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-1.

Cultivation

Soil

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

Climate

It requires a warm, humid climate with plenty of sunshine and a rainfall ranging

from about 200-250cm, well distributed over the year. In areas where the rainfall is poor, it can be grown with supplemental irrigations. It grows well at altitudes between 1000 -1200 m.

Propagation

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

Nursery raising

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

The seeds collected during the month of January – February are usually sown in the nursery during April – May.

Transplanting

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

Manures and fertilizers

Lemon grass is an exhaustive crop and it requires 275 kg N, 25 kg P_2O_5 and 175 kg K_2O/ha/annum. In order to promote growth and to obtain a higher oil yield the crop is applied with 2t/ha of compost made from spent grass and 2t/ha of wood ash at the time of bed formation. In addition, it has to be supplied with chemical fertilizers. Under Odakkali conditions, it was found that an application of 100kg N in 3 to 4 split doses was found to be optimum, though a response up to 200kg was recorded. The response to P and K was found to be erratic. The application of 50kg ha each P_2O_5 and K_2O as a basal dose gave encouraging results in West Bengal. It is recommended to apply 60:45:35 kg/ha N, P_2O_5 and K_2O as a basal dose and 60kg N in 3 to 4 splits/annum as top dressing during the growing season as an optimum dose. Lemon grass is also reported to respond well to the application of copper, iron, calcium and sulphur.

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

Interculture

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

Irrigation

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

Pests and diseases

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

The leaf diseases can be controlled by prophylactic sprays of Dithane M-45 and

Dithane Z-78 @ 3 g/l thrice at intervals of 15 days.

Harvesting and yield

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

Factors influencing the oil –yield:

The factors influencing the oil production during distillation are:

i)Storage of the plant material

ii) Treatment of the material

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.

20 Palmarosa

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,

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 P_2O_5 and 40kg K_2O/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 $FeSO_4$ and $MnSO_4$ 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.

21 Vetiver-

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.
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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 P_2O_5 and K_2O 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.

22Rosemary and Thyme

- **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 P2O5, 40 kg of K2O 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.

23 Scented geranium

- **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 P_2O_5 and 35 kg K_2O/ha are incorporated into the soil. A second dose of nitrogen at 35 kg/ha is applied about 2 months after the first application, Further, nitrogen is given in two equal split doses for each harvest-the first dose being just after the crop is harvested and the second two months later. Altogether, 210 kg/ha/yr of N is applied to the crop in six equal doses to cover three harvests. 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.

24 Patchouli-

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

PatcholiPatchouli 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 K20/ 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.

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25 Ocimum

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

Irrigation

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

Weeding

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

Interculture

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

Diseases and pests

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.

26 Artemisia

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

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.

27 Ambrette

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, P_2O_5 at 35 kg and K_2O at 40 kg/ha have resulted in the best yields under Bangalore conditions. Of these, a full dose of P and K and 40 kg N are applied as a basal dose, while the remaining 80 kg N is applied in two equal split doses of 40 kg each at 60 days and 120 days after sowing. The fertilizer mixture is applied about 10 cm away from the plants and mixed well into the soil.

Interculture

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

Pests and diseases

Pests

There are several diseases and pests which infect this crop and result in low yields. The spotted boll worm *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.

Pests and diseases

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28 French Jasmine

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.

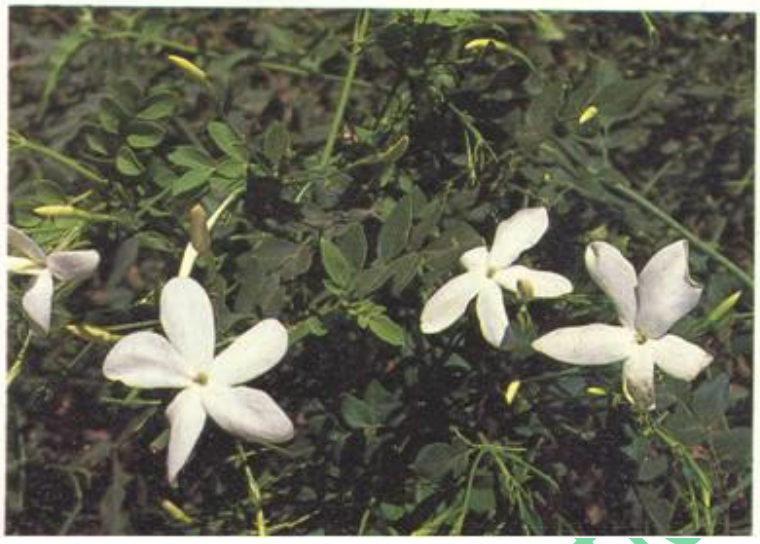
- India is now second largest producer of jasmine 'concrete' after Egypt, exporting most of its produce to Europe.

- **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.

29 Oil bearing rose

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 P_2O_5 and K_2O, 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 P_2O_5 and KO_2 are placed and covered with soil.

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

30 Tuberose

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 P_2O_5/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 P_2O_5 and 40 kg K_2O/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.

31 Lavender

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-ol, 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 14-15^{0}C. 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.

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 requirements

1. 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

8. Farm map
9. Soil analytical data
10. Water quality data
11. Crop production practices
12. Plant protection measures
13. Animal husbandry details
14. Crop rotation plan
15. Details on seed and planting materials.

2. 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

21. Manures of human excreta
22. Industrial sludges
23. All Mineral fertilizers
24. Manures and fertilizers with high load of heavy metals
25. 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.

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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:

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 stewar

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 2-8oC; frozen products should be stored at less than -20oC. 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

.....Thenks.....You .....

ID. No. ……

SEMESTER FINAL EXAMINATION 2015-16

COLLEGE OF HORTICULTURE

VCSG Uttarakhand University of Horticulture & Forestry, Bharsar-246 123

Pauri Garhwal, Uttarakhand

Programme: B.Sc. (Hons.) Horticulture (2nd Year) Roll No. ……

Course Title: Medicinal and Aromatic Crops (HPM-100) Date of Examination:

Credit Hours: 3 (2+1) Time: 09:30am - 12:30pm (3 Hrs.)

Max. Marks: 50.00 Marks Semester: I st 2015-16

Note: (i) All the questions are compulsory, cutting & over writing is not allowed.
(ii) The question paper consists of two parts, Part-I (objective) of 20.00 marks and the Part-II (subjective) of 30.00 marks.
(iii) Write the answer of Part-1 on the question paper itself.

PART-I, Objective (Max. Marks: 20.00)

Question No. 1: Fill in the blanks. (0.50 x 10.0=5.0 Marks)

1) The chief constituents of the oil of Geranium are ……and……
2) ……..is a family of *Rauvolfia serpentina*.
3) Vincristine sulphate is being marketed under the trade name ONCOVIN, which is used against……
4) *Catharanthus roseus* is native of ……
5) Directorate of Medicinal and Aromatic Plants Research is situated at ……..
6) AICRP on MAP & B is an abbreviation of……..
7) Centre for Aromatic Plants (CAP) is situated at …….
8) AYUSH stands for……..
9) IUCN stands for……..
10) 'Jhelum' is a variety of ……

Question No. 2: State whether the following statements True (T)/False (F)? (0.50 x 10.0=5.0 Marks)

1) *Picrorhiza kurrooa* is hepatoprotective.
( )
2) Paper Ebyrus is a scroll of Chinese Traditional System.
( )
3) Charak Samhita is known as "Encyclopedia of Indian Medicine".
( )
4) Imhotep is known a god of healing in Greek civilization.
( )

5) *Dioscorea deltoidea* is endemic to western Himalaya.
( )

6) Quinine protects the skin against sunbun.
( )

7) *Dioscorea deltoidea* is an annual climber.
( )

8) The entire produce (dried roots) of Ashwagandha is stored into 7 grades.
( )

9) Sarpagandha can be propagated by seed only.
( )

10) Geranium is a bushy, medicinal plant.
( )

Question No. 3: Tick (√) the correct answer. (0.50 x 10.0=5.0 Marks)

1) Following is known as 'Father of Modern Medicine'.
a) Hippocrates b) Plinays c) Theophrastus d) Galen

2) For his contribution in medicine, he is known as "Father of Experimental Medicine".
a) Charak b) Pelletier c) Galen d) Al Razi

3) A commercial oil "Margosa" is derived from……
a) Citronella b) Artemisia c) Neem d) Deodar

4) Biological source of 'Davana oil' is…….
a) Vetiver b) Lemongrass c) Artemisia d) None of these

5) Following is plant(s) of "Astaverga" of Ayurveda.
a) Meda and Mahaweda b) Kakoli c) Jeevak d) All of these

6) 'Aka Upkar' is a high yielding clone of……...
a) Geranium b) Cinchona c) Pyrethrum d) Isabgol

7) HRDI is situated in the district ……..
b) Pauri Garhwal b) U.S. Nagar c) Chamoli d) Tehri Garhwal

8) Family of *Picrorhiza kurrooa* is…….
a) Apocynaceae b) Solanaceae c) Scrophulariaceae d) None of these

9) CITES protect endangered……
a) Plants b) Animals c) Plants and Animals d) Plants, Animals and Humans

10) ……..is commonly known as 'winter cherry' and 'Indian Ginseng'. .
a) Sarpagandha b) Long pepper c) Belladonna d) None of these

Question No. 4: Match the following. (0.50 x 10.0=5.0 Marks)

A.	**MAPs**	**Botanical Name**
	a. Betelvine	**1.** *Piper betel*
	b. Pyrethrum	**2.** *Chrysanthemum cinerariifolium*
	c. Geranium	**3.** *Pelargonium graveolens*
	d. Lavender	**4.** *Lavandula officinalis*
	e. Patchouli	**5.** *Pogostemon cablin*
B.	**MAPs**	**Economic part**
	a. Sarpagandha	**1.** Root
	b. Ocimum	**2.** Leaf

c. Cinchona	**3.** Bark
d. Medicinal Yam	**4.** Tuber
e. Isabgol	**5.** Seed

PART II, Subjective (Max. Marks: 30.00)

Question No. 5: Differentiate among the following (Attempt any three). **(2.50 x 3.0=7.5 Marks)**

1) Endangered and vulnerable species
2) Mode of propagation in periwinkle by seeds and vegetation
3) Area of occurrence and area of occupancy
4) Medicinal and Aromatic plants
5) Chemical composition & uses of Long pepper and Ashwagandha
6) Concrete and balsam

Question No. 6: Write short notes on any three. (2.50 x 3.0=7.5 Marks)

1) Critically endangered species
2) Any five (5) threatened species of India
3) Major aromatic crops in India
4) Chemical composition & uses of Belladona
5) Grading of Ashwagandha
6) Propagation of Dioscorea

Question No. 7: Long type question (Attempt any three). (5.0 x 3.0=15.0 Marks)

1) Describe the cultivation of Geranium under the following heads
   1. Climate and soil **2.** Propagation techniques **3.** Nutrient management **4.** Harvesting and Yield
2) Explain the agro- techniques of Vetiver/Khus under the following heads.
   1. Soil and field preparation **2.** Improved varieties **3.** Nutrient management **4.** Harvesting and yield
3) Explain the agro- techniques of Periwinkle under the following heads.
   1. Soil and field preparation **2.** Improved varieties **3.** Nutrient management **4.** Harvesting and yield
4) Describe the cultivation of Ashwagandha under the following heads
   2. Climate and soil **2.** Propagation techniques **3.** Nutrient management **4.** Harvesting and Yield
5) Describe the cultivation of Ocimum under the following heads
   1. Climate and soil **2.** Propagation techniques **3.** Nutrient management **4.** Harvesting and Yield
6) Describe the prospectus, opportunities and constraints of MAPs in Uttarakhand.

GENERAL INFORMATION:-

1. Scientific name- *Bursera spp.*
2. Family-Burseraceae
3. Mode of pollination-Crosspollination(entomophilic)
4. Part used-Outer husk of berries and leaves.

Bursera have 45 species-

Important species are as follows-

1. *B. aloexylon*
2. *B.delpechiana*
3. *B.fragroides*
4. *B.glabrifolia*

1. BOTANICAL DESCRIPTION:- Deciduous,dioecious tree.
2. Leaves imparipinnate,serrate or nearly entire.
3. Flowers green,pentamerous,calyx small,lobes rounded,petals valvate in bud.
4. Stamen ten or nearly equal.
5. Ovary hairy,surrounded by a broad crenate disc.
6. Fruits fleshy and dark green berries,turning to reddish brown as they mature.

1. CHEMICAL COMPOSITION:- Methyl heptanol-1.5%
2. Linalool-47.7%

3. Linalyl acetate-40.8%
4. Sesquiterpene and other viscous substances-8%
5. Other constituents-Myrcene,Limonene,Trans-linalool oxide,Cis-linalool oxide,Neryl acetate,Cis-and trans-2,6,6-trimethyl-2-vinyl-5 acetoxytetra hydropyrane.

1. USES:- Berries and leaves yield essential oil called Linaloe oil.
2. It is used as raw material for extraction of linalool.
3. Its oil is used in numerous perfumes,cosmetics and in scenting soaps and transparent soaps.
4. Also used in flavouring food and beverages.

Cultivation:- CLIMATE

- Temperature-36˚-38˚C.
- Rainfall-500-900mm.
- Altitude-760msl.

SOIL-

1. Well drained sandy soil,with neutral PH.

- PROPOGATION:- By stem cutting and seeds.
- Commercially by stem cuttings.
- Propogation by stem cuttings-
- Healthy mother plant of more than five year age is preferred.
- Best season for raising cutting-Feb-march.
- Length of cuttings-0.5-1m
- Cuttings are planted in earthen pods of about 12 cm in dia and 25 cm height.
- Pods containing cuttings are kept under shade and watering is done at appropriate intervals.
- First sprout appears in about 30-40 days and healthy root system develops in about 4-6 months.
- Transplanting-
- Rooted cuttings are transplanted to main field during rainy season in pits of 60 cm^3 ay

spacing of 6m.

- Irrigate for a week and then fill with top soil and compost.

Watering is done at regular intervals.

- They are very hardy and once established,do not need much care.
- No serious pest and diseases are noticed.
- Plants raised from cuttings set fruits first year itself while those from seeds take about five years.
- HARVESTING:- Berries start setting by may and matre by july-aug,when they are harvested,dried and dehusked.
- 1kg of dried husk is obtained from 5-6 kg of fully mature berries.
- Plant gives a successful crop by third or fourth year.
- Earlier fruit setting is not allowed to induce adequate vegetative development.
- Picked or fallen fruits on clean ground are collected by sweaping floor of plantation.

1. EXTRACTION OF OIL:- 1 ha of plantation containing 300 plants(10 years old) yields about 1500 kg of berries.
2. Yield of husk is 18% of berry weight(255 kg/ha).
3. Oil content of husk is 10%,thus yielding about 25 kh/ha of oil.

Topic-Muskdana(*Abelmoschus moschatus)*

- Botanical ClassificationCommon Name : Muskdana musk mallow, musk okra, musk seeds, ornamental okra etc.
- Botanical Name : *Abelmosch moschatus*
- Parts-Used :Seeds, Seeds Oil
- Plant Type :Herbs
- Origin :India
- Chr. No. :(n=36)
- Family : Malvaceae

Introduction

- *Abelmoschus moschatus* is also known as Musk Ambrette, and is derived from the seeds of the musk mallow plant.
- It is a relative of hibiscus sometimes known as *Hibiscus abelmoschus* and is indigenous to India.
- This plant is cultivated for its seeds, which have a characteristic musk-like odor.
- The seeds are the source of ambrette, an aromatic oil used in perfumery.
- The plant is indigenous to India and is cultivated throughout the tropics.

- The seeds have a sweet, flowery, heavy fragrance similar to that of musk.
- The seeds are valued medicinally for their diuretic, demulcent and stomachic properties.
- The oil for perfumery is extracted by steam distillation of crushed seeds

Morphology

View :

- It is a soft plant, with soft hairy stems.
- It has an underground tuber that dies back in the dry season.

Leaf :

- Leave are cordate, lower suborbicular in outline, cordate, upper narrower.
- Leaves margins are coarsely toothed.

Flower :

- Flowers are regular and bisexual, hairy yellow with purple centre.

Fruit :

- Fruits are fulvous hairy, oblong and acute.

Seeds :

- Seeds are sub reniform and blackish
- Seeds are also musk-scented.

Height

- It attains 0.5 to 2.5 meters height.

Chemical Constituents-

- The main constituent is a sesquiterpene alcohol, fornesol.
- Analysis of volatiles report myricetin-3-glucoside and a glycoside of cyanidin in flowers,
- an aromatic constituent in seeds, beta-sitosterol and
- beta-D-glucoside, myricetin and its glucoside in leaves and petals and
- beta-sitosterol from dry fruit husk.
- Uses It helps in purification of the mouth and improves taste of the mouth.
- It improves digestive activities in the body.
- It is effective in diarrhea.
- It helps in heart muscles toning.
- Respiration system is also checked by it and helps in expelling out the extra amount of mucus in the tract.
- It is also checks vomiting.
- The bark is processed into fibre and root mucilage as a sizing for paper.
- It also helps in checking out the urinary tract and its related ailments.

- Powder is also being used in eye related troubles.
- It is used in urine diseases like gonorrhea.
- It is also used in heart related problems and asthma.
- Seed steeped in alcohol are applied to the bites of serpents.
- Seeds rubbed to a paste with milk are used to cure itch.
- Ambrette seed oil has been used in Chinese medicine for treatment of headaches.
- The oil is used in high-grade perfumery.
- The flowers are used for making zarda, an indigenous flavoured tobacco.
- The seeds are used as sachet powders as an insect-repellent.
- The bitter, sweet, acrid, aromatic seeds are used as a tonic and are considered "cooling, digestive, constipating, stimulant.
- Ambrette seed oil has been used in Chinese medicine for treatment of headaches.
- The oil is used in high-grade perfumery.
- The flowers are used for making zarda, an indigenous flavoured tobacco.
- The seeds are used as sachet powders as an insect-repellent.
- The bitter, sweet, acrid, aromatic seeds are used as a tonic and are considered "cooling, digestive, constipating, stimulant.

Origin & Distribution-

Origin : It is native to India.

- It is found commonly in Madhya Pradesh.

Description : It is a tropical weedy herb native to India valued for its scented seed.

- In Hindi, it is popularly known as mushkdana.
- It is an annual growing plant in many hotter parts of the world.
- The seeds root and leaves are having different uses.

Species

- The genus Abelmoschus has six species distributed in the South and South East Asia and in North Australia.
- *Abelmoschus moschatus,*
- *A. manihot and*
- *A. esculentus* , contain wild and cultivated forms.
- *A. ficulneus,*
- *A. crinitus,* and
- *A. angulosus,* are only wild.

Climate

- Ambrette is cultivated as pre-kharif crop in India.

- It is colder climate plant.
- It tolerates temperatures down to about -5°C.
- It can also cultivate in tropical climates for its many uses.
- Mean annual rainfall: 1000-1400mm,

Soil

- Plant can grow well in light sandy, medium loamy and heavy clay soils.
- Soil should be with well drained condition.
- It requires moist soil.
- The plant prefers acid, neutral and basic (alkaline) soils,
- It tolerates a pH in the range 6-7.8.
- It cannot grow in the shade.

Sowing-Method

Land Preparation :-

- Land is prepared by ploughing and leveling.
- Decomposition manure is applied and mixed well in the soil.
- Ridges and furrows are opened keeping a spacing of 60 cm.
- Treat the seeds with “captain” at the rate of 6 gm/Kg of seeds.

Seeds are soaked in water for 24 hrs

Cropping Method

- Seeds are sown April in the field.
- The seed germinates best at a temperature around 24°c.
- The seed can also be sown in late April in warm areas.
- The field is irrigated soon after sowing.
- After 6 to 12 days of germination, Nitrogen is applied in furrows about 10cm away from the plants.

Manures

- At the time of field preparation well rotted FYM @20t/h must be mixed.
- It does not require a heavy dose of fertilizer.
- A fertilizer dose of 25 kg Nitrogen and 25 kg P_2O_5 is recommended as basal dose.
- After first irrigation 25 kg/ha Nitrogen is good for the growth of the crop.
- Application of dried Neem leaves (500Kg/ha) at last ploughing increased oil content and quality.
- The use of chemical inputs resulted in negative impact on oil content and quality.