Artemisia pallens*) belongs to the family Asteraceae, is an important aromatic herb. The davana herbs are commonly used in garlands, bouquets and religious offerings in most parts of the year. The leaves and flowers contain the essential oil valued for its exquisite and delicate aroma and is used in high grade perfumes and cosmetics. The oil of davana contains hydrocarbons (20%), esters (65%) and oxygenated compounds (15%). The esters are the major constituents responsible for the characteristic smell of davana. The essential oil of davana which is a brown, viscous liquid with a rich, fruity odour has acquired a considerable reputation in the international trade, particularly in USA and Japan where it is being used for flavoring cakes, pastries, tobacco and beverages. India has the monopoly of production and export of davana oil in the world.

Origin and Distribution

The plant grows wild in the temperate Himalayas. It is common in the Kashmir valley, the Shimla and Nainital Hills.

Area and Production
Davana is commercially cultivated in Karnataka, Maharastra, Kerala, Tamil Nadu and Andhra Pradesh in area of about 1000 ha. with an annual production of 8 ton davana oil. In Tamil Nadu, it is grown in Dharmapuri, Krishnagirii, Cumbum, Bodi regions.

Description of the Plant

Davana is an aromatic, erect herb, about 60cm tall with much divided leaves and small yellow flowers.

Cultivation

Soil

The crop is found growing on various types of soils from sandy loam to medium black. However, a fertile, well drained sandy loam soil which is rich in organic matter is ideal.

Climate

Season is an important aspect to be considered when davana is grown for extracting essential oil. The oil content in the plant was maximum when the crop was grown during the winter season compared to the other seasons. Thus, when the crop is grown for the production of oil it should be planted during the first week of November. A few light showers with moderate winter conditions and no frost is conducive to the good growth of the plant. High temperature and heavy rains at the time of flowering have not only been found to affect the plant growth adversely, but also reduces the oil content and ultimately the oil yield.

Nursery raising

Davana is propagated by seeds. As the seeds lose viability rapidly only the seeds from the previous season should be used for sowing. About 1.5kg of seed is required to produce enough seedlings to transplant into an area of one hectare.

Usually, nursery beds 2m long and 1m width are preferred. The surface of the beds should be clod free. It is then incorporated with finely prepared FYM at the rate of 10kg per bed. Sowing of seeds at the rate of 1g/sq m is desirable. The seeds may be sown either dry or after wetting them along with sand for about 48 hours. In the latter case, the seeds are thoroughly mixed with sand @ 4-5 times their volume. To this mixture, water is added so that the sand is sufficiently wet. It is then tied in a cloth bag and stored in a warm place for 48 hours. This will hasten the sprouting of seeds and radical will emerge at the end of 48 hours. The nursery bed is then flooded with water to make a pool and the sprouting seed and sand mixture is broadcasted all over the bed, homogeneously. This method helps in uniform distribution of seeds. When the seeds have settled down a thin layer of sand is spread over just enough to cover them. The seeds will germinate within 2-3 days of sowing. Hand watering is done till the seedlings establish themselves (7-10 days) after which the beds are irrigated directly though the water channels.

While sowing the dry seeds they are mixed with sand and in the ratio of 1: 10 and broadcasted homogeneously all over the bed. A thin layer of sand is then spread uniformly to cover the seeds and the beds are hand watered twice a day. To prevent the ants from carrying away the seeds an application of 10kg/ha of Heptachlor to the soil about 10 days prior sowing has been helpful. Using this method the germination of seeds is observed in about 4-5 days.

In areas where there are rains at the time of nursery raising, the seedlings may be grown on raised nursery beds which will also help in reducing the incidence of damping – off disease.
As there is very slow growth of seedlings initially, foliar spray of urea (0.1%) at weekly intervals, 3 weeks after sowing may be given to boost their growth.

Transplanting

The seedling will be ready for transplanting in about 6-8 weeks from the date of sowing. At this stage, the seedlings should be about 10cm tall.
Before transplanting the field is thoroughly prepared by bringing the land to a fine tilth with repeated ploughings. It is then laid out into plots of convenient size by laying out bunds and channels. The size of the plot depends on the conditions prevailing locally. However, generally, plots of 3-4 m x 1.5-2.0 m size are preferred as it facilitates irrigation, weeding and other intercultural operations. After the preparation of the plots, the soil is incorporated with 6 t/ha of well decomposed FYM or compost. The plots are irrigated a day prior to transplanting. The seedlings are then transplanted at a spacing of 15 cm between rows and 7.5cm between plants. Trials have shown that transplanting davana plants closer together results in higher herbage yield and subsequently, higher oil yield compared to wider spacing, which results in larger plants but lower herbage and oil yield per unit area.

Manures and Fertilizers

Davana responds well to the application of manures and fertilizers. Well decomposed FYM at the rate of 6t/ha is incorporated in to the soil at the time of land preparation. Subsequently, a fertilizer dose of 40kg P and 40kg K /ha is given at the time of transplanting. The N is applied at the rate of 120kg/ha in three equal split doses. The first dose is given at 10 days after transplanting and the subsequent two doses at 15 days intervals thereafter.

Irrigation

After transplanting, the plots are immediately provided with light irrigation. Later irrigation is provided daily till the seedlings are well established (10-12 days) and, subsequently once in 3-4 days depending on the weather conditions.

Interculture

The field is kept weed-free by regular weeding as and when required. In all about 2-3 hand weeding during the early period of growth will help to keep the weeds down.

Growth regulator application

Growth regulators have been used to boost the growth and yield in many crops. In davana also, an application of GA at 200 ppm after fives weeks of transplanting has been found to increase the herb and essential oil yield per unit area.

Pest and Diseases

Insect pests:

No serious attack of insect pests has been reported in davana. However, some insect pests like leaf eating caterpillars, aphids and termites have been observed to affect the crop.

Diseases

Damping off

The disease is caused by fungus belonging to the Rhizoctonia spp. It is usually severe at the nursery stage, particularly when there is high humidity and cloudy weather conditions resulting in the heavy mortality of seedlings. Controlling the irrigation will reduce the incidence of the disease. Treating the seeds with Emisan @ 0.2% before sowing and then drenching the seed beds with the above chemicals a week after germination controls the disease.

Harvesting and yield

The crop starts flowering after 110 – 115 days of sowing, which will be around the 2nd or 3rd week of February. In order to obtain the maximum essential oil yield, the plants should be harvested when about 50% of them have come to the flowering stage. This is usually at the end of February or in the 1st week of March, about 120-125 days after sowing. Harvesting is done by cutting the plants from base. Although there are reports about the possibility of obtaining a ratoon crop in davana, it is not practical as the main crop is harvested only during the month of March and the ratoon starts sprouting by the end of March or the beginning of April which, due to the high temperatures prevailing during this period, results in poor growth of the plants and mutilated flower buds which may even fail to open. The crop, thus obtained, becomes uneconomical as the flower heads are the major contributors of oil.

*****☺*****

Lesson 27

Ambrette - Importance, chemical composition, origin, distribution, area, production, climate and soil requirements, propagation techniques, planting and after care, nutritional requirements, plant protection, harvesting and extraction of oil.

Importance and chemical composition

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

The seeds also possess medicinal properties and are employed in the treatment of diseases due to 'kapha', 'vata' and in stomach and urinary troubles, gonorrhoea, nervous debility, hysteria and skin diseases. They are a stimulant, antiseptic, stomachic, cooling, tonic, carminative and aphrodisiac.

The plant yields good quality fiber. The leaves are used for cleaning sugar. The tender leaves and shoots are reported to be used in soups and the green pods are sometimes used as vegetables. The seeds are also reported to possess insecticidal properties.

Origin and distribution

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

Plant description

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

Cultivation

Soil

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

Climate

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

Propogation

Ambrette is propagated by seeds.

Land preparation and sowing

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

Manures and fertilizers

Well-decomposed FYM is applied to the soil @ 15 t/ha. Since ambrette is a heavy feeder, it also requires chemical fertilizers in large quantities. Fertilizer trials have shown that an application of N at 120 kg, P2O5 at 35 kg and K2O at 40 kg/ha have resulted in the best yields under Bangalore conditions. Of these, a full dose of P and K and 40 kg N are applied as a basal dose, while the remaining 80 kg N is applied in two equal split doses of 40 kg each at 60 days and 120 days after sowing. The fertilizer mixture is applied about 10 cm away from the plants and mixed well into the soil.

Interculture

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

Pests and diseases

Pests

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

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

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

Diseases

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

Collitotrichum hibisci is reported to cause anthracnose. For controlling this disease, the seeds should be treated with Agrosan GN or Cerason before and the crop may be sprayed with Bordeaux mixture. Leaf-spot disease is caused by Alternaria hibiscicum, and Phytophthora spp. causes leaf blight. Fusarium wilt caused by Fusarium vasinfection has also been reported. On the drying stems and branches, a sooty black fungus (Pseudotorula verrucospora) has been observed.

Harvesting and yield

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

The pods have to be shade-dried after harvest. The seeds are separated from the pods by beating the pods with sticks or by splitting the dry pods by hand. The seeds have to be cleaned, shade-dried and stored. A normal crop may give a yield of 9-10 q/ha of seeds. The essential oil is extracted using steam distillation methods. However to extract the fatty substances, solvent extraction method is followed.

*****☺*****

Lesson 28

French Jasmine -Importance , chemical composition origin, distribution, area, production, climate and soil requirements, species and varieties, propagation techniques, planting and after care, pruning, intercropping, nutritional requirements, plant protection, harvesting, packaging and extraction of oil.

Importance and chemical composition

- French Jasmine (*Jasminum grandiflorum)* (Family: Oleaceae) has a unique place in perfumery because of its high value of oil traded as 'concrete'.
- Its flowers produce a gently pleasing delicate aroma.
- The concrete or absolute extracted through solvent extraction is used in manufacturing of high value perfumes and their umpteen fragrance formulations.
- In India, its cultivations have spread in southern states after development of a culture, 'Pitchi'.
- It blooms for 6-7 months (mid-May to early-December) in Tamil Nadu and Karnataka.
- India is now second largest producer of jasmine 'concrete' after Egypt, exporting most of its produce to Europe.

Description of the plant

French jasmine is a climbing shrub, but is trained into bushes under cultivation. It has compound opposite leaves, made up of 7-11 leaflets. It produces bisexual flowers in first year of planting. Because of its heterogamous nature of flowers there is no setting of seed. Therefore, it is raised through stem-cuttings. The flower buds do not emit any fragrance. But on opening in early morning, the petals emit fragrance. They continue to give out sweet, pleasing aroma for about 16hr after plucking. The oil evaporates fast in sunlight. Photo courtesy: L.Hegde

Area and production

Tamil Nadu leads in production of J. grandiflorum with an estimated area of 2000 hectares.

Varieties

CO 1 - Clonal selection from germplasm. Suitable for both loose flower production and oil extraction. Pink streaks are found on external surface of petal. The average yield of flowers is 10 t/ha. with a concrete recovery of 0.29 per cent.

CO 2 - Induced mutant from CO1 Pitchi. It has bolder pink buds with long corolla tube with yield of 11t/ha.

Arka Surabhi – A selection from the germplasm obtained from Lucknow is released from IIHR, Bengalore. It is pink pin type with flower yield of about 10 tons/ha and a concrete yield of 0.35%.

Cultivation

Soil and climate

Jasmine can be grown in a variety of climate and soils. Generally, it prefers mild tropical climate for proper growth and flowering. Mild winter, warm summer, moderate rainfall and sunny days are ideal climatic requirement. Loamy garden soils are best-suited for cultivation of all species and varieties. With liberal appli¬cation of manure and assured water supply, jasmines can also be grown suitably in sandy soils. In clayey soil, flower production is hampered to a great extent. It is highly susceptible to water logging. This type of soil can be improved by adding lime and applying organic manures. A mild climate with well-distributed rainfall of 80-100 cm and sunshine all-round the year is desirable.

Propagation

Easy means of propagation is by stem cuttings. High percentage of rooting and increased number of long roots is obtained when cuttings are taken during April-September. The 15cm long shoot tip cuttings having 4 leaves are treated with 4000ppm IBA and planted in vermiculite or sand under mist give best performance in rooting and survival of rooted cuttings. A large number of Jasminum species, can be propagated from stem cuttings under mist in a sand medium with the treatment of 4, 000ppm IBA.

Planting

The land preparation is done by deep ploughing (2 times). The plants are raised through rooting of 20 cm long stem-cuttings, prepared from near mature wood and planted in pits during rainy season, Pits of 30 cmx30 cm size are dug at 1.8 x 1.5m or 2 x 2 m spacing, and connected by a irrigation channel. It is filled with a mixture of top soil and dry leaf powder mixed with farmyard manure to which 15g Aldrex is added to protect the plants from termite attack.

