Sustainable Use and Conservation of Basil's Diversity in Upper Gangetic Plains of Uttar Pradesh

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Introduction

The basil (*Ocimum* spp., Fam. Lamiaceae) is an economically important medicinal herb due to presence of essential oils which contains monoterpenes, sesquiterpenes and phenyl-propanoids (Paton *et al.*, 1999). Its essential oil is the natural source of methyl chavicol, methyl cinnamate, camphor, neral, geranial, linalool, eugenol, thymol, methyl isoeugenol, etc. which are used in pharmaceutical, cosmetic and flavouring industries. Besides these chemicals beta-carotene (vitamin-A precursor) is also present in the leaves of basil. The leaves of holy basil (*Ocimum tenuiflorum* L.; syn. *O. sanctum* L.) are used against various ailments and diseases like cough, cold, fever, constipation, stomach pain, vomiting, loose motions, headache, nose and lung problems, arthritis, memory and tranquility problems, nerve disorders, general weakness, anemia, etc. The basils are capable in removing the negative ions present in the atmosphere and thus purify the airs. Such novel functions of the basils enable human beings to be resistant against several bacterial diseases. The tea prepared from leaves of sacred basil is used to check vomiting, rheumatic pain and loose motions. Tea prepared from basil leaves and black pepper can reduce high fever. Basil contain anti-oxidants in good quantity may help to maintain good health and long life. Basil is characterized by great diversity among its constituent species including morpho-physiological characters, colour of flower, leaf and stem and chemical constituents of essential oil. On the basis of multiple practical uses of various species of *Ocimum* have been locally named as 'Kapur Tulsi' (*O. kilimandscharicum*), 'Rama and Shyama Tulsi' (*O. tenuiflorum*), 'Nimboo Tulsi' (*O. africanum*), 'Babui Tulsi' (*O. basilicum*), 'Van Tulsi' (*O. gratissimum*), 'Pudina Tulsi' (*O. canum*; syn, *O. americanum*), etc. In addition to these uses, *Ocimum* is widely cultivated as a pot herb for culinary uses, and for the fresh herb market, the export of *Ocimum* from Israel alone is worth 4 million US dollars per year (Darrah, 1980). In India as well it constitutes an important component of ever growing herbal market. Holy basil is commercially cultivated in hot and humid region of the India for production of leaves by growers/farmers. Eugenol is the major chemical constituent of essential oil present in the leaves, having various uses in flavouring and pharmaceutical industries. Indian basil is extensively cultivated in Indonesia, Egypt, Morocco, France, Greece, Hungary and USA (Bahl *et al.*, 2000). In India, *O. basilicum* (source of methyl chavicol) and *O. gratissimum* (source of eugenol) are mainly cultivated in Assam, West Bengal, U.P., Bihar, Haryana, Punjab, M.P., Maharashtra and Jammu (Prakasa Rao *et al.*, 2007) in about 3000ha area with annual essential oil production of 250-300t (Singh *et al.*, 1998; Varshney, 1997). An estimated production of basil oil is 250 tonnes in India; the bulk of this oil has methyl chavicol (75%) and linalool as the major constituent (Maheshwari, 1995; Bahl *et al.*, 2000). In a study of essential oils of different geographical origins, Lawrence (1988) found that the main constituents of the essential oil of basil are produced by two different biochemical pathways, the phenylpropanoids (methyl chavicol, eugenol, methyleugenol and methyl cinnamate) by the shikimic acid pathway, and the terpenes (linalool and geraniol) by the mevalonic acid pathway. Basil is an important essential oil crop with around 350 tonnes of essential oil being produced throughout the world annually and about half of this is produced from *Ocimum basilicum* L. and its close relatives. About 30 species of genus *Ocimum* are distributed in the tropical and subtropical regions of the world and few species are commercially cultivated in temperate regions

(Paton, 1992). Among 30 (Paton, 1992) -160 (Pushpangadan and Bradu, 1995) species of *Ocimum*, mainly 5 species are either wild or commercially cultivated in Upper Gangetic plains of India viz. *Ocimum basilicum*, *O. tenuiflorum*, *O. africanum, O. kilimandscharicum,* and *O. gratissimum*. In this regard, CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow has put successful R & D efforts to develop various improved high yielding varieties like Kusumohak, Vikarsudha, CIM- Saumya, CIM-Sharada and CIM- Surabhi of *O. basilicum*, CIM-Ayu (green type), CIM-Angana (purple type) and CIM- Kanchan of *O. tenuiflorum*, CIM- Jyoti of *O. africanum*, etc.

