Introduction
INTRODUCTION

A. Scope of study

India possesses rich diversity of plant materials from which a variety of herbal products and essential oils could be extracted. Until recent past, India has been a leading producer and exporter of perfumes. India has the potential to capture its pre-eminent position as a leading producer of perfumes, cosmetics and soaps if the products are standardized to cater to the present sophisticated needs of American and European consumers (Anonymous, 1986-'95). Perfumery chemicals are one of the fastest growing items of the World Trade and Indian perfumes are likely to find an attractive international market. Production of perfumery and cosmetic materials is increasing both due to the growing population as well as the changing life styles.

United States of America is the largest producer and user of flavours and fragrances. However, France has been remaining historically as the largest producer and exporter of fragrance materials for up-market fragrance and skincare products. The firms accounting for the largest share of worldwide sales of flavours and fragrances are located in USA, Western Europe, Brazil, China, Hongkong, India and Singapore. They play an important role in the international trade of the raw materials which are the essential ingredients in flavour and fragrance compositions (Laszlo Somogyi, 1996).

Though India has enormous natural resources to produce a number of important essential oils and resinoids, it lacks technical capability to become self-sufficient in perfumery and cosmetics (Anonymous, 1986). In India nearly 20 per cent of the 3800 tonnes of chemicals used annually in perfumes and flavours come from essential oils (Menon, 1986). There is considerable scope for India to increase the production of essential oils that are currently exported, by increasing the cultivation of various essential oil-bearing plants. India has an array of aromatic flora occurring in the wild state due to its considerable diversity in edaphic and climatic conditions. These aromatic plants are the natural sources of perfumes and fragrances exploited by the essential oil industries across the world.
Research on seeds of medicinal and aromatic plants is inadequate. Seed is the basic input in Agriculture. Certified bulk seeds of superior cultivars of medicinal and aromatic crops are in short supply, particularly for saffron (Crocus sativus). Even quality seeds of periwinkle (Catharanthus roseus), rauvolfia (Rauvolfia serpentina) and palmarosa (Cymbopogon martinii) that are widely cultivated are not readily available in bulk. This is mainly because no corporate sector has entered into commercial seed production of these crops. Nevertheless, Union Department of Horticulture (Ministry of Agriculture) has recently provided funds to initiate seed production of recognized newly bred varieties at 16 locations in the country. In spite of all these efforts by the Government, research on seed production of these crops has not gained momentum. Seed-testing procedures for maintaining pure and viable seeds and any such related technology will immensely help new seed production units. Lower seed setting, poor seed viability, higher dormancy and lower percentage of germination have been recognized as major obstacles. Seed setting is extremely poor in safed musli (Chlorophytum tuberosum). Viability of seeds in neem, valerian and lavender is very brief. Seed germination is extremely poor in many plants of Lamiaceae such as sweet basil and rama tulsi and these need further investigation.

Indian Council for Agricultural Research has a proposal to establish skilled human resources in Seed Biology and Seed Technology together with laboratory facilities in the Department of Seed Research at State Agricultural Universities. The commercial cultivation practices that are standardized for some medicinal and aromatic plants have to be popularized among the farmers for rapid expansion and for a good market support. This needs research on seed production and techniques to conserve the seeds for a certain period of time.

Soil salinity and alkalinity are serious problems in many areas of our country. Equally alarming is the secondary salinization due to continuous use of water of poor quality for irrigation that convert productive soils into non-productive in course of time. Successful cultivation of crop on cultivable but salt affected wastelands needs suitable reclamation and management strategies. Efforts are on to breed tolerant varieties or search for non-traditional crops that can withstand such hazards (Anonymous, 1986).
Some of the aromatic crops recommended for cultivation in these problematic soils are German chamomile (*Matricaria chamomeli* Hill), Lemon grass (*Cymbopogon citratus* Wats.), Palmarosa (*Cymbopogon martinii* var. *motia* Wats.), and Vetiver (*Vetiveria zizanioides* Nash). Some of the medicinal plants recommended for cultivation are Egyptian henbane (*Hyoscyamus niger* Linn.) Isabgol (*Plantago ovata* Forsk.), Periwinkle (*Catharanthus roseus* G.Don) and Sweet basil (*Ocimum basilicum* Linn.)

Improvement of soil through cropping results in higher CO₂ production and mobilisation of CaCO₃ at favourable moisture and temperature in the rhizosphere. The potentiality of medicinal and aromatic plants in this regard depends on their tolerance to alkaline soils and ability to withstand water-logging to build up CO₂ production and leaching of salts resulting from cation exchange. Sharma, J.R-etal., 1996

Because of the ever-increasing demand of medicinal and aromatic plant products, there is a growing need to cultivate these crops. To increase their production more areas need to be brought under cultivation. Since there is much pressure on good quality land for cultivation of food and other crops, it can be a very meaningful exercise if marginal and cultivable wastelands especially the saline lands are utilized for the cultivation of these crops of high value(Patra and Singh, 1998).
B. Essential oil plants:

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area under cultivation (ha)</th>
<th>Production in India (tonnes)</th>
<th>Production in the world (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIL</td>
<td>3200</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>DAVANA</td>
<td>100</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>EUCALYPTUS</td>
<td>1500</td>
<td>80</td>
<td>1600-1750</td>
</tr>
<tr>
<td>LEMON GRASS</td>
<td>6000</td>
<td>600</td>
<td>800-1300</td>
</tr>
<tr>
<td>PALMAROSA</td>
<td>LIMITED</td>
<td>60</td>
<td>76</td>
</tr>
<tr>
<td>PEPPERMINT</td>
<td>1600</td>
<td>100</td>
<td>2000</td>
</tr>
<tr>
<td>SANDAL WOOD</td>
<td>1500</td>
<td>0.001</td>
<td>15-20</td>
</tr>
</tbody>
</table>

(Anonymous, 1992)

Some of the major oil-importing countries of these aromatic oil plants include Australia, France, Germany, Japan, Netherland, Russia, Singapore, Spain, Switzerland, United Kingdom and United States of America. Hence in the present work an attempt has been made to get pure and viable bulk seeds of sweet basil, one of the important aromatic plants having therapeutic potential. The essential oil price of basil oil was reported to be $104. /Kg in New York (Rs.4685/kg)(Anonymous, 1999).

About 60 species of Ocimum are found to grow in tropical and sub-tropical regions of the world, from sea level to an altitude of about 1800 m (Ashok Sharma et al., 1987). Mabberly (1997) reported that there are 150 species of Ocimum distributed in warm temperate to tropical regions of the world. Of these, Ocimum basilicum Linn., commonly called sweet basil is considered to be the most important one for its sweet basil oil. Sweet basil is a native of Persia from where it was sent to the Botanic Garden at Calcutta under the Persian name, "Debanshan" and "Deban Macwassi". It is known to have been cultivated for at least three thousand years by Europeans and Asians for folklore and religious rituals. It got established wherever it migrated with extreme variation of its progeny (Roxburg William, 1832).
C. Ocimum basilicum L.

The correct nomenclature of species and varieties of *Ocimum* L. from which commercial basil is obtained has been of great concern, since more than fifty species and forms have been recorded, making the true botanical identity of the basil cited in some literature is questionable (Ashok Sharma et al., 1987). The difficulty in classifying the more than 60 varieties of *Ocimum basilicum* L. has been attributed to the polymorphic character of the taxon. The frequent cross pollinations within the taxon also adds to the genetic diversity of the species resulting in the recognition of the large number of subspecies, varieties and forms (Srivastava, 1980).

Gamble (1956) has recognized the following varieties of *Ocimum basilicum* L.

*Ocimum basilicum* var. *thrysiflorum* Benth.

*Ocimum basilicum* var. *purpurascens* Benth.

*Ocimum basilicum* var. *pilosum* Benth.

Matthew (1983) makes a mention of 3 varieties of *Ocimum basilicum* on the basis of colour of the vegetative parts and leaf characters.

The varieties listed by him are:

*Ocimum basilicum* var. *thrysiflorum* Benth.

*Ocimum basilicum* var. *purpurascens* Benth.

*Ocimum basilicum* var. *pilosum* Benth.

Henry et al. (1987) have recognized the following varieties of *Ocimum basilicum*

*Ocimum basilicum* var. *thrysiflorum* Benth.

*Ocimum basilicum* var. *purpurascens* Benth.

*Ocimum basilicum* var. *pilosum* Benth.

D. Classification of Ocimum basilicum L.

Paton and Putievsky (1996) classified *Ocimum basilicum* into the following categories.

*Ocimum basilicum* var. *purpurascens* Benth.

*Ocimum basilicum* var. *difforme* Benth.

*Ocimum basilicum* var. *minimum* Linn.

*Ocimum basilicum* var. *basilicum*

*Ocimum basilicum* cv. *dark opal*
The morphological characters of these varieties and cultivars of *Ocimum basilicum* are given in Table A2.

**Table A2: Morphological Characters of taxa under *Ocimum basilicum* L.**

(Paton and Putievsky, 1996)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Pl. ht</th>
<th>Largest Leaf length x width (mm)</th>
<th>Stem Indumentum</th>
<th>Leaf colour</th>
<th>Leaf form</th>
<th>Inflorescense colour</th>
<th>Fruiting Calyx &amp; Upperlip Lowerlip (mm)</th>
<th>Corolla Length Upperlip Lowerlip (mm) Colour</th>
<th>Stamen Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>var. purpurascens</td>
<td>82</td>
<td>120 x 60</td>
<td>scattered patent hairs</td>
<td>green</td>
<td>flat</td>
<td>purple</td>
<td>6/7</td>
<td>8-10/10-12 pink</td>
<td>12-15</td>
</tr>
<tr>
<td>var. difforme</td>
<td>64</td>
<td>130 x 90</td>
<td>scattered retorse hairs</td>
<td>green</td>
<td>bullate</td>
<td>green</td>
<td>7/8</td>
<td>7/9 white</td>
<td>11</td>
</tr>
<tr>
<td>var. minimum</td>
<td>73</td>
<td>18 x 30</td>
<td>retorse hairs</td>
<td>green</td>
<td>flat</td>
<td>green</td>
<td>6/6</td>
<td>5-7/8 white</td>
<td>8</td>
</tr>
<tr>
<td>var. basilicum (flat leaves)</td>
<td>87</td>
<td>180 x 130</td>
<td>scattered hairs on opposing faces</td>
<td>green</td>
<td>flat to slightly convex</td>
<td>green</td>
<td>7/8</td>
<td>9/10 white</td>
<td>12</td>
</tr>
<tr>
<td>var. basilicum basilicum (convex leaves)</td>
<td>120</td>
<td>190 x 110</td>
<td>scattered retorse hairs on opposing faces</td>
<td>green</td>
<td>convex and slightly crisped</td>
<td>green</td>
<td>6/7</td>
<td>7/12 white</td>
<td>11-12</td>
</tr>
<tr>
<td>cv. dark opal</td>
<td>61</td>
<td>75 x 47</td>
<td>scattered retorse hairs</td>
<td>purple</td>
<td>convex and slightly crisped</td>
<td>purple</td>
<td>6/7</td>
<td>6/12 pink</td>
<td>12-13</td>
</tr>
</tbody>
</table>
Ocimum basilicum var. basilicum “EC 174526” was taken for this present research study.

**Botanical Description of EC 174526**

Annuals, up to 1 metre tall, with short root-stock. Stems much branched, obtusely 4-angled, sparsely or densely villous. Leaves opposite decussate, ovate-lanceolate, 4-6 x 2-3 cm, cuneate at base, distantly crenulate along margins, acute at apex; petiole c. 1 cm long. Inflorescence 10-20 cm long; cymes verticillate. Flowers bisexual; bracts ob lanceolate, c. 7 x 4 mm, ciliate at margin, acuminate at apex. Pedicel c. 2 mm long. Calyx 5-lobed; upper lip suborbicular, c. 3 mm long; lower lip lanceolate-ovate, c. 4 mm long; calyx tube 3 mm long, sparsely hairy without and densely hairy within. Corolla 7-10 mm long, 1.5 mm wide, bilipped, whitish; tube glabrous; upper lip c. 4 mm long; lower lip c. 5 mm long, fimbriate. Stamens 4, epipetalous, didynamous, dorsifixed; longer filament c. 7 mm long; shorter filament c. 4 mm long; posterior filament base with tufted hairs. Ovary 4-lobed, each lobe ovuled; style c. 6 mm long. Fruit a group of 4 nutlets, enclosed within persistent and accrescent calyx, c. 6 mm long. Nutlets black, ellipsoid, c. 3 x 1 mm, subtrigonal, mucilagenous when wet.

**E. Basil oil**

For commercial purposes, the following types of oil are recognized based on chemical composition and geographical source.

**European type**: The main constituents of oil are methyl chavicol and linalool. It has no camphor. This group comprises French and American sweet basil oils which are laevorotatory in nature and are very much in demand in trade because of its high quality and fine odour.

**Reunion type**: The main constituents of this oil are methyl chavicol and camphor, but linalool is absent. This group comprises oils distilled in Reunion Island, Comoros, Madagascar and Seychelles which are dextro-rotatory and is somewhat of lower quality.

Maheshwari and Singh, 1989
Methyl cinnamate type: Methyl Chavicol and Linalool form the principal constituents of this oil. Methyl cinnamate is present in substantial amounts. The oil distilled in Egypt, Sicily, Bulgaria, Erstwhile British East India and Haiti come under this group which are laevorotatory.

Eugenol type: The principal constituent of this oil is eugenol. This type comprises oils distilled in Java, Seychelles, and Samoa, these are dextrorotatory. (Srivastava, 1980)

Only one chemotype rich in methyl chavicol is used commercially. In order to augment the basil germplasm in India, NBPGF obtained small seed samples from European countries. The initial evaluation studies of 18 exotic germplasm were undertaken under Delhi conditions. The performance of these materials have been studied under Madras conditions in the present work. Essential oil was distilled and subjected to determination of Physico – chemical properties, major components and odour value (Maheshwari and Singh, 1989).

The germplasm was assessed for 19 agro-botanical conditions, both qualitatively and quantitatively. The adult plant varied in height from 50-100 cm. Leaf shape varied from ovate to subovate. Inflorescence colour and flower colour varied from white to pink. Herbage yield of plants (fresh weight) per 3 m row varied between 1 kg and 2.8 kg. Herbage yield per plant varied between 0.2 and 0.5 kg. Oil recovery varied between 0.16 and 0.3%.

General soil and climatic conditions required for the cultivation of the species, the common pests and diseases that affect the plant and suitable measures to be taken to overcome pests and diseases will be discussed in sequel.

F. Soil and Climate

This crop (sweet basil) grows well in well drained loamy or sandy-loam soils. In the hilly areas of North India, it is advisable to raise this as a kharif crop. In the plains of North India, South India and Assam, it could however be grown both as kharif and rabi crops. In areas with heavy seasonal rainfall, the crop could be raised before the onset of monsoon.
The plant thrives best on moderately fertile but well drained loamy or sandy-loam soils (Richters, 2000). The clayey soils are not used for its cultivation. The best soils are those which are in good physical condition and have good water holding capacity. The waterlogged lands must invariably be avoided (Ashok Sharma et al., 1987)

G. Pests and Diseases

Commonly occurring pests and diseases of sweet basil are as follows:

Pests

1. At nursery stage ants are the most important damaging pest. To ward off the ants, application of BHC DUST (5%) around the nursery areas is very effective.
2. Leaf rollers are pests that cause defoliation of leaves. Spraying malathian is effective.
3. Tingid bug: Cochlochila bullita (Stal) Horvath also causes defoliation of leaves. Spraying Malathion/Thiodon is effective (Srivastava, 1980).

Diseases

Leaf blight: This is caused by Corynospora cassicola, Colletotrichum capsici and Alternaria sp. Symptoms are brown coloured chlorotic spots on leaves. This can be controlled by spraying Dithane Z-78 or Dithane M-45.

Wilt disease: This is caused by Fusarium oxysporum. Symptoms are the die back of the whole plants. Spraying Tafason / Agalol controls the disease.

Scab: This is caused by Elsinoe arxii. Symptom is defoliation of leaves.

Rhizosphere & Mycoflora disease: This is caused by Aspergillus candidus, Penicillium hamicola, Humicola sp. and Alternaria tenuis. Spraying of Agrimycin / Phytomycin / Dithane M-45 / Thiram controls the disease (Srivastava, 1980).
H. Names in regional languages

Sanskrit - Munjariki, Vaxvara
Hindi - Babuitulsi, Gulal Tulsi, Kalitulsi, Mania
Marathi - Marva, Sabza
Gujarathi - Damaro, Nasabo, Sabza
Telugu - Bhutulsi, Rurdrajada, Vepudupacha
Tamil - Tirunirupachai, Karpura Tulasi
Kannada - Karpura Tulasi
Oriya - Dhala Tulasi, Kapur Kanti
Kashmir - Niaxbo
Punjabi - Furruiji, Mashk, Baburi, Niyazbo, Paar.
(Mukerjee 1940 and Anonymous, 1966)

I. Uses

Sweet basil is cultivated in India on a commercial scale because the oil owes its importance to its extensive use in condimentary products, cosmetics, toiletry, perfumery and confectionary industries particularly in European countries.

**Cosmetics:** It is used as a fragrance ingredient in perfumes, hair dressings, dental creams and mouth washes.

**Food:** Used as a spice and in chartreuse liquor. The oil and oleoresin are extensively used as a flavouring ingredient (below 0.005 ppm) in all major food product (Vjazov, 1956).

J. Medico-ethnobotany

The plant finds use as an ophthalmic drug in Phulbani, Orissa, in the preparation of various ointments curing eye diseases such as night blindness, cataract, conjunctivitis and eyesores. The tribals of Phulbani district use this to improve the eye sight (Sahoo, 1955).
Folk medicine: It is used as a cure for cold, warts and worms. It is widely used as a medicinal herb in Far East (China, India). It is especially used to promote blood circulation (Patel and Bhatt, 1977). It possesses insecticidal, bactericidal and insect repellant properties. It has been found to be effective in controlling houseflies and mosquitoes (Jain et al., 1987).

Seeds possess demulcent, diuretic, diaphoretic and cooling properties. They are given internally in cases of habitual constipation and piles. They are used in poultices for sores and sinuses (Anonymous, 1966).

Seeds are also used in anasarca, bowel complaints in cholera, cough, convulsions, cramps, dropsy, earache, epilepsy, diarrhoea, dysentery, fever, headache, stomach ache and wounds. It is also used against snake bites and for deaddiction of alcoholics (Anonymous, 1966).

The plant is considered as stomachic, anthelmintic alexipharmic, antipyretic, diaphoretic, expectorant, carminative, stimulant and pectoral. An infusion of the plant is given for cephalgia. It is also used as a gargle for foul breath. The plant is used in homeopathic medicines. Root barks and leaves are cyanogenetic.

The juice of the leaves has a slightly narcotic effect and it removes irritation in the throat. It is used as a nasal douche and as a nostrum for earache and also for ringworm (Anonymous, 1966).

K. Important chemical constituents

There are 4 major constituents in Basil seed oil

1) Linalool (48.2%)
2) Methyl Chavicol (31.6%)
3) 1.8 cineole + Limonene (7.37%)
4) β – Caryophyllene (12.8%)

(Lawrence and Hogg, 1972)
L. Composition of basil seed oil:

Palmatic acid – 7.0 %, Stearic acid – 0.2 %, Oleic acid – 11.0 %,
Linoleic acid – 60.0 % and Linolenic acid – 21 %
The mucilage (9.3 %) yields on hydrolysis uronic acid, glucose, xylose and rhamnose.
The unsaponifiable fraction is reported to contain sitosterol, β- olenic acid and urosolic acid (Anonymous ,1966).

The present study is aimed to develop suitable seed technology and cultivation practices of the crop so as to produce high yield of essential oil, as there is no good records on its agrotechniques in Tamil Nadu compared to its commercial viability. Only 2 varieties have been so far released in sweet basil. They are (1) Kusumohak released by Bahl et al.(1999) and (2) Vikar-sudha, released by Dwivedi et al.(1999). Both varieties have been released from CIMAP, Lucknow. No variety has been released so far in Tamil Nadu to cater to the need of essential oil. Hence effort has been made to cultivate the crop under Tamil Nadu conditions and to identify the problems encountered during cultivation. Major problem encountered in commercial cultivation identified was dormancy in seeds resulting in poor seed germination. Since the crop is mainly propagated through seeds, some of the seed technological studies such as seed production, assessing seed quality and seed viability studies were carried out in the present work to have better knowledge on seeds. Phytochemical analysis of this sweet basil culture was also carried out with particular reference to its essential oil content and to detect the time of collection that can yield high essential oil.

M. Objectives of the study:

An attempt is made in the present work to fulfill whatever lacunae noticed in the existing agronomical, phytochemical and pharmacognostic knowledge. There is no record on indepth studies on pharmacognosy especially on the development of gland. As far as the phytochemical work is concerned, percentage yield of oil in South Indian soil conditions have been studied and a trial was conducted to determine the best time of collection of herb and seed for getting good yield. The following are the objectives of the present study:
1) To study the flowering behaviour, seed development and seed maturation.
2) To study the effect of transplanting age of the plant and leaf removal frequencies on the seed yield and quality.
3) To standardize the forms of manures, fertilizers and their doses for better seed yield and essential oil yield.
4) To study the effect of different concentrations of micronutrients on herb and essential oil yield.
5) To study the germination behaviour of freshly harvested seeds and seeds stored for different periods.
6) To improve the germination of freshly harvested seeds using mild alkali and acid.
7) To break the dormancy of seeds using chemicals.
8) To standardize the biochemical tests for seed viability and vigour of fresh and stored seeds.
9) To study the pharmacognosy of leaf samples during various stages of crop growth.
10) To study the phytochemistry of essential oil during various stages of crop growth.