Pruning

The vines are pruned from late-December till mid-January at 90cm length, maintaining 9-11 shoots to obtain maximum flower yield. After pruning, soil around bushes should be dug out to facilitate aeration and induce growth. Sometimes, when vegetative growth is large, a light pruning in July may be done to induce lateral branching and flowering. The plantation needs fortnightly irrigation during dry season.

Manures and fertilizers

The application of 100, 150 and 100g of N, P and K per bush annually produces maximum flower yield. The plantation should be kept weed-free. Spraying of Gramoxone at monthly interval controls

weeds. Usually, January-April is ideal season for intercropping to obtain additional income.

Irrigation

Moderate watering is good for jasmine. It is more essential in flowering season. During blossoming, the water should be applied twice a week if there is no rain and once a week during rest of the months. Soon after the cessation of flowering, watering is to be completely stopped until pruning and fertilizer application. With the advancement of cold weather, the plants begin to shed leaves. After pruning and manuring, watering is resumed. With the close of each flowering phase, watering is completely stopped for weeks together till the appearance of fresh flowering buds.

Harvesting and oil extraction

The flower crop (mature buds and open flowers in early stage) is picked in early morning (5-8 AM). The open flower crops are processed for extraction of oil immediately. It continues to produce blooms from May to early-December. The yield in first year is low (500 kg) but it increase to 5 tonnes in second year and 10 tonnes/ha in third year onwards. Although decline may commence after 10 years, relatively satisfactory economic yield continues to be received up to 15 years in a well-managed plantation. Usually, food-grade hexane or petroleum ether is employed as a medium of solvent extraction and oil along with waxes is extracted and separated out at low temperature and dried in vacuum. On an average, 340-400 kg of flowers are needed to produce 1 kg of concrete; the commercial yield of concrete being 10 kg/ha over the years.

For production of its 'absolute' (mainly used to measure purity of the produce), the 'concrete' 'is dissolved in absolute' alcohol and waxes are removed through filtration. The 'absolute' or 'otto' is a semi-viscous, dark coloured material, emitting fragrance of fresh jasmine flowers.

*****☺*****

Lesson 29

Oil bearing rose -Importance, chemical composition origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, rejuvenation, harvesting and extraction of oil.

Importance and chemical composition

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

Rose oil is one of the most valuable perfumery materials from ancient times. All high-grade perfumes contain at least some quantities of rose oil. The best quality rose oil imparts characteristic flowery top-notes to perfumes, the absolute adds lasting tonalities and increases the fixation of odours. The different products of rose are used in cosmetics, beverages, cold drinks, foodstuffs, tobacco flavoring like snuff and chewing tobacco, fruit flavours, soft drinks, alcoholic liquors and medicines. It is reported that 3 drops of rose oil three times a day is useful for the treatment of gallstones. The rose flowers possess a laxative property due to the presence of a flavanol glycoside.

Origin and distribution

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

Area and production

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

Description of the plant

R. damacena is a perennial shrub with a long lifespan of 20 to 30 years under cultivation. It grows to a height of 2.5-3m. The stems possess numerous, moderately hooked, falcate prickles of unequal size, intermixed with glandular bristles. The leaf is stipulate, compound and imparipinnate, with 5-7 leaflets: the stipules are adnate. The leaflets are moderately large, ovate to oblong and serrate. The flowers are borne in groups of 5 to 7 in axillary terminal corymbs. The flowers are sweet-scented, pink, red or sometimes white-striped. The pedicel possesses densely packed acicular and hispid glands. The sepals are leafy, pinnate, reflexed, and persist after flowering. The petals are over seventy, light-pink fading to white. The fruit is pseudobacate, made up of several hard achenes enclosed within a succulent calyx tube. The fruits (hips) are ovoid, bright-red, pulpy and rich in Vitamin C.

The damask rose has many commercial varieties known in cultivation. *R.damascena* var. *trigintipetala* is called Kanzanlik rose and is grown in Bulgaria. This is similar to R. damascena which is grown in Aligarh district. Another strain of *R. damascena* var. *bifera* is grown in the Kannuaj district of Uttar Pradesh. In the Aligarh district of Uttar Pradesh two other types are grown, one of which flowers twice a year and is called 'Dofasali', the other flower only once, as usual.

Varieties

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

Besides, the scientists at the Institute of Himalayan Bioresource Technology (IHBT), Palampur, have developed tow new varieties 'Jwala' and 'Himroz' for high flower and oil yield. 'Jwala' is suitable for cultivation in subtropical northern plains, low hills and mild temperate regions up to 1200 m altitude. It flowers in March-April and then in September and is tolerant to hailstorms, rains and high velocity winds. Jwala bears short clusters of flowers in compact bunches: the weight of a single flower varied between 2.2 to 5.0 g.

'Himroz' is ideal for cultivation in mild temperate to cold temperate regions (1200-2500 m). It is winter tolerant and grows in cold areas without any visual sign of winter injury. It flowers for 22-25 days during the early summer and the weight of a single flower varies from 1.8 to 4.00 g.

Cultivation

Soil

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

Climate

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

Preparation of land

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

Propagation

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

Preparation of nursery

A mixture of FYM (4:1) is added to the nursery-beds and mixed well into the soil. After leveling the field, P2 O5 and K2 O @ 20:40 kg/ha are also added as inorganic fertilizers.

The propagation material (cuttings) are taken from healthy, flowering bushed during November-December, usually 25 to 30 cm-long stem-cuttings with one year growth, preferably the anterior portion with four to five nodes of 1 to 2 cm diameter, are taken. The basal end of the cuttings is treated with Indole Butyric Acid (IBA @ 200-250 ppm) solution for four hours before planting, which helps in inducing roots. The beds are frequently irrigated. The cuttings begin to sprout after a month's time (30 to 35 days) and the beds are kept free from weeds. When the cuttings have attained a height of 10 to 15 cm, a dose of 20 kg N/ha in the form of nitrogenous inorganic fertilizer are applied 4 to 5 cm away from the plants and mixed well into the soil. Monthly spraying of Benlate (0.1%) or Bavistin is done to keep away diseases.

Rooted cuttings are transplanted into the field after one year from mid-November to mid-January.

The rooting percentage of the cuttings from the year-old shoot ranges from 50 to 60% whereas from the other shoots, it is 25 to 30%.

Transplanting

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

Manures and fertilizer

FYM @ 18-20 t/ha mixed with 100-125 kg N, P and K (18:32:16) mixed with fertilizers should be applied at the time of transplanting the rooted cuttings. Since rose plants remain economically viable for 15-20 years, the soil around the plant must be sufficiently supplied with nutrients. Therefore, the need to apply fertilizer every year is evident. A total of 160 kg/ha N, 80 kg/ha each of P2O5 and K2O, should be applied each year in the form of inorganic fertilizers to get a good yield of flowers. Fertilizers should be applied at a depth of 20-30 cm beside the rose-bushes, which is the peripheral zone containing most of the feeding roots. Phosphorus and potash are applied as a basal dose whereas, nitrogen is given in three equal splits during May, July and September. The application of fertilizers along with NAA (20 ppm) spray and 1% micronutrient mixture enhances the flower yield.

Irrigation

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

Inter cultivation

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

Intercropping

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

Pruning and training

Rose plants require a dormant or resting period before flowering. Hence, pruning is an essential operation for obtaining a good flower yield. Its intensity and shape vary with the age of the plant. The first pruning is done after plant attains two years of age of the plant. The first pruning is done after the plant attains two years of age. At 1050 m height from the ground-level, shoots and branches are removed with the help of secateurs, leaving 8 to 10 primary branches in the shape of an umbrella. Whatever shoots appear during the growth phase are also removed, as they do not bear flowers. The time for pruning is during the first week of November to early December in temperate climates. In subtropical climates, heavy pruning at 30-45 cm of the plant-height is done during December-January and the soil around the base of the rose plants is dug up to bare the primary roots which facilitates the chilling of roots and, in February, the soil is again heaped at the base of the plant. The plants take about 70 to 90 days to flower after pruning. The other purpose of pruning is to train plants in the

desired form, to keep the desired size, to remove injured and diseased parts, to remove the terminal buds and change the growth habit, to encourage bushy roses, to provide more horizontal expansion and finally to produce more flower-buds.

Pests and diseases

Pests

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

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

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

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

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

Caspid Bugs *(Lygocoris pubulinus)*: These pale-green insects suck the sap from the shoot-tips mainly from young flower-buds, causing the flower petals to develop small holes. The application of Carbofuron or Phorate @ 10 kg/ha to the soil after pruning, at the time of bud-formation, is recommended for the control of this insect.

Brown and Scurfy Rose Scale (*Aulacapis rosae)*: The scales occur on the stems and suck the sap from the stems, resulting in the drying up of the shoot. The incidence is more during the rainy/autumn season. For control of this insect, foliar sprays of Monocrotophos (0.15%) or Carbaryl (0.3%) is recommended.

Diseases

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

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

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

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

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

Flowering, Harvesting, yield and Distillation of flowers

Flowering

In northern India, the main season of flowering is 30-40 days during March-April. It reaches a peak in the middle of March and then starts declining. However, sporadic flowering does occur during September and October. Though the flowering stars in the second year after planting, it is always economical to harvest flowers from third year onwards. The flowers of the early crop are heavier than those received late in the season.

Harvesting and yield

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

Distillation of flowers

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

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

Rejuvenation

Yearly observations have shown that rose plantations do not have a uniform rate of production. In the first 5 to 6 years the flower yield rises, but after the sixth year the flower production declines. After 8-10 years, the roses become unprofitable, necessitating rejuvenation.

Autumn is the most favourable time for rejuvenation. The bushes are cut down to the base and on both sides of the rows, trenches 18-20 cm deep are opened and the soil is spread in the inter-row space. In these rows, 20-30 t of FYM along with 60 kg/ha each of P2O5 and KO2 are placed and covered with soil.

In the spring, new shoots develop and out of them only six to eight vigorous branches are allowed to grow. After 2 years, the yields of rose flowers reach the previous level and the life of plantation is increased by a further 8-10 years.

*****☺*****

Lesson 30

Tuberose (Polianthes tuberosa L.)-Importance, chemical composition origin, distribution, area, production, climate and soil requirements, species and varieties, propagation techniques, planting and after care, growth regulators, nutritional requirements, plant protection, harvesting, ratoon cropping and extraction of oil.

Importance and chemical composition

Tuberose (*Polianthes tuberosa* L.), belonging to the family, Amaryllidaceae, is essentially a florist's flower- a leading commercial crop because of its multifarious uses. The fleshy, white, tubular flowers emit a strong odour and hence are cultivated on a large scale in some parts of the world for the extraction of highly valued natural flower oil, the tuberose oil. The predominant charac¬teristics of this crop are its lingering, delightful fragrance and excellent keeping quality.
The tuberose oil contains methylbenzoate, methyl anthranilate, benzyl alcohol, benzyl benzoate, butryic acid, phenyl acetic acid, methyl salicylate, eugenol, geraniol, nerol both free and as acetates, farnesol, methyl vanillin and piperomel. The leaves, flowers, bulbs and roots are reported to contain sterols, triterpenes, carbohydrates, saponins and traces of alkaloids.

The tuberose flower oil of commerce is one of the most sought after and expensive raw materials in perfumery. The fresh flowers give a concrete yield of 0.08 to 0.11 %, of which nearly 18 to 23% constitutes the alcohol-soluble 'absolute'. The essential oil is used in only the highest grade perfumes. Sometimes, the oil is used in flavouring candy, beverages and baked food.

Origin and distribution

The tuberose is a native of Mexico. It is grown largely in the southern states of America, Italy, France, Morocco, South Africa, Taiwan, Egypt and many other tropical and subtropical areas in the world.

Area and production

In India, tuberose is cultivated on a commercial scale in Ranaghat, Kolaghat and Panskura in West Bengal, Devanahalli, Tumkur and Mysore in Karnataka; the East Godavari, Guntur, Chittoor and Krishna districts of Andhra Pradesh; Coimbatore in Tamil Nadu and Pune and Thane in Maharashtra. The annual world production of tuberose concrete is about 6-12 tones. India is exporting sizable quantities (approx. 0.5-1.0 ton) of tuberose concrete. There are a few units in India producing tuberose concrete and many of them are located in South India. Reliable estimates on the total area under tuberose cultivation in India are not available.

Description of the plant

P.tuberosa has a tuberous root-stock and a mass of basal foliage. The leaves are pale-green, long, narrow and very dense. The leaves at the base are 30 to 40 cm long, 1.2 to 1.5 cm in width, sometimes reddish near the base. The flowering stems are long and can reach a height of up to 100 cm, although 60 to 75 cm is normal. It is approxi¬mately the top third of the stem which bears the pure, white, waxy-textured raceme of blooms. The flowers are borne in pairs on a lax spike and are 3 to 6 cm in length. The segments are 1 to 2 cm long, the tube is long, narrow and funnel-shaped, slightly bent near the base. The filaments are attached to the upper part of the corolla. The ovary is 3-celled, there are 3 stigmas which are ovate-falcate. The fruit is crowned by a persistent perianth, and the seeds are flat.

Species and varieties

There are about fifteen species under this genus, of which twelve species have been reported from Mexico and Central America. Of these, nine species have white flowers, one is white and red and two are red. With the exception of *P. tuberosa* L., all the others are found growing wild.
There are four types of tuberoses named on the basis of the number of rows of petals they bear. Of the four types single, semi double, double and variegated - available, the single type has the most fragrance. The flowers are pure white and are popular among the growers for the production of essential oil.

Among the single varieties, 'Calcutta Single' and 'Single Mexican' are grown in Tamil Nadu. Recently, a single type variety, 'Suvasini', has been released by the IIHR, Bangalore. Another single-flowered variety, 'Rajat Rekha', a mutant, has been released by the National Botanical Research Institute (NBRI), Lucknow.

The 'Semi-double' type bears white flowers with two to three rows of corolla segments. The 'Double' type has more than three rows of corolla segments and is white in colour. The flowers tinged with red in the 'Double' type are known as 'Pearl'.

The variety 'Pearl Double' has been assessed for flower-yield and quality under different agro-climatic conditions in India. Another double variety, 'Swarna Rekha' a mutant, has been released by

the NBRI, Lucknow. In this variety, the leaf-margin is streaked with golden-yellow. Recently, 'Shrinagar', a double variety, has been released by the IIHR, Bangalore. A high concrete yielding 'Suvasini' is also released for cultivation from IIHR, Bangalore. There are some streaked leaf-forms, known as 'variegated', where¬as in others the flowers have little tinge of red in the bud-stage, which turns to white when fully open. Other varieties include 'Albinos' and 'Excelsior'

Cultivation

Soil

Tuberose can be grown on wide variety of soils from light, sandy loam to a clay loam. The soil should be at least 45 cm deep, well drained, friable, rich in organic mater and nutrients with plenty of moisture in it. The soil should have a pH range from 6.5 to 7.5 with good aeration. The crop can be grown even in high saline-alkaline soils with better agronomical practices. It is observed that the vegeta¬tive growth and flowering are affected by increasing the levels of NaCl and very a low concentration of CaCI2.

Climate

The crop is best suited for cultivation in tropical to subtropical and temperate climates. The crop is reported to flower profusely through¬out the year, if the climate is mild and free from extremes of high and low temperature. A temperature range from 20-30°C is considered ideal for this crop. If the temperature is above 40°C, the spike length and quality of the flowers are affected. Very low temperature and frost will damage the plants and flowers. Tuberoses grow well in a sunny situation. Although the plant is photosensitive, exposure to a day-length of about 16 hours appreciably promotes vegetative growth and enhances the emergence of the first flower-spike by 10 days. The length of the flower-spike also increases under long days.

Season

Tuberoses are generally planted in February-March in the plains and April-May in the hills. The bulbs can also be planted during July-August. Tuberoses can be planted all year round in Bangalore, but a higher flower-yield is obtained from the April-May planting. To obtain flowers almost throughout the year, sequential planting can be practiced.

Land preparation

The land is ploughed deep, twice, to a depth of 45 cm. The first ploughing is done in January and the second about a month before planting. At the time of the second ploughing, 20-50 t/ha FYM is incorporated into the soil. Then the soil is brought to a fine tilth by breaking the clods and removing the weeds. The field is laid out into plots of convenient sizes with irrigation channels, ridges and furrows at the recommended spacing.

Propagation

Tuberoses are propagated by bulbs, bulb lets and seeds. Multiplication by bulb-segments and micro propagation from scale stem-sections is also possible. Propagation by bulbs is the most common method practiced for the commercial multiplication of tuberoses. The bulbs remain dormant during the winter months in places where the temperature is low and, if early planting is desired, the dormancy can be success¬fully broken by dipping the bulbs in 4% Thiourea solution for one hour. Ethylene chlorohydrin can also be used for breaking the dormancy.
The bulbs are separated from the clumps by rubbing off the loose scales and the long roots should

also be removed. Spindle-shaped bulbs with a diameter of 2.6 to 3 cm size are used for planting. However, if the bulbs are very large they may be cut into 2-3 vertical sections, each containing a bud and part of the basal plate. Each of these sections is treated with copper fungicide and planted vertically with their tips just showing above the surface. About 8-9 t (1.0 to 1.5 lakhs) of bulbs are required to plant an area of one hectare.

Planting

The density of planting markedly influences the yield and quality of the flowers. The planting distance varies with the soil and climatic conditions. Spacing of 15 x 20 cm, (for Maharashtra), 25 x 25 cm (for West Bengal), 30 x 30 cm (for Lucknow), 30 x 22.5 cm (for Bangalore) and 20 x 20 cm (for South India) have been recommended for this crop. While planting, the bulbs are planted at the recommended plant-spacing, 3.5 cm deep on the sides of the ridges. The plots are irrigated immediately after planting.

Manure and fertilizers

Depending on the soil fertility, 20-30tonnes of FYM is applied. The neutral clay soils of Tamil Nadu the recommendation is 100 kg N and 60 kg P2O5/ha. For achieving increased essential oil content in flowers and for the maximum recovery of concrete, a fertilizer dose of 80 kg N, 60 kg P2O5 and 40 kg K2O/ha has been recommended. Of the full recommended dose of fertilizers, half the N, the full doses of P and K are applied at the time of planting and the remaining half of N is given as a top-dressing after 45 days of planting. Apart from N, P and K, calcium, magnesium, sulphur, iron, zinc, manganese, aluminium, boron and copper have also been found to influence the growth and flowering in tuberoses.

Irrigation

Irrigation is given immediately after planting. Subsequently, the crop is irrigated at 5-7 days intervals, taking into consideration the weather conditions. In the summer months, irrigation is recom¬mended twice a week.

Interculture

In order to keep the plots free of weeds and to avoid the exposure of bulbs, the plots are weeded and earthed-up once a month. Earthing-up enables the spikes to grow erect, despite strong winds and rains. The application of Atrazine (3 kglha) as a pre-emergent weedicide keeps the plots weed-free. A pre-emergent treatment of Gramaxone (3 kg/ha) followed by three post- emergent sprayings at intervals of 110 days in between the rows also keeps the crop weed¬ free. Mulching the plots with strips of black polythene, dried grass and chopped straw is effective in controlling weeds.

Growth regulators

The effects of pre-planting treatment of bulbs with GA3, ethrel or thiourea promoted early appearance of flower and the number of flower spikes but reduced the number of bulbs per plant. Treatment with GA3 (200ppm) produced highest number of longer spikes with maximum number of florets.

Pests and diseases

Tuberose is hardy crop and is not much affected by attacks of insect pests and diseases.

Pests

Aphids and grasshoppers are found to feed on flower buds and leaves. They can be controlled by a 0.1 % spray of Malathion or Rogor at an interval of 15 days. The leaves become yellow or bronze, due to the sucking of sap by red spider mites. A spray of Metasystox (0.2%), wettable sulphur (0.3%) or Kelthane (0.5%) is recommended for effective control. The flowers also get deformed by thrips attack. The control measure suggested is to spray Nuvacron (0.1 %) or the application of Thimet to the soil. Root-knot nematode (*Meloidogyne incognita)* and greasy streak nematode (*Aphelencoides besseyi)* are reported to cause damage to the crop, which is characterized by the stunted growth of the plants. The leaf size is reduced and the flowers look sickly and, ultimately, the roots rot. The application of Thimet or Furadan (20 kg/ha) to the soil has been recommended for control.

Diseases

The fungi, *Scelerotium rolfsii,* deposits prominent, coarse, mycelial masses on the leaf surface or near the soil-level. Later, the infested spots exhibit a light-green colour due to rotting which extend and cover the whole leaf. Drenching the soil around the stem with Brassicol @ 1 % and the soil with 0.3% has been recommended for control.

The fungi, *Alternaria polyantha*, causes leaf-spot disease, which is characterized by the appearance of brown spots with faint concentric rings on the mid-rib. Bordeaux mixture (0.4%), Zineb (0.5%) or Ziram spray will effectively control the disease.

The other diseases reported are leaf-spot and blight caused by *Botrytis elliptica,* rust and powdery mildew, which are not serious. Suitable fungicides may be administered to control them when the damage is noticed.

Harvesting and yield

Flowers are ready for harvest in about 3 to 3½ months of planting. August-September is the peak period of flowering. Depending on the purpose, harvesting is done by cutting the fully-opened spikes from the base or single flowers are harvested as they open by day; the picking of individual flowers should be completed by 8.00 a.m. The flowers have a shelf-life of 3 days. About 17-18 t/ha flowers can be expected from a well-maintained garden.

About 150 kg of flowers are required to produce 1 kg of concrete. The extracted flowers will contain some natural perfume and are treated with petroleum ether to obtain the absolute of chassis as a valuable by-product (yield 1.2-1.5%). In recent years, the process of Enfleurage has been partly replaced by solvent extraction, which requires much less labour though the yield of the absolute reduces considerably. The extrac¬tion of the tuberose flowers with petroleum either yields 0.08-0.11 % of concrete, which gives 18-23% of absolute on treatment with alcohol. The concrete yield is about 17-18 kg/ha which gives 3.5 kg absolute and 0.8 kg distillable oil.

Ratoon cropping

After harvesting the main crop, the flower stalks are headed back (cut to the base) and the plots are manured and irrigated. About 3-4 ratoon crops can be taken from a single planting.

*****☺*****

Lesson 31

Lavender -Importance, chemical composition origin, distribution, area, production, climate and soil requirements, varieties, propagation techniques, planting and after care, training and pruning, nutritional requirements, plant protection, harvesting regeneration of old plantation and extraction of oil.

Importance and chemical composition

Lavender (*Lavendula Linn*.) is a small genus of perennial aromatic herbs, semi-shrubs or shrubs of Lamiaceae family. It includes about 28 species. Three species of Lavendula are extensively utilized for extracting essential oils. These are True Lavender, *L.angustifolia* Mill sub sp. angustifolia (Syn.*L.officinalis Chiax, L.vera Dc.,)* Spike lavender, *L.latifolia* Mill., *L.spica*.DC and Lavandin, *L.intrmedia Emeric*; ex Loiset Mill., *L.spica.* DC and Lavandin, *L.intermedia Emeric; ex Loiset* (Syn.L.hybrida Revr.,). The latter is a hybrid between true lavender and spike lavender. 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.

Lavender oil has a delightfully clean, refreshing and sweet odour. Its main constituent is the ester, linalyl acetate, which ranges from 30 to 60% and to which the characteristic lavender odour is is attributed. Another compound which is present only in small amounts but plays an important role in the odour is ethyl-n-amyl ketone. Free linalool is also a major component, particularly of the English lavender oil, which has a peculiar heavy and slightly camphoraceous odour. The other compounds present in lavender oil are: α-pinene, camphene, β-pinene, limonene, cineole, cis-oscimene, trans ocimene, camphor terpinen-4-0l, caryophyllene, lavandulyl acetate, lavandulol, α-terpineol and borneol.

Lavender oil is one of the most popular scents, its delightfully refreshing odour blends well with many other essential oils. Lavender water, a mixture of oil in water and alcohol, is a highly popular toilette articles in England. The best quality oil (50% esters) is used in the preparation of high-grade perfumes, second quality (38 to 42% esters) for lavender water, toilette waters eau de cologne,etc.; and low grade (30 to 35% esters) oil in the scenting of soaps and talcum powders. 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.

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.

Origin and distribution

Lavender is indigenous to the Mediterranean region, growing wild in the higher hills of Southern France, Italy and Bulgaria. It is also cultivated in several other countries in Europe and elsewhere.

Area and production

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. No data is available on area and production of lavender in India.

Description of the plant

Lavender (2n=42 or 48) 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, these are quadrangular, grayish and pubescent. The leaves are opposite, long, narrow, lanceolate and grayish-green, with a downy appearance. The flowers are densely packed in layers and seem to be in whorls. The flower is mauve to violet shade, tinged with a light blue.

Lavandin has two forms: Spikevero and Verospike. The former has a general appearance like spike lavender, while the latter is like true lavender. The tufts of the spikevero form are strongly developed, reaching over 1 m in height and 90-11 cm in diameter within row and 120-170 towards the inter-row spaces, its leaves are broad, shovel-like and grey- green. The floriferous stalks are usually branched. The ear is compact, long, slightly tilted. Its flowers are large and almost always sterile. The verospike forms smaller tufts, has darker green and less smoky leaves. The floriferous stalks are long, but usually not branched. Their floscules are compact, with less floret per node (6-10).

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,A-9,B-2 and B-11.

Cultivation

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).

Climate

Lavender is a temperate, photophilous 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.

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

i) 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 14-15ºC. The seedlings should be pruned periodically to avoid follicle formation and to achieve regular growth of the young plants.

ii) 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.

Application of fertilizers

Generally, a basal does of 20 kg N, 40 kg P2O5 and 40 kg K2O is applied before planting. While 80 kg of N/ha is applied in four split doses during each year. The CIMAP centre at Srinagar has obtained the highest spike-yield (100 kg/ha) by 150 kg N/ha in limed plots.

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.

Lavender plantations which are over three years should be machine hoed, 3-4 times between the rows. One digging is done before the blossoming in the spring.

Training and pruning

No training is required and the plants are allowed to grow until harvest.

Harvesting, Extraction of essential oil and Yield

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

About 10 tonnes of fresh herbage is obtained in one hectare.

*****☺*****

Lesson 32

Organic production of Medicinal plants

Introduction

The medicinal plants are necessarily to be cultivated organically and there is no other option. The medicinal plants were collected so far from the forest where there was no cultural intervention and plants have grown luxuriously in nature. Such wild gathering phase was over by now and many of the commercially important herbs are to be grown under cultivation owing to its increasing demand. Eg. Senna, Gloriosa, Coleus forskohlii, and Aswagandh.

Microflora Management

Soil microbes are the entities which give life to the soil. They thrive in humus and cause ionic degradation to release the elements for plant growth. The soil devoid of microbes are supposed to be sterile one. The root growth and the canopy growth are the directly influenced by the extent of microbes present in the soil. Few microbes aid in digestion and fermentation of organic matter applied to the soil, some acts against many of the damaging fungi or bacteria and many help to build up the soil.

Sustain soil dynamics

Soil is a living entity. It has the digesting capability. Any organics buried into the soil get digested in no time and converted into humus and minerals. Soil has aerobic and anaerobic respiration through their capillaries. Soil has water movement both against and also the gradient. Soil is capable of reviving a life of a plant either through seed or through plantlets. It regenerates. Digestion, respiration, circulation and regeneration capability keep the soil always in a dynamic state and thus makes it a living entity.

Zero residual toxicity

Cereals and pulses carry less load to human system in as much as they contain only 6-10% moisture where as the fruits, vegetables, spices and plantation and medicinal plants as well carry heavy load of toxins due to the higher water content. The residual toxicity of pesticides, fungicides and weedicides get carried to the human system through food. Organic cultivation primarily aims to get rid of the toxic loads of pesticide chemicals rather than the fertilizers.

Bio inputs in organic production and other versions of organic farming

Bio manures

Bio manures though contain less quantity of essential nutrients, they help to build the capacity of the soil to generate its own nutrients. They help to enrich the humus, sustain microflora, accelerates soil dynamics. They help the plants to become sturdier and tolerant to pests and diseases. Farm yard manure is a universally accepted bio manure while goat manure is supposed to be superior but its availability is limited. The poultry manure is available in bulk but should be used after an year without complete degradation. Poultry manure is suggested to crops which require irrigation once in five days. Organic cakes viz., neem, castor, groundnut, pungam etc., are enriched form of organics which are to be applied in lesser quantities. Pressmud is composted and now made available as

manure but cost is prohibitive. Vermicompost is most sought after item and can be produced within the farm. It is best suited for high value medicinal plants. Vermi wash and casting are enriched form of vermi compost.

Bio fertilizers

Many of the fungi and bacteria are useful to upgrade the soil quality and helps for maximum root ramification and absorption of elements by plants VAM (Vascular Arbuscular Mycorhizae), phosphobacteria, rhizobial cultures, azospirillum, blue green algae and azolla are few bio inputs which are largely in use whether organic cultivation is practiced or otherwise.

Bio control agents

Herbal pesticides are made out of plant extracts. The plants which are non-browsable by animals are best source of herbal pesticides. The leaf or whole plant or urine extracts acts as a pesticide. Calatropis, Prosopis, Aloe, Clerodendron, Vitex, Neem are few examples. The composition and quantity may vary for each kind of pest and disease. Further, some of the fungi (Trichoderma viride and Pseudomonas fluorescence, Pseudomonas harzianum) can act against many of the harmful fungi and bacteria and safeguard the soil environment.

Bio promoters

Panchagavya, a product combination of cows dung, urine, curd, milk and ghee acts as a growth promoter as well as immunity booster. It has its roots in vriksayurveda and now made applicable to plants, animals and human as a remedy to many of the ailments. Cow's urine is patented by CSIR in US patent office for its efficacy to enhance the potency of antibiotics. Manchurian tea decoction and moringa leaf extract also possess the same efficacy as that of panchagavya.

Other versions of organic farming

Bio dynamic farming

Organic farming system when extrapolated with plants and stars became biodynamic farming. Moon and Saturn are taken into account as moon influence the water (90% of plants and human consists of water only) and Saturn governs the agriculture. The crop operations which are (-) ve in nature like, cutting, pruning, harvesting, etc can be done during the waning phase of moon, while the crop operations which are (+) in nature viz., planting or sowing, application of manures etc can be performed during the waxing phase of the moon. There is an agricultural almanac developed for this purpose taking into account the stellar movements.

Agnihotra

System advocates inclusion of sound waves in a particular frequency through mantras which they say purify the environment and ensures cosmic flow on the field for better expression of crops. The essential feature of organic cultivation is that the farming should be made viable without any extra input from outside. The farm waste, farm animal waste are to be recycled in such a way that the crops enjoy all the comfort from soil and atmospheric environment and derive nourishment continuously over years from the revitalized soil and atmosphere.

Organic certification

As the public becomes increasingly concerned about the negative effects of industrial and high input intensive agriculture on the environment and on their health, the demand for safe food is increasing day by day. In this context, organic horticulture offers a bright light in the troubled future of farming community by providing an economically and environmentally healthy alternative for their survival.

Now organic horticulture is experiencing rapid worldwide growth through the creative energy of thousands of grassroots organizations, farmers and traders.

The historical data on organic farming indicated that, it was started in 1924 with a biodynamic concept and the pioneers gave different names. The global development of organic farming is reflected by International Federation for Organic Agriculture Movement (IFOAM), during 1972 and it now crossed with a membership of more than 200 organizations from 130 countries. Australia is the absolute organic boom country having more than 10% of the agricultural area under organic farming. Switzerland accounts for 14% area and Denmark for 35%. There is a very good awareness among the peoples of developed countries and now all are in the way to shift from inorganic to organic farming practices.

Organic certification for medicinal plants

The reports on organic agriculture showed that, most of the farming communities from the developed countries have already switched over to organic farming system and now having organic produces of many crops and allied activities. Now the organic growers were in the stage of selling their products with premium prices through some measures. In this context, organic certification becomes an important and inevitable step to be implemented to sell their products in the domestic or in global market.

Organic certification in Horticulture especially in medicinal plants provides transparency in certification and improves the images of organic agriculture. The organic certification by any agency includes the following programmes:

i. Certification - Carried out by the certification manager
ii. Inspection - Done by inspection manager well trained in organic standards
iii. Adopting standards - Carried out by the quality control manager

The certification programs vary with country or regions and the certification label is very particular to the country. All the standard used in certification was developed early by IFOAM and is reviewed every two years by the General Assembly of IFOAM. IFOAM has established an accreditation programme for supervising the international trade of organic products.

Various Organic standards

The standards are indicated as directions of sustainability and should be looked upon at global level. The standards acknowledge measure of comparison of or qualitative or quantitative value for degree or level of requirement of excellence or attainments and rules of production.
The organic standards were defined as minimum production practices and requirements, which must be followed strictly if the agricultural products to be labeled as organic. The standards may be of
1. Global standards : i. Mandatory Standards
ii. Voluntary standards
2. Regional standards
3. National standards
4. Certification standards

Global Standards

Mandatory standards

Abide by law and regulations and passed by government or regulatory bodies. eg. CODEX standards – are set by world level organizations like FAO and WHO at global level. These are reference standards for any dispute or problems.

Voluntary standards

These standards influence the organic farming at world level.
Eg. IFOAM standard. The major advantages were

- It can influence the mandatory standard
- It includes new techniques and various types of innovations.
- It recognizes the traditional standards in a continuous manner.

Regional standards

- Developed by mandatory standards

eg. EU regulations

National standards and certification standards

National programme for organic products (NPOP, 2000) India

It provides a means for certification programme in our country to establish their equivalence to regulatory requirements worldwide in the organic production, processing and trade. The main aim is to develop National Standards to prepare specific standards, to institute a logo "Indian Organic", and to approve certification bodies.

Certification standards and similarities among standards

It is developed by certifying bodies through committee meeting and each agency has its own standards. Organic standards were defined on the minimum production practices and handling requirements which must be followed for the resulting agricultural products to be labelled as organic.

There are many standards viz., Soil Association Standards (SA), European Commission regulations (EU), CODEX Standards IFOAM Standards etc. Each standard has its own production practices and all have similarities and dissimilarities.

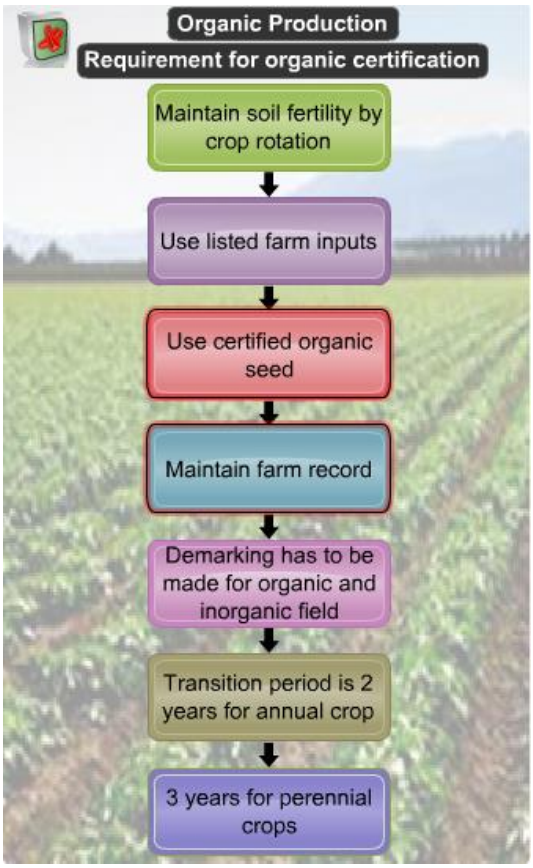
- Both EC and SA standards request 3rd party recognized certificate for export
- Emphasizing on audit
- Request annual inspection
- Accreditation
- Defines conversion plans
- Emphasis on sustainable organic farming.

Requirement for organic certification

The requirements for organic certification are outlined in much detail in the legislation that is used as the basis for certification. Summarised briefly, the main requirements of regulation for the producers of agricultural crops are:

1. Soil fertility has to be maintained by means of crop rotation, adapted cultivation techniques and nutrient cycles. Pest attacks need to be minimised by means of a healthy soil, natural enemies and adapted crop varieties. Only those farm inputs (fertilizers, pesticides, etc.) that are listed in the

regulation may be used in organic farming.
2. Only certified organic seeds should be used.
3. All farm or processing activities needs to be carefully documented on every level, thus ensuring a full traceability of the product flow.
4. If there is also a conventional unit, organic unit has to be clearly separated from the inorganic unit and the same product may not be produced in both units. Conventional and organic products may not be mixed at any stage.
5. Farms that are converting to organic farming have to undergo 2 (annual crops) or 3 years (perennial crops) of transition period. After the first 12 months, the products can be marketed as "organic in conversion".
6. Organic products need to be labelled as "organic" or "organic in conversion" throughout the whole chain of harvest, transport, storage, processing and export.
7. Specific requirements apply for organic live stock and honey production.
8. Every farm, processor or exporter producing or handling organic produce need to be inspected and certified once in a year by an accredited certification agency.



Certification agencies

Indian certification agencies

Government of India through Director General of Foreign Trade, New Delhi, allowed the export of organic products only if they are produced, processed and packed under a valid organic certificate issued by a certification agency accredited by one of the accredited agencies designated by the Government of India. The Government of India has already recognized the agencies viz, **Agricultural and Processed Food Product Export Development Authority** (APEDA), **Spice Board, Coffee Board** and **Tea Board** as Accreditation agencies. The organic market in India has not yet taken off as it is in

other countries. There are very few domestic Inspection and certification agencies.

In India, the first indigenous agency received accreditation from the Spice Board is M/s. Indian Organic Certification Agency (INDOCERT), Cochin during 2003. It is supported by two International Organizations viz, M/s FIBL, (Research Institute of Organic Agriculture) and M/s Bio.inspecta, an internationally accredited Swiss Organic certification Agency. FIBL support INDOCERT in planning, management, consultancy, assistance in developing structures, procedures, documents, technical training of the staff and also support in obtaining accreditation requirements. M/s Bio.inspecta assists to start inspections for the export market right from the beginning to co certification.

Tamil Nadu government has created a new department by name '**Department of Organic Certification'** accredited by APEDA to certify the organic production system in Tamil Nadu.

Certification requirements

4. Organic production standards Conversion requirements

- Conversion period starts from the date of application
- Bio - fencing boundary must be provided between organic and inorganic farming fields.
- Farm once converted to organic should not be reverted to conventional farming
- Conversion period - annuals - 12 months before sowing, Perennials - 24 months before first harvest
- Conversion period can be extended by the certification committee based on the usage of land and environment conditions.
- Maintenance of farmers dairy is required which contains the details of farm map, input and output records, storage details, livestock details, purchase and sale record.
- For differentiating the farm under different conversion period, different coloured dairies will be used as given below.

First year - Red colour
Second year - Blue colour
Third year - Green colour
The farmer should provide the conversion plan details which includes.

Basic data of the farm

1. Farm map
2. Soil analytical data
3. Water quality data
4. Crop production practices
5. Plant protection measures
6. Animal husbandry details
7. Crop rotation plan
8. Details on seed and planting materials.

5. Crop production standards

Seed / plant materials

- Only Certified organic seed and plant materials should be used
- If organic seeds and planting materials are not available, chemically untreated inorganic seed materials may be used until the period of organic seed availability
- Genetically engineered plants / seeds are not permitted

Sowing / land preparation

- Seed treatment must be done with biological sources only
- Proper spacing between crops must be maintained
- Uniformity in sowing dates should be adopted
- Maintaining the required plant population is needed
- Adopting summer deep ploughing for in situ moisture conservation
- Incorporation of crop residues/manures is a must

Diversity in crop production

- Marginal lands in the farm must be allotted to farm forest
- Crop rotation with legumes and deep rooted crops must be adopted

Irrigation schedule

- Dry spell for more than 15 - 20 days for crops should not be permitted
- Proper irrigation should be ensured at critical stages
- Avoiding excessive irrigation

Fertilization policy

- Maintenance of soil health to achieve sustainable productivity on long-range basis is required.
- Fertilization management should minimize nutrient losses
- No inorganic sources of fertilizers to be used for crop production
- Use of biodegradable materials from microbial/plant/animal origin is only permitted
- Split application of organic manures is recommended to apply 75% as basal and 25% at later stage
- Off-farm material usage is restricted The following materials listed under are not allowed for crop production

1. Manures of human excreta
2. Industrial sludges
3. All Mineral fertilizers
4. Manures and fertilizers with high load of heavy metals
5. All synthetic nitrogenous fertilizers.

The use of vermicast, compost of spent mushroom, by products from oil palm, coconut, cocoa, blood meal, bone meal, sea weed are restricted.

Plant protection measures

- Thermic weed control and physical methods of pest, disease and weed management must be followed.
- Use of bio pesticides / bio herbicides are only permitted
- Biological control through NPV, Bacillus thuringiensis (B.T.), Trichogramma etc. can be allowed.
- Pheromone traps / sticky traps are allowed
- The use of synthetic herbicides, fungicides, insecticides, pesticides, synthetic growth regulators/dyes, genetically engineered organisms and products for plant protection are not permitted.
- The preparations from Neem, Tephrosia, Propohil can be used as repellants and pest control measures.
- Use of copper salts and mineral powder are not permitted.

International certification

Imported organic produce from Latin America is subject to certification standards and guidelines just as stringent as produce produced in the United States. Under the US Organic Foods Production Act of 1990 (OFPA), the USDA is required to review the certifiers of imported organic produce, in order to ensure that they meet the requirements of the US National Organic Program (NOP).

Foreign certification agencies may apply directly to the USDA for recognition and are evaluated on the same criteria as domestic agencies. Alternately, foreign governments may apply to the USDA or the US government for recognition of equivalency in their organic oversight program. Once accreditation or recognition is granted, organic products produced under the supervision of the certifying agent or foreign government will be eligible for import to the US as certified organic.

International organic certification agency

The following are the some of the International agencies involved in certification of organic products.
1. International Federation of Organic Agriculture Movements (IFOAM) : The federation's main function is coordinating the network of the organic movement around the world. IFOAM is a democratic, grassroot oriented federation.

2. USDA National Organic Program

3. The Ecological Farming Association : formerly the Committee for Sustainable Agriculture, is a nonprofit educational organization that promotes ecologically sound agriculture.

4. Organic Farming Research Foundation (OFRF) : Sponsors research related to organic farming practices, disseminates research results to organic farmers and to growers interested in adopting organic production systems, and educates the public and decision-makers about organic farming issues.

5. Organic trade Association : is a national association representing the organic industry in Canada and the United States. Members include growers, shippers, processors, certifiers, farmer associations, brokers, consultants, distributors and retailers.

6. Community Alliance with Family Farmers (CAFF) : Political and educational

7. Institute for Market ecology (IMO) : It is one of the first and most renowned international agencies for inspection, certification and quality assurance of eco-friendly products. Since more than 20 years, IMO has been active in the field of organic certification but it is also expert in the sectors of natural textiles, sustainable forestry, and social accountability monitoring. IMO is closely co-operating with the popular private label Naturland (IFOAM accredited) and conducts Naturland inspections world-wide.

8. SKAL: SKAL International, Netherlands is a certification and inspection organisation, which certifies organic products, processes and inputs. Further sustainable forest/wood and textile are certified. SKAL International operates worldwide in Western and Eastern Europe, South America and Southern Asia. Through the network of the shareholder nearly all countries in the world can be covered.

9. ECOCERT INTERNATIONAL: ECOCERT SA, Germany is an inspection and certification body accredited to verify the conformity of organic products against the organic regulations of Europe, Japan and the United States.

Steps in organic certification

The following are the steps to be followed strictly in certification.

1. A preliminary enquiry by the Operator for information
2. Certifier sends the applications which requests for the basic data on farm, livestock details, processing units etc.
3. Operator fills the application and sent to certifier
4. Application is to be screened by the certifier
5. Sending invoice for certification and inspection cost
6. Certification contract
7. Inspection visit
8. Assessment of inspection report
9. Certification decision
10. Issue of certificate.

*****☺*****

Lesson 33

Good Agricultural Practices for Medicinal plants

Introduction

Interest in traditional systems of medicine and in particular herbal medicines, has increased substantially in both developed and developing countries over the past two decades. Global and national markets for medicinal herbs have been growing rapidly and significant economic gains are being realized. According to the Secretariat of the Convention on Biological Diversity, global sales of herbal products totaled an estimated US$ 60 000 million in 2000. As a consequence, the safety and quality of herbal medicines have become increasingly important concerns for health authorities and the public. Some reported adverse events following the use of certain herbal medicines have been associated with a variety of possible explanations, including the inadvertent use of the wrong plant species, adulteration with undeclared other medicines and/or potent substances, contamination with undeclared toxic and/or hazardous substances, overdosage, inappropriate use by health-care providers or consumers, and interaction with other medicines, resulting in an adverse drug interaction.

Among those attributable to the poor quality of finished products, some clearly result from the use of raw medicinal plant materials that are not of a sufficiently high quality standard. The safety and quality of raw medicinal plant materials and finished .products depend on factors that may be classified as intrinsic (genetic) or extrinsic (environment, collection methods, cultivation, harvest, post-harvest processing, transport and storage practices).Inadvertent contamination by microbial or chemical agents during any of the production stages can also lead to deterioration in safety and quality. Medicinal plants collected from the wild population may be contaminated by other species or plant parts through misidentification, accidental contamination or intentional adulteration, all of which may have unsafe consequences. The collection of medicinal plants from wild populations can give rise to additional concerns related to global, regional and/or local over-harvesting, and protection of endangered species. The impact of cultivation and collection on the environment and ecological processes, and the welfare of local communities should be considered. All intellectual property rights with regard to source materials must be respected. WHO has cooperated with other United Nations specialized agencies and international organizations in dealing with the above-mentioned issues. Such cooperation will be further strengthened through the development and the updating of relevant technical guidelines in these areas.

Safety and quality assurance measures are needed to overcome these problems and to ensure a steady, affordable and sustainable supply of medicinal plant materials of good quality. In recent years, good agricultural practices have been recognized as an important tool for ensuring the safety and quality of a variety of food commodities, and many Member States have established national good agricultural practice guidelines for a range of foods. However, quality control for the cultivation and collection of medicinal plants as the raw materials for herbal medicines may be more demanding than that for food production; possibly for this reason, only China, the European Union, and Japan have recently developed guidelines on good agricultural practices for medicinal plants. Since their guidelines were established to meet the requirements of specific regions or countries, they may not be universally applicable or acceptable. At a WHO Informal Meeting on Methodologies for Quality

Control of Finished Herbal Products, held in Ottawa, Canada from 20 to 21 July 2001, the entire process of production of herbal medicines, from raw materials to finished herbal products, was reviewed.

It was recommended that WHO should give high priority to the development of globally applicable guidelines to promote the safety and quality of medicinal plant materials through the formulation of codes for good agricultural practices and good collection practices for medicinal plants. It was envisaged that such guidelines would help to ensure safety and quality at the first and most important stage of the production of herbal medicines.

Objectives

Within the overall context of quality assurance, the WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants are primarily intended to provide general technical guidance on obtaining medicinal plant materials of good quality for the sustainable production of herbal products classified as medicines. They apply to the cultivation and collection of medicinal plants, including certain post-harvest operations. Raw medicinal plant materials should meet all applicable national and/or regional quality standards. The guidelines therefore may need to be adjusted according to each country's situation.

The main objectives of these guidelines are to:

- contribute to the quality assurance of medicinal plant materials used as the source for herbal medicines which aims to improve the quality, safety and efficacy of finished herbal products;
- guide the formulation of national and/or regional GACP guidelines and GACP monographs for medicinal plants and related standard operating procedures; and
- encourage and support the sustainable cultivation and collection of medicinal plants of good quality in ways that respect and support the conservation of medicinal plants and the environment in general.

These guidelines should be considered in conjunction with the existing documents and publications relating to the quality assurance of herbal medicines and to the conservation of medicinal plants for example:

- Good Manufacturing Practices for pharmaceutical products:
- Supplementary guidelines for manufacture of herbal
- Quality control methods for medicinal plant materials, medicinal products
- Guide to good storage practices for pharmaceuticals
- Good trade and distribution practices (GTDP) for pharmaceutical starting materials
- General guidelines for methodologies on research and evaluation of traditional medicine
- Guidelines for the assessment of herbal medicines
- WHO monographs on selected medicinal plants
- WHO/IUCN/WWF Guidelines on the conservation of medicinal plants

In addition, these guidelines should be seen in the context of the relevant guidelines and codes of practices developed by the Joint FAO/WHO Codex Alimentarius Commission, particularly as

medicinal plants may be subject to general requirements for foods under some national and/or regional legislation. Examples of Codex Alimentarius texts that may be applicable to medicinal plants include:

- Codex Alimentarius Code of Practice - General Principles of Food Hygiene
- Codex Alimentarius Guidelines on production, processing, labelling and marketing of organically produced foods
- Codex Alimentarius Code of hygienic practice for spices and dried aromatic plants. The WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants do not provide sufficient guidance for the production of organic herbal medicines, and other national, regional and/or international guidelines should be consulted.

Structure

The guidelines are divided into five sections: section 1 provides a general introduction, sections 2 and 3 discuss good agricultural practices for medicinal plants and good collection practices for medicinal plants, respectively.

Section 4 outlines common technical aspects of good agricultural practices for medicinal plants and good collection practices for medicinal plants, while section 5 considers other relevant issues.

Identification/authentication of cultivated medicinal plants

Selection of medicinal plants

Where applicable, the species or botanical variety selected for cultivation should be the same as that specified in the national pharmacopoeia or recommended by other authoritative national documents of the end-user's country. In the absence of such national documents, the selection of species or botanical varieties specified in the pharmacopoeia or other authoritative documents of other countries should be considered.
In the case of newly introduced medicinal plants, the species or botanical variety selected for cultivation should be identified and documented as the source material used or described in traditional medicine of the original country.

Botanical identity

The botanical identity – scientific name (genus, species, subspecies/ variety, author, and family) – of each medicinal plant under cultivation should be verified and recorded. If available, the local and English common names should also be recorded. Other relevant information, such as the cultivar name, ecotype, chemo type or phenotype, may also be provided, as appropriate. For commercially available cultivars, the name of the cultivar and of the supplier should be provided. In the case of landraces collected, propagated, disseminated and grown in a specific region, records should be kept of the locally named line, including the origin of the source seeds, plants or propagation materials.

Specimens

In the case of the first registration in a producer's country of a medicinal plant or where reasonable doubt exists as to the identity of a botanical species, a voucher botanical specimen should be submitted to a regional or national herbarium for identification. Where possible, a genetic pattern should be compared to that of an authentic specimen. Documentation of the botanical identity should be included in the registration file.

Seeds and other propagation materials

Seeds and other propagation materials should be specified, and suppliers of seeds and other propagation materials should provide all necessary information relating to the identity, quality and performance of their products, as well as their breeding history, where possible. The propagation or planting materials should be of the appropriate quality and be as free as possible from contamination and diseases in order to promote healthy plant growth. Planting material should preferably be resistant or tolerant to biotic or abiotic factors. Seeds and other propagation materials used for organic production should be certified as being organically derived. The quality of propagation material - including any genetically modified germplasm - should comply with regional and/or national regulations and be appropriately labelled and documented, as required. Care should be taken to exclude extraneous species, botanical varieties and strains of medicinal plants during the entire production process. Counterfeit, substandard and adulterated propagation materials must be avoided.

Cultivation

Cultivation of medicinal plants requires intensive care and management. The conditions and duration of cultivation required vary depending on the quality of medicinal plant materials required. If no scientific published or documented cultivation data are available, traditional methods of cultivation should be followed, where feasible. Otherwise a method should be developed through research. The principles of good plant husbandry, including appropriate rotation of plants selected according to environmental suitability, should be followed, and tillage should be adapted to plant growth and other requirements. Conservation Agriculture (CA) techniques should be followed where appropriate, especially in the build-up of organic matter and conservation of soil humidity. Conservation Agriculture also includes "no-tillage" systems.

Site selection

Medicinal plant materials derived from the same species can show significant differences in quality when cultivated at different sites, owing to the influence of soil, climate and other factors. These differences may relate to physical appearance or to variations in their constituents, the biosynthesis of which may be affected by extrinsic environmental conditions, including ecological and geographical variables, and should be taken into consideration. Risks of contamination as a result of pollution of the soil, air or water by hazardous chemicals should be avoided. The impact of past land uses on the cultivation site, including the planting of previous crops and any applications of plant protection products, should be evaluated.

Ecological environment and social impact

The cultivation of medicinal plants may affect the ecological balance and, in particular, the genetic diversity of the flora and fauna in surrounding habitats. The quality and growth of medicinal plants can also be affected by other plants, other living organisms and by human activities. The introduction of non-indigenous medicinal plant species into cultivation may have a detrimental impact on the biological and ecological balance of the region. The ecological impact of cultivation activities should be monitored over time, where practical.

The social impact of cultivation on local communities should be examined to ensure that negative impacts on local livelihood are avoided. In terms of local income- earning opportunities, small-scale cultivation is often preferable to large-scale production, in particular if small-scale farmers are organized to market their products jointly. If large scale medicinal plant cultivation is or has been

established, care should be taken that local communities benefit directly from, for example, fair wages, equal employment opportunities and capital reinvestment.

Climate

Climatic conditions, for example, length of day, rainfall (water supply) and field temperature, significantly influence the physical, chemical and biological qualities of medicinal plants. The duration of sunlight, average rainfall, average temperature, including daytime and night-time temperature differences, also influence the physiological and biochemical activities of plants, and prior knowledge should be considered.

Soil

The soil should contain appropriate amounts of nutrients, organic matter and other elements to ensure optimal medicinal plant growth and quality. Optimal soil conditions, including soil type, drainage, moisture retention, fertility and pH, will be dictated by the selected medicinal plant species and/or target medicinal plant part.

The use of fertilizers is often indispensable in order to obtain large yields of medicinal plants. It is, however, necessary to ensure that correct types and quantities of fertilizers are used through agricultural research. In practice, organic and chemical fertilizers are used. Human excreta must not be used as a fertilizer owing to the potential presence of infectious microorganisms or parasites. Animal manure should be thoroughly composted to meet safe sanitary standards of acceptable microbial limits and destroyed by the germination capacity of weeds. Any applications of animal manure should be documented. Chemical fertilizers that have been approved by the countries of cultivation and consumption should be used. All fertilizing agents should be applied sparingly and in accordance with the needs of the particular medicinal plant species and supporting capacity of the soil. Fertilizers should be applied in such a manner as to minimize leaching.

Growers should implement practices that contribute to soil conservation and minimize erosion, for example, through the creation of streamside buffer zones and the planting of cover crops and "green manure" (crops grown to be ploughed in), such as alfalfa.

Irrigation and drainage

Irrigation and drainage should be controlled and carried out in accordance with the needs of the individual medicinal plant species during its various stages of growth. Water used for irrigation purpose should comply with local, regional and/or national quality standards. Care should be exercised to ensure that the plants under cultivation are neither over- nor under-watered. In the choice of irrigation, as a general rule, the health impact of the different types of irrigation (various forms of surface, sub-surface or overhead irrigation), particularly on the risks of increased vector-borne disease transmission, must be taken into account.

Plant maintenance and protection

The growth and development characteristics of individual medicinal plants, as well as the plant part destined for medicinal use, should guide field management practices. The timely operations such as topping, bud nipping, pruning and shading may be used to control the growth and development of the plant, thereby improving the quality and quantity of the medicinal plant material being produced. Any agrochemicals used to promote the growth of or to protect medicinal plants should be kept to a minimum, and applied only when no alternative measures are available. Integrated pest

management should be followed where appropriate. When necessary, only approved pesticides and herbicides should be applied at the minimum effective level, in accordance with the labelling and/or package insert instructions of the individual product and the regulatory requirements that apply for the grower and the end-user countries. Only qualified staff using approved equipment should carryout pesticide and herbicide applications. All applications should be documented. The minimum interval between such treatments and harvest should be consistent with the labelling and/or package insert instructions of the plant protection product, and such treatments should be carried out in consultation and with the by agreement of the buyer of the medicinal plants or medicinal plant materials. Growers and producers should comply with maximum pesticide and herbicide residue limits, as stipulated by local, regional and/or national regulatory authorities of both the growers' and the end-users' countries and/or regions. International agreements such as the International Plant Protection Convention and Codex Alimentarius should also be consulted on pesticide use and residues.

Harvest

Medicinal plants should be harvested during the optimal season or time period to ensure the production of medicinal plant materials and finished herbal products of the best possible quality. The time of harvest depends on the plant part to be used. Detailed information concerning the appropriate timing of harvest is often available in national pharmacopoeias, published standards, official monographs and major reference books. However, it is well known that the concentration of biologically active constituents varies with the stage of plant growth and development. This also applies to non-targeted toxic or poisonous indigenous plant ingredients. The best time for harvest (quality peak season/time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts. During harvest, care should be taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials. Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity. If harvesting occurs in wet conditions, the harvested material should be transported immediately to an indoor drying facility to expedite drying so as to prevent any possible deleterious effects due to increased moisture levels, which promote microbial fermentation and mould. Cutting devices, harvesters, and other machines should be kept clean and adjusted to reduce damage and contamination from soil and other materials. They should be stored in an uncontaminated, dry place or facility free from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Contact with soil should be avoided to the extent possible so as to minimize the microbial load of harvested medicinal plant materials. Where necessary, large drop cloths, preferably made of clean muslin, may be used as an interface between the harvested plants and the soil. If the underground parts (such as the roots) are used, any adhering soil should be removed from the medicinal plant materials as soon as they are harvested. The harvested raw medicinal plant materials should be transported promptly in clean, dry conditions. They may be placed in clean baskets, dry sacks, trailers, hoppers or other well-aerated containers and carried to a central point for transport to the processing facility.

All containers used at harvest should be kept clean and free from contamination by previously harvested medicinal plants and other foreign matter. If plastic containers are used, particular attention should be paid to any possible retention of moisture that could lead to the growth of mould. When containers are not in use, they should be kept in dry conditions, in an area that is protected from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Any mechanical damage or compacting of the raw medicinal plant materials, as a consequence, for

example, of overfilling or stacking of sacks or bags that may result in composting or otherwise diminish quality should be avoided. Decomposed medicinal plant materials should be identified and discarded during harvest, post-harvest inspections and processing, in order to avoid microbial contamination and loss of product quality.

Personnel
Growers and producers should have adequate knowledge of the medicinal plant concerned. This should include botanical identification, cultivation characteristics and environmental requirements (soil type, soil pH, fertility, plant spacing and light requirements), as well as the means of harvest and storage.

All personnel (including field workers) involved in the propagation, cultivation, harvest and post-harvest processing stages of medicinal plant production should maintain appropriate personal hygiene and should have received training regarding their hygiene responsibilities. Only, properly trained personnel, wearing appropriate protective clothing (such as overalls, gloves, helmet, goggles, face mask), should apply agrochemicals. Growers and producers should receive instruction on all issues relevant to the protection of the environment, conservation of medicinal plant species, and proper agricultural stewardship.

Good collection practices for medicinal plants

This section describes the general strategies and basic methods for small- and large-scale collection of fresh medicinal plant materials. Collection practices should ensure the long term survival of wild populations and their associated habitats. Management plans for collection should provide a framework for setting sustainable harvest levels and describe appropriate collection practices that are suitable for each medicinal plant species and plant part used (roots, leaves, fruits, etc.). Collection of medicinal plants raises a number of complex environmental and social issues that must be addressed locally on a case by case basis. It is acknowledged that these issues vary widely from region to region and cannot be fully covered by these guidelines. More guidance can be found in the WHO/IUCN/WWF Guidelines on the conservation of medicinal plants.

Permission to collect
In some countries, collection permits and other documents from government authorities and landowners must be obtained prior to collecting any plants from the wild. Sufficient time for the processing and issuance of these permits must be allocated at the planning stage. National legislation, such as national "red" lists, should be consulted and respected. For medicinal plant materials intended for export from the country of collection, export permits, phytosanitary certificates, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) permit(s) (for export and import), CITES certificates (for re-export), and other permits must be obtained, when required.

Technical planning
Prior to initiating a collection expedition, the geographical distribution and population density of the target medicinal plant species should be determined. Distance from home base and quality of the target plant(s) available are factors to be considered. When the collection sites have been identified, local and/or national collection permits should be obtained. Essential information on the target species (taxonomy, distribution, phenology, genetic diversity, reproductive biology and ethnobotany)

should be obtained. Data about environmental conditions, including topography, geology, soil, climate and vegetation at the prospective collecting site(s), should be collated and presented in a collection management plan. Research on the morphology of the target medicinal plant species and variability of its populations should be carried out in order to develop a "search image" for the species. Copies of photographs and other illustrations of the target medicinal plant(s) from books and herbarium specimens, and ethnographical information (common or local names) of the target species and plant parts are useful field instruments, especially for untrained workers. Botanical keys and other taxonomic identification aids are useful at collection sites where either related species, or unrelated species of similar morphological characteristics may be found. Rapid, safe and dependable transportation to carry personnel, equipment, supplies and collected medicinal plant materials should be arranged in advance.

A collection team familiar with good collecting techniques, transport, and handling of equipment and medicinal plant materials, including cleaning, drying and storage, should be assembled. Training of personnel should be conducted regularly. The responsibilities of all those involved in collection should be clearly set out in a written document. All stakeholders, in particular, manufacturers, traders and government, are accountable for the conservation and management of the targeted medicinal plant species. The social impact of field collection on local communities should be examined and the ecological impact of field collection activities should be monitored over time. The stability of the natural habitat (s) and the maintenance of sustainable populations of the target species in the collection area (s) must be ensured.

Selection of medicinal plants for collection

Where applicable, the species or botanical variety selected for collection should be the same as that specified in the national pharmacopoeia or recommended by other authoritative national documents of the end-user's country, as the source for the herbal medicines concerned. In the absence of such national documents, the selection of species or botanical varieties specified in the pharmacopoeia or other authoritative documents of other countries should be considered. In the case of newly introduced medicinal plants, the species or botanical variety selected for collection should be identified and documented as the source material used or described in traditional medicine in original countries.

Collectors of medicinal plants and producers of medicinal plant materials and herbal medicines should prepare botanical specimens for submission to regional or national herbaria for authentication. The voucher specimens should be retained for a sufficient period of time, and should be preserved under proper conditions. The name of the botanist or other experts who provided the botanical identification or authentication should be recorded. If the medicinal plant is not well known to the community, then documentation of the botanical identity should be recorded and maintained.

Collection

Collection practices should ensure the long-term survival of wild populations and their associated habitats. The population density of the target species at the collection site(s) should be determined and species that are rare or scarce should not be collected. To encourage the regeneration of source medicinal plant materials, a sound demographic structure of the population has to be ensured. Management plans should refer to the species and the plant parts (roots, leaves, fruits, etc.) to be collected and should specify collection levels and collection practices.

It is incumbent on the government or environmental authority to ensure that buyers of collected plant material do not place the collected species at risk. Medicinal plant materials should be collected during the appropriate season or time period to ensure the best possible quality of both source materials and finished products. It is well known that the quantitative concentration of biologically active constituents varies with the stage of plant growth and development. This also applies to non-targeted toxic or poisonous indigenous plant ingredients. The best time for collection (quality peak season or time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts.

Only ecologically non-destructive systems of collection should be employed. These will vary widely from species to species. For example, when collecting roots of trees and bushes, the main roots should not be cut or dug up, and severing the tap root of trees and bushes should be avoided. Only some of the lateral roots should be located and collected. When collecting species whose bark is the primary material to be used, the tree shouldn't be girdled or completely stripped of its bark; longitudinal strips of bark along one side of the tree should be cut and collected. Medicinal plants should not be collected in or near areas where high levels of pesticides or other possible contaminants are used or found, such as roadsides, drainage ditches, mine tailings, garbage dumps and industrial facilities which may produce toxic emissions. In addition, the collection of medicinal plants in and around active pastures, including riverbanks downstream from pastures, should be avoided in order to avoid microbial contamination from animal waste. In the course of collection, efforts should be made to remove parts of the plant that are not required and foreign matter, in particular toxic weeds. Decomposed medicinal plant materials should be discarded.

In general, the collected raw medicinal plant materials should not come into direct contact with the soil. If underground parts (such as the roots) are used, any adhering soil should be removed from the plants as soon as they are collected. Collected material should be placed in clean baskets, mesh bags, other well aerated containers or drop cloths that are free from foreign matter, including plant remnants from previous collecting activities. After collection, the raw medicinal plant materials may be subjected to appropriate preliminary processing, including elimination of undesirable materials and contaminants,

Washing (to remove excess soil), sorting and cutting: The collected medicinal plant materials should be protected from insects, rodents, birds and other pests, and from livestock and domestic animals. If the collection site is located some distance from processing facilities, it may be necessary to air or sun-dry the raw medicinal plant materials prior to transport. If more than one medicinal plant part is to be collected, the different plant species or plant materials should be gathered separately and transported in separate containers. Cross-contamination should be avoided at all times. Collecting implements, such as machetes, shears, saws and mechanical tools, should be kept clean and maintained in proper condition. Those parts that come into direct contact with the collected medicinal plant materials should be free from excess oil and other contamination.

Personnel

Local experts responsible for the field collection should have formal or informal practical education and training in plant sciences and have practical experience in fieldwork. They should be responsible for training any collectors who lack sufficient technical knowledge to perform the various tasks involved in the plant collection process. They are also responsible for the supervision of workers and the full documentation of the work performed. Field personnel should have adequate botanical

training, and be able to recognize medicinal plants by their common names and, ideally, by their scientific (Latin) names.

Local experts should serve as knowledgeable links between non-local people and local communities and collectors. All collectors and local workers involved in the collection operation should have sufficient knowledge of the species targeted for collection and be able to distinguish target species from botanically related and/or morphologically similar species. Collectors should also receive instructions on all issues relevant to the protection of the environment and the conservation of plant species, as well as the social benefits of sustainable collection of medicinal plants. The collection team should take measures to ensure the welfare and safety of staff and local communities during all stages of medicinal plant sourcing and trade. All personnel must be protected from toxic and dermatitis-causing plants, poisonous animals and disease-carrying insects. Appropriate protective clothing, including gloves, should be worn when necessary.

Post-harvest processing

Inspection and sorting

- Raw medicinal plant materials should be inspected and sorted prior to primary processing. The inspection may include:
- Visual inspection for cross-contamination by untargeted medicinal plants and/or plant parts;
- Visual inspection for foreign matter;
- Organoleptic evaluation, such as: appearance, damage, size, colour, odour, and possibly taste.

Primary processing

Appropriate measures of primary processing are dependent on the individual materials. These processes should be carried out in conformity with national and/or regional quality standards, regulations and norms. In some cases, purchasers may request that specific protocols are followed. These protocols should also comply with national and/or regional regulatory requirements that apply in the producer and the purchaser countries. As far as possible, standard operating procedures should be followed. If modifications are made, they should be justified by adequate test data demonstrating that the quality of the medicinal plant material is not diminished. Harvested or collected raw medicinal plant materials should be promptly unloaded and unpacked upon arrival at the processing facility. Prior to processing, the medicinal plant materials should be protected from rain, moisture and any other conditions that might cause deterioration. Medicinal plant materials should be exposed to direct sunlight only where there is a specific need for this mode of drying.

Medicinal plant materials that are to be used in the fresh state should be harvested/collected and delivered as quickly as possible to the processing facility in order to prevent microbial fermentation and thermal degradation. The materials may be stored under refrigeration, in jars, in sandboxes, or using enzymatic and other appropriate conservation measures immediately following harvest/collection and during transit to the end-user. The use of preservatives should be avoided. If used, they should confirm to national and/or regional regulations for growers/collectors and end-users. Medicinal plant materials that are to be employed fresh should be stored under refrigeration, in jars, in sandboxes, or using enzymatic or other appropriate conservation measures, and transported to the end-user in the most expeditious manner possible.

The use of preservatives should be avoided. If used, this should be documented and they should confirm to national and/or regional regulatory requirements in both the source country and the end-user country.

All medicinal plant materials should be inspected during the primary-processing stages of production, and any substandard products or foreign matter should be eliminated mechanically or by hand. For example, dried medicinal plant materials should be inspected, sieved or winnowed to remove discoloured, mouldy or damaged materials, as well as soil, stones and other foreign matter. Mechanical devices such as sieves should be regularly cleaned and maintained. All processed medicinal plant materials should be protected from contamination and decomposition as well as from insects, rodents, birds and other pests, and from livestock and domestic animals.

Drying

When medicinal plant materials are prepared for use in dry form, the moisture content of the material should be kept as low as possible in order to reduce damage from mould and other microbial infestation. Information on the appropriate moisture content for particular medicinal plant materials may be available from pharmacopoeias or other authoritative monographs. Medicinal plants can be dried in a number of ways: in the open air (shaded from direct sunlight); placed in thin layers on drying frames, wire-screened rooms or buildings; by direct sunlight, if appropriate; in drying ovens/rooms and solar dryers; by indirect fire; baking; lyophilization; microwave; or infrared devices. When possible, temperature and humidity should be controlled to avoid damage to the active chemical constituents. The method and temperature used for drying may have a considerable impact on the quality of the resulting medicinal plant materials. For example, shade drying is preferred to maintain or minimize loss of colour of leaves and flowers; and lower temperatures should be employed in the case of medicinal plant materials containing volatile substances.

The drying conditions should be recorded. In the case of natural drying in the open air, medicinal plant materials should be spread out in thin layers on drying frames and stirred or turned frequently. In order to secure adequate air circulation, the drying frames should be located at a sufficient height above the ground. Efforts should be made to achieve uniform drying of medicinal plant materials and so avoid mould formation. Drying medicinal plant material directly on bare ground should be avoided. If a concrete or cement surface is used, medicinal plant materials should be laid on a tarpaulin or other appropriate cloth or sheeting. Insects, rodents, birds and other pests, and livestock and domestic animals should be kept away from drying sites. For indoor drying, the duration of drying, drying temperature, humidity and other conditions should be determined on the basis of the plant part concerned (root, leaf, stem, bark, flower, etc.) and any volatile natural constituents, such as essential oils. If possible, the source of heat for direct drying (fire) should be limited to butane, propane or natural gas, and temperatures should be kept below 60 °C. If other sources of fire are used, contact between those materials, smoke and medicinal plant material should be avoided.

Specific processing

Some medicinal plant materials require specific processing to: improve the purity of the plant part being employed; reduce drying time; prevent damage from mould, other microorganisms and insects; detoxify indigenous toxic ingredients; and enhance therapeutic efficacy. Common specific processing practices include pre-selection, peeling the skins of roots and rhizomes, boiling in water, steaming, soaking, pickling, distillation, fumigation, roasting, natural fermentation,

treatment with lime and chopping.

Processing procedures involving the formation of certain shapes, bundling and special drying may also have an impact on the quality of the medicinal plant materials. Antimicrobial treatments of medicinal plant materials (raw or processed) by various methods, including irradiation, must be declared and the materials must be labelled as required. Only suitably trained staff using approved equipment should carry out such applications, and they should be conducted in accordance with standard operating procedures and national and/or regional regulations in both the grower/collector country and the end-user country. Maximum residue limits, as stipulated by national and/or regional authorities, should be respected.

Processing facilities

The following elements should be considered when establishing a quality assurance system and be adapted to the different steps of production and production sites.

Location

Facilities should preferably be located in areas that are free from objectionable odours, smoke, dust or other contaminants, and are not subject to flooding.

Roadways and areas used by wheeled vehicles

Roadways and areas serving the establishment, within its boundaries or in the immediate vicinity, should have a hard paved surface suitable for wheeled vehicles. There should be adequate drainage, and provision should be made for cleaning.

Buildings

Buildings should be of sound construction and maintained in good repair. Dirty areas, such as those used for drying and milling, must be isolated from clean areas, preferably in separate buildings. All construction materials should be such that they do not transmit any undesirable substance to medicinal plant materials. Once construction is completed, construction materials should not emit toxic vapours. The use of materials that cannot be adequately cleaned and disinfected, such as wood, should be avoided unless they would clearly not be a source of contamination.

Buildings should be designed to provide adequate working space and storage room to allow for satisfactory performance of all operations;

- facilitate efficient and hygienic operations by allowing a regulated flow in processing from the arrival of the raw medicinal plant materials at the premises to the dispatch of the processed medicinal plant materials;
- permit appropriate control of temperature and humidity;
- permit the separation by partition or other means of processes that may cause cross contamination, especially to isolate dirty areas (drying and milling) from clean areas;
- permit control of access to different sections, where appropriate;
- permit easy and adequate cleaning and facilitate proper supervision of hygiene;
- prevent the entry of environmental contaminants such as smoke, dust, etc.;
- prevent the entrance and harbouring of pests, livestock and domesticated animals;
- where appropriate, prevent direct sunlight from entering a particular section.

Medicinal plant material handling areas

- Floors, where appropriate, should be of waterproof, non-absorbent, washable, non slip and non-toxic material, without crevices, and should be easy to clean and disinfect. Where appropriate, floors should slope sufficiently for liquids to drain into trapped outlets.
- Walls, where appropriate, should be covered with waterproof, non-absorbent and washable materials, sealed and free from insects, and should be light coloured. Up to a height appropriate for handling operations, they should be smooth and without crevices, and should be easy to clean and disinfect. Where appropriate, angles between walls, between walls and floors, and between walls and ceilings should also be sealed and covered to facilitate cleaning.
- Ceilings should be designed, constructed and finished so as to prevent the accumulation of dirt and minimize condensation, mould development and flaking, and should be easy to clean.
- Windows and other openings should be constructed so as to avoid accumulation of dirt, and those that open should be fitted with insect-proof screens. Screens should be easily removable for cleaning and kept in good repair. Internal window sills, if present, should be sloped to prevent use as shelves.
- Doors should have smooth, non-absorbent surfaces and, where appropriate, be self closing and close-fitting.
- Stairs, lift cages and auxiliary structures such as platforms, ladders and chutes should be situated and constructed so as not to cause contamination to medicinal plant materials. Chutes should be constructed with inspection and cleaning hatches.
- Overhead structures and fittings should be installed in such a manner as to avoid contamination of medicinal plant materials (both raw and processed) by condensation and drip, and should be protected to prevent contamination in case of breakage. They should not hamper cleaning operations. They should be insulated, where appropriate, and be designed and finished so as to prevent the accumulation of dirt and to minimize condensation, mould development and flaking. They should be easy to clean.
- Living quarters, food preparation and eating areas, changing facilities, toilets and areas where animals are kept should be completely separated from and should not open directly onto medicinal plant material handling areas.

Water supply

An ample supply of water, under adequate pressure and at suitable temperature, should be available with appropriate facilities for its storage, where necessary, and distribution, and with proper protection against contamination.

- Ice should be made from potable water; it should be manufactured, handled and stored so as to protect it against contamination.
- Steam used in direct contact with medicinal plant materials or surfaces in contact with medicinal plant materials should contain no substances that may be hazardous to health or may contaminate the medicinal plant materials.
- Non-potable water used for steam production, refrigeration, fire control and other similar purposes not connected with processing should be carried in completely separate pipes, identifiable preferably by colour, and with no cross-connection with or back siphonage into the system carrying potable water.
- Potable water should be used for washing and wet sterilization procedures.

Effluent and waste disposal

Facilities should have an effective effluent and waste disposal system, which should at all times be maintained in good order and repair. All effluent pipes (including sewage systems) should be large enough to carry peak loads and should be constructed so as to avoid contamination of potable water supplies.

Changing facilities and toilets

Adequate, suitable and conveniently located changing facilities and toilets should be provided. Toilets should be designed so as to ensure hygienic removal of waste matter. These areas should be well lit, ventilated and, where appropriate, heated. Hand-washing facilities with warm or hot and cold water, a suitable hand-cleaning preparation and hygienic means of drying should be provided adjacent to toilets and located so that employees have to pass them when returning to the processing area. Elbow-operated taps are desirable and, where hot and cold water is available, mixer taps should be fitted. If paper towels are supplied, a sufficient number of towel dispensers and waste receptacles should be provided near to each washing facility. Notices should be posted directing personnel to wash their hands after using the toilet.

Hand-washing facilities in processing areas

Adequate and conveniently located facilities for hand-washing and a hygienic means of drying should be provided whenever the process demands. Where appropriate, facilities for hand disinfection should also be provided. Warm or hot and cold water and a suitable hand-cleaning preparation should be provided. Elbow-operated taps are desirable and, where hot and cold water is available, mixer taps should be fitted. If paper towels are supplied, a sufficient number of towel dispensers and waste receptacles should be provided adjacent to each washing facility. The facilities should be furnished with properly trapped waste pipes leading to drains.

Disinfection facilities

Where appropriate, adequate facilities for cleaning and disinfection of working implements and equipment should be provided. These facilities should be constructed of corrosion-resistant materials, should be easy to clean, and should be fitted with hot and cold water supplies.

Lighting

Adequate natural or artificial lighting should be fitted throughout the facility. Where appropriate, the lighting should not alter colours and the intensity should be not less than:

- 540 lux at all inspection points
- 220 lux in work rooms
- 110 lux in other areas.

Lighting fixtures and light bulbs suspended over medicinal plant materials at any stage of processing should be of a safety type and protected to prevent contamination of the medicinal plant materials in case of breakage.

Ventilation

Adequate ventilation should be provided to prevent excessive heat, steam condensation and dust and to remove contaminated air. Air should never flow from a dirty area to a clean area. Ventilator openings should be provided with a screen or other protective enclosure of non-

corrosive material. Screens should be easily removable for cleaning.

Storage of waste and unusable materials

Facilities should be provided for the storage of waste and unusable materials prior to removal from the premises. These facilities should be designed so as to prevent access to the waste or unusable materials by pests and to avoid contamination of medicinal plant materials, potable water, equipment and buildings of the premises. Clearly marked waste bins should be provided and emptied daily.

Bulk packaging and labeling

Processed medicinal plant materials should be packaged as quickly as possible to prevent deterioration of the product and to protect against unnecessary exposure to potential pest attacks and other sources of contamination. 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. 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. Whenever possible, the packaging used should be agreed upon between supplier and buyer. Reusable packaging material such as jute sacks and mesh bags should be well cleaned (disinfected) and thoroughly dried prior to reuse, so as to avoid contamination by previous contents. All packaging materials should be stored in a clean and dry place that is free from pests and inaccessible to livestock, domestic animals and other sources of contamination.

A label affixed to the packaging should clearly indicate the scientific name of the medicinal plant, the plant part, the place of origin (cultivation or collection site), the cultivation or collection date and the names of the grower/collector and the processor, and quantitative information. The label should also contain information indicating quality approval and comply with other national and/or regional labeling requirements. The label should bear a number that clearly identifies the production batch. Additional information about the production and quality parameters of the medicinal plant materials may be added in a separate certificate, which is clearly linked to the package carrying the same batch number. Records should be kept of batch packaging, and should include the product name, place of origin, batch number, weight, assignment number and date. The records should be retained for a period of three years or as required by national and/or regional authorities.

Storage and transportation

Conveyances used for transporting bulk medicinal plant materials from the place of production to storage for processing should be cleaned between loads. Bulk transport, such as ship or rail cars, should be cleaned and, where appropriate, well ventilated to remove moisture from medicinal plant materials and to prevent condensation. Organically grown medicinal plant materials should be stored and transported separately or in a manner that ensures their integrity.

Appropriate security measures should be applied to the storage and transport of medicinal plant materials that are potentially toxic or poisonous. Whenever required and when possible, 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. Fumigation against pest infestation should be carried out only when necessary, and should be carried out by licensed or trained personnel. Only registered chemical agents authorized by the regulatory authorities of the source country and the countries of intended end-use should be used. All fumigation, fumigation agents, and dates of application should be documented. When freezing or saturated steam is used for pest control, the humidity of the materials should be checked after treatment.

Equipment

Materials

All equipments and utensils used in the handling of medicinal plants should be made of materials that do not transmit toxic substances, odour or taste, are non-absorbent, are resistant to corrosion and are capable of withstanding repeated cleaning and disinfection. Surfaces should be smooth and free from pits and crevices. The use of wood and other materials that cannot be adequately cleaned and disinfected should be avoided, except when their use would clearly not be a source of contamination. The use of different metals in such a way that contact corrosion may occur should be avoided.

Design, construction and installation

All equipments and utensils should be designed and constructed so as to prevent hygienic hazards and permit easy and thorough cleaning and disinfection. Where practicable, they should be accessible for visual inspection. Stationary equipment should be installed in such a manner as to permit easy access and thorough cleaning. Containers for unusable materials or waste should be leak-proof, constructed of metal or other suitable impervious materials, should be easy to clean or be disposable, and should close securely. All refrigerated spaces should be equipped with temperature measurement or recording devices.

Identification

Equipment used for waste or unusable medicinal plant materials should be identified and not be used for usable medicinal plant materials.

Quality assurance

Compliance with quality assurance measures should be verified through regular auditing visits to cultivation or collection sites and processing facilities by expert representatives of producers and buyers and through inspection by national and/or local regulatory authorities.

Documentation

Standard operating procedures should be adopted and documented. All processes and procedures involved in the production of medicinal plant materials and the dates on which they are carried out should be documented. An example of a cultivation record is provided in Annexure 5. The types of information that should be collected include:

- Seeds and other propagation materials
- Propagation
- Cultivation or collection site
- Crop rotation at the site
- Cultivation
- Application of fertilizers, growth regulators, pesticides and herbicides

- Unusual circumstances that may influence the quality (including chemical composition) of the medicinal plant materials (e.g. extreme weather conditions, exposure to hazardous substances and other contaminants, or pest outbreaks)
- Harvest or collection
- Processing
- Transportation
- Storage
- Application of fumigation agents.

Multiple sets of good herbarium specimens should be prepared and preserved for confirmation of plant identity and reference use. A photographic record (including film, video, or digital images) of the cultivation or collection site and the medicinal plants under cultivation or collection should be made, whenever possible. All agreements between the grower or collector, processor and purchaser, and intellectual property and benefit-sharing agreements should be recorded. Batch numbers should unambiguously and clearly identify all batches from each cultivation or collection area.

Assignment of batch numbers should take place at an early stage of production. Collected and cultivated medicinal plant materials should carry different batch numbers. Where applicable, the results of audits should be documented in an audit report which contains copies of all documents, analysis reports, and local, national and/or regional regulations, and which are stored according to their requirements.

Personnel (growers, collectors, producers, handlers, processors).

General

All personnel should receive adequate botanical and agricultural or collection training. All personnel required to apply agrochemicals should be trained in their use. Producers and collectors should receive adequate training and possess sufficient knowledge about appropriate harvesting and techniques employed for plant maintenance and protection for the medicinal plants to be cultivated. To avoid deterioration of harvested medicinal plant materials during the post-harvest handling and primary processing stages, proper training of all personnel involved is required.

Personnel should be instructed on all relevant issues regarding environmental protection, the conservation of plant species and proper soil management to conserve fields for cultivation and for soil erosion control. The prevention of environmental degradation is an essential requirement to ensure the sustainable long-term use of medicinal plants resources. National and/or regional regulations governing labour should be respected in the employment of staff for all phases of medicinal plant materials production.

Health, hygiene and sanitation

All production of medicinal plant materials by agriculture and collection should conform to national and/or regional regulations on safety, materials handling, sanitation and hygiene. All those involved in the handling and processing of cultivated or collected medicinal plants should in all processing procedures comply with national and/or regional regulations on hygiene. All personnel should be protected from contact with toxic or potentially allergenic herbs by means of adequate protective clothing, including gloves.

Health status

All personnel known, or suspected, to be suffering from or to be a carrier of a disease or illness likely

to be transmitted through medicinal plant material, should not be allowed to enter any harvest, production or processing area if there is a likelihood of their contaminating medicinal plant materials. Any persons suffering from diseases or symptoms of illness should immediately report to the management. A medical examination of personnel should be carried out if clinically or epidemiologically indicated.

Illness and injuries

All personnel with open wounds, inflammations or skin diseases should be suspended from work or required to wear protective clothing and gloves until full recovery. Persons suffering from known airborne or food-borne communicable diseases, including dysentery and diarrhoea, should be suspended from work in all areas of production and processing, in accordance with local and/or national regulations. Health conditions that should be reported to the management for consideration regarding medical examination and/or possible exclusion from handling of medicinal plant materials include: jaundice, diarrhoea, vomiting, fever, sore throat with fever, visibly infected lesions (boils, cuts, etc.) and discharges from the ear, nose or eye. Any personnel who have cuts or wounds and are permitted to continue working should cover their injuries with suitable waterproof dressings.

Personal cleanliness

Personnel who handle medicinal plant materials should maintain a high degree of personal cleanliness, and, where appropriate, wear suitable protective clothing and gloves, including head covering and footwear. Personnel should always wash their hands at the start of handling activities, after using the toilet, and after handling medicinal plant materials or any contaminated material.

Personal behaviour

Smoking and eating should not be permitted in medicinal plant processing areas. Personnel who handle medicinal plant materials should refrain from behaviors that could result in contamination of the materials, for example, spitting, sneezing or coughing over unprotected materials. Personal effects such as jewellers, watches or other items should not be worn or brought into areas where medicinal plant materials are handled if they pose a threat to the safety or quality of the materials.

Visitors

Visitors to processing and handling areas should wear appropriate protective clothing and adhere to all of the personal hygiene provisions mentioned above.

Other relevant issues

Ethical and legal considerations

The cultivation, collection and harvesting of medicinal plants, as well as the post-harvest processing of medicinal plant materials, must be carried out in accordance with legal and environmental requirements and with the ethical codes or norms of the community and country in which the activities take place. The provisions of the Convention on Biological Diversity must be respected.
Intellectual property rights and benefits-sharing
Agreements on the return of immediate and/or long-term benefits and compensation for the use of source medicinal plant materials must be discussed and concluded, in writing, prior to collection or cultivation. Contract cultivation of medicinal plants from propagation materials obtained from indigenous medicinal plants of a given country may carry varying degrees of property rights. The issue of rights of access to genetic resources is more complex, especially if the propagation materials

have a long history as an item of international commerce, and are not indigenous to a given country.

Threatened and endangered species

Medicinal plants that are protected by national and international laws, such as those listed in national "red" lists, may be collected only by relevant permission according to national and/or international laws. The provisions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) must be complied with. Endangered medicinal plant species must be sourced only in accordance with national and/or regional legislation. When medicinal plant materials from threatened, endangered or protected medicinal plant species are obtained through cultivation, they should be accompanied by appropriate documentation in accordance with national and/or regional regulations, to certify that no such medicinal plant materials collected from the wild are included.

*****☺*****