Methodology

Extensive surveys and explorations of the Lucknow, Barabanki, Raebareli, Amethi and Sultanpur were undertaken for the collection of voucher specimens of the aromatic plant species from different areas at regular intervals in different seasons. Collected voucher specimens were processed, preserved, accessioned and deposited in the herbarium of our institute for the future reference and study following the technique of Jain and Rao (1977). Identification of the aromatic basils was done based on taxonomical characters with the help of available flora and local herbaria.

Taxonomical Key

1a. Throats of fruiting calyx closed by the up curved 2 median teeth of anterior lip, anterior much shorter than posterior; mostly shrubs or undershrubs. . . . . *O. gratissimum*

1b. Throats of fruiting calyx open, the 2 median teeth of anterior lip as long as or longer than posterior; mostly herbs with stems woody at base:

2a. Calyx tube glabrous or thinly covered with minute glandular hairs inside; nutlets unchanged when wet . . . . . *O. tenuiflorum*

2b. Calyx tube with a ring of hairs at throat inside; nutlets producing mucilage when wet . . . . . .

3a. Flower with pedicel nearly as long as calyx; appendage of posterior stamens hairy . . . . *O. kilimandscharicum*

3b. Flower with pedicel much shorter than calyx; appendage of posterior stamens glabrous

4a. Fruiting calyx up to 5 mm long; corolla 4-5.5 mm long

5a. Fruiting calyx 2-3 mm long; stem internodes with short adpressed or retrose hairs . . . . . *O. americanum*

5b. Fruiting calyx 4-5.5 mm long; stem internodes with long, spreading and sometimes retrose hairs . . . . . *O. africanum*

4b. Fruiting calyx up to 6-8 mm long; corolla 7-8 mm long . . . . . *O. basilicum*

The phenological data and the status of species were also being assessed. Assessment and selection of *Ocimum* species were undertaken based on their distribution and popular utilization pattern in the area. Potentially, *Ocimum* species were selected and conserved in our herbal garden for future reference and sustainable utilization.

Results and discussion

Owing to vast diversity of edapho-climatic condition prevailed in India, a large number of basils occur in wild habitats. Only a limited number of commercially valued plants both from its natural vegetation and cultivation are produced. Survey and excursions were made in all five districts of Uttar Pradesh during January 2013 to March 2015 at different intervals in different season. Voucher specimens of *Ocimum* species were collected, preserved and mounted on herbarium sheets for accession and incorporation in the herbarium of

CSIR-CIMAP. The brief description of following 5 wild, naturalized and cultivated *Ocimum* species along with latest botanical name, common name (s), family, habitat, major chemical constituents, biological activity, etc. have been provided:

MAP shows surveyed and project area of 5 districts of Uttar Pradesh.

After exhaustive survey and collection of *Ocimum* species in India, we have found various genetic and chemotypic diversities in natural population. Some species of *Ocimum* are citral rich, camphor rich, methyl cinnamate, methyl chavicol and linalool rich. On the basis of chemotypic variability various authorities named it as *Ocimum basilicum* and *O. americanum* (syn. *O. canum*). The populations of *O. americanum* and *O. africanum* are often intermixed and erroneously identified as *O. americanum* in most of herbaria in India. The taxonomy of *Ocimum* is in a state of confusion. In the literature concerning *Ocimum*, particularly the work pertaining to economic and industrial fields, same species is often referred to by more than one name or vice- versa. The circumscription of *Ocimum* itself is also a matter of dispute among taxonomists. Estimates of species in the world vary from 30 to 160 (Paton, 1992; Pushpangadan and Bradu, 1995).

Ocimum africanum (Lemon basil) was described by Joao de Loureio in 1970. Over the next 50 years separate systematic botanists gave it two names, *O. citriodorum* Vis. and *O pilosum* Willd. The same species is also found as *O. basilicum* var. *anisatum*, *O. americanum* sensu Pushpangadan & Sobti non L., etc. Although *O. americanum* is well known in Indian Floras, the following nomenclature (author citation), dichotomous key and description will facilitate to distinguish it from other closely related species. It is hoped that the present report will attract other Indian taxonomists for the correct appraisal of *O. africanum* in India.

Ocimum africanum Lour., Fl. Cochinch. 2; 270. 1790; Suddee, S. et al. in Kew Bull. 60: 28–29. 2005. *O. citratum* Rumph. in Herb. Amboin. 5: 266, t. 93, f.1. 1747. *O. pilosum* Willd., Enum. Pl. 2: 629. 1809. *O. basilicum* L. var. anisatum Benth., Labiat. Gen. Sp. 4. 1832. *O. basilicum* L. var. *pilosum* (Willd.) Benth., Prodr. 12:33. 1848. *Ocimum* × *citriodorum* Vis. in Linnaea 15: Litt. Ber. 102. 1841. *Ocimum americanum* L. var. *pilosum* (Willd.) A. J. Paton, in Kew Bull. 47:426. 1992. *O. americanum* sensu Pushpangadan & Sobti non L. in Cytologia 47: 575. 583.1982. 'Lemon basil'.

1. ***Ocimum africanum*** Lour.; Mamiri, Lemon Basil, Nimboo Tulsi; Lamiaceae.

   Description: An aromatic, annual or short lived perennial herb, up to 50 cm high; stems densely pubescent with long, spreading and sometimes retrorse hairs. Leaves elliptic-lanceolate or ovate-lanceolate, 0.8-3.5 × 0.6-2 cm, entire or shallowly serrate at margins, apex acute, base cuneate or obtuse, glandular punctuate, glabrescent above, hairy on veins beneath, sometimes pubescent on both surfaces with longer hairs on veins beneath; petioles 0.2-1.8 cm long, pubescent. Verticels up to 1 cm apart; axis densely pubescent with retrorse hairs; bracts ovate, up to 5 mm long; pedicels 1-2 mm long, recurved, finely pubescent. Calyx campanulate, 2-2.5 mm long, 4 – 5.5 mm long in fruit; posterior lip rounded, decurrent on tube; anterior lip with 2 median lanceolate teeth; tube with a ring of dense hairs at throat. Corolla white or light purple, 4-5.5 mm long; posterior lip with 4-lobed with oblong obovate villous lobes, anterior lip boat-shaped; tube straight, glabrous. Stamens 4, slightly exserted, posterior 2 shorter. Nutlets oblong, 1-1.5 mm long, black, minutely tuberculate (Fig 1).

Fig 1. *Ocimum africanum* field view

Close up of Inflorescene

Fig 2. *Ocimum africanum* Lour. variety CIM-Jyoti

Fig 3. *Ocimum basilicum* L. variety CIM-Saumya

Fig 4. *Ocimum basilicum* L. variety Vikarsudha

Fig 5. *Ocimum basilicum* L. variety Kusumohak

Fig 6. *Ocimum basilicum* L. variety CIM- Sharada

Fig 7. *Ocimum basilicum* L. variety CIM- Surabhi

Fig 8. *Ocimum basilicum* (camphor rich)

Fig 9. *Ocimum gratissimum*

Fig 10. *Ocimum kilimandscharicum*

Fig 11. *Ocimum tenuiflorum* (green type: CIM- Ayu)

Fig 12. *Ocimum tenuiflorum*
(Purple type: CIM- Angana)

Status: Common in waste places along roadsides.

Flowering and Fruiting: September - December.

Parts Used: Aerial parts

Medicinal Uses: Plant- carminative, diaphoretic, stimulant; leaf- in fever, skin diseases, cold, catarrh and bronchitis in children, bechic (Husain *et al.*, 1992).

Major Chemical Constituents: Essential oil: Citral (71.9%: 31.7% neral and 40.2% geranial), methyl chavicol (3.5%), citronellal (2.8%), geraniol (2.3%), β- ocimene (0.6%), 1, 8-cineole (1.3%), linalool (2.3%).

Biological Activity: Plant- effect on CNS, hypothermic; leaf extract- antibacterial; essential oil- antifungal (Husain *et al.*, 1992).

CSIR-CIMAP, Lucknow has developed on one high yielding improved variety CIM-Jyoti in O. africanum (Fig 2.). The average herb yield is 200 q/h and oil yield 150 kg/ha with 68-75% citral content in variety CIM- Jyoti against parental check having herb yield 175 q/h and oil yield 100 kg/ha with citral content 10-15 %, respectively. This variety has produced citral in a short duration of 70-80 days. It also fits in crop rotation/intercropping between wheat and paddy and with other vegetables crops of small farmers.

2. Among *Ocimum* spp., *O. basilicum* is the most economically important essential oil bearing aromatic crops because its leaves/herb are used in flavour, fragrance and pharmaceutical industries. Inter-specific hybridization and polyploidy is the most important cause for natural diversity in *O. basilicum* which created a lot of taxonomical confusion and challenges for taxonomists (Harley and Heywood, 1992; Tucker, 1986). Therefore, taxonomy of *O. basilicum* is complicated by existence of numerous varieties, cultivars, chemotypes and landraces within the species that do not differ significantly in morphology (Simon *et al.*, 1990). Due to presence of more diversity in chemical constituents and morphology, CSIR-CIMAP, Lucknow has developed many varieties in *O. basilicum* for commercial cultivation.

2a. ***Ocimum basilicum*** L. var. CIM-*Saumya*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Basil is a low-growing annual herb 30-100 cm long. Stem square, slightly hairy; leaves ovate, entire to slightly toothed leaves; flowers whitish- pink, appear along the leaf axils in verticillasters; fruit consist of 4 nutlets; seeds small, black and mucilaginous.

Status: Grown for medicinal as well as experimental purposes. This variety has been developed by CSIR-CIMAP, Lucknow (Fig 3.).

Flowering and Fruiting: August - September.

Parts Used: Aerial parts

Herb yield: 290 q/ha, Oil Yield: 190 Kg/ha; Methyl chavicol (55%) and Linalool (40%).

Medicinal Uses: Flower- carminative, diuretic, stimulant, demulcent; seed- anti-odontalgic, anti- gonorrhoeic, anti-dysenteric; root- in bowel complaints of children (Husain et al., 1992). In Homoeopathy, the fresh mature leaves are used to treat spermatorrhoea, blood dysentery, haematuria, inflammation and congestion of kidney. Basil cures headaches, aids digestion and is a mild laxative. In Ethiopia, leaves are used against malaria, headaches and diarrhoea (Anonymous, 2003).

Major Chemical Constituents: Essential oil contains 1, 8- cineole, eugenol, limonene, ocimene, geranial, cis-3-hexenol, citronellol, alpha- terpineol, camphor, methyl eugenol, methyl cinnamate as minor and linalool, methyl chavicol (estragole) as major components. Methyl cinnamate may be a major constituent in some chemovars (Husain et al., 1992).

Biological Activity: Essential oil- antibacterial, antifungal (Husain *et al.*, 1992). The essential oil showed moderate repellent activity (Anonymous, 2003).

2b. ***Ocimum basilicum*** L. var. *Vikarsudha*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Erect glabrous herb, 70-90 cm tall bearing ovate leaves with entire dentate margin having non-glandular uniseriate hairs on surface. White with bluish tinge flower, hermaphrodite, zygomorphic with bicarpellary syncarpous superior ovary. Fruits are dark brown nutlets measuring 2.5-2.7mm in length. Matures at 75-90 days after transplanting (DAT) with a seed rate of 120g/ha to raise seedling, planted at spacing of 45 x 30cm. It grows in February-March and May-June cropping seasons (Fig 4.). This variety was developed through hybridization between exotic basil from Australia (EC331886-CSIRO No. L6323) and local adaptive landrace (Badaun local) having essential oil yield potential about 261kg/ha with 0.7% oil content. The essential oil have methyl chavicol (78%) and Linalool (16%) as major and 1,8-cineole, L-camphor, Limonene, Eugenol, camphene germacrene-D, methyl eugenol as minor chemical constituents (Dwivedi et al., 1999).

2c. ***Ocimum basilicum*** L. var. *Kusumohak*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Erect annual herb, green hard stem and simple dark green ovate brittle leaves, whole herb contain 0.38% essential oil content, whole herb has 45% linalool and 37% methyl chavicol but inflorescence contain 56% linalool and 17% methyl chavicol at mid flowering stage (Fig 5.). This variety was developed through half sib progeny selection from Argentina seed genetic stock having essential oil yield potential about 134kg/ha (Kumar et al., 1999).

2d. ***Ocimum basilicum*** L. var. CIM- *Sharada*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: The cultivar CIM EOH-1 basil has been developed by CSIR-CIMAP through intensive breeding efforts for high yield of herb and essential oil with desirable quality of higher Methyl chavicol 85-89 %. The variety CIM EOH-1 consistently shows higher herbage and oil content and methyl chavicol content in the field evaluation yield trials. The average herb yield is 280-290 q/h and oil yield 190-200 kg/ha in variety CIM EOH-1 V/S parental check CIM- Saumya herb yield 200 q/h and oil yield 122 kg/ha with methyl chavicol content 50-55 %, respectively. In these days essential oil having good amount of methyl chavicol is in high demand (Fig 6.).Hence, the planned breeding and selection process was undertaken at CSIR- CIMAP, Lucknow and developed variety CIM Sharada of *Ocimum basilicum*.

2e. ***Ocimum basilicum*** L. var. CIM- *Surabhi*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Bushy growth habit, annual, tall having plant height 80-85cm, medium green leaves colour, leaf length 6.3cm, leaf width3.4cm having essential oil yield potential about 166kg/ha with 0.75% essential oil content and about 75% linalool content (Fig 7.). This variety is ready to harvest in 80-85 days after transplanting.

2f. ***Ocimum basilicum*** L.; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Basil is a low-growing annual herb 30-100 cm long; stem square, slightly hairy; leaves petiolated, ovate, 2.5-5.0 cm long, entire to slightly toothed leaves; flowers whitish- pink, appear along the leaf axils in verticillasters; fruit consist of 4 nutlets; seeds small, black and mucilaginous (Fig 8.).

Status: Commonly occur along waste places during monsoon.

Flowering and Fruiting: August- November.

Parts Used: Aerial parts.

Medicinal Uses: Stimulant, relaxant, headache, fever, carminative, etc.

Major Chemical Constituents: Essential oil- camphor (42.8%), limonene (7.3%), alpha-pinene (5.6%) and beta- pinene (4.6%), methyl chavicol (4.1%).

Biological Activity: Antibacterial, anti-fungal, antimicrobial (Saha *et al.*, 2013; Husain *et al.*, 1992).

3. ***Ocimum gratissimum*** L.; Van Tulsi; Lamiaceae.

Description: Erect perennial herb or soft shrub, up to 2 m; leaves opposite, ovate-lanceolate, variously pubescent on both surfaces, gland dotted below, margins often only dentate in the upper half; Inflorescences were terminal, simple or sparingly branched; calyx densely pubescent on the outside, lower lip often closing the mouth and obscuring the small white corolla (Fig 9.).

Status: Grown for experimental/medicinal purposes.

Flowering and Fruiting: August – December.

Parts Used: Aerial parts

Medicinal Uses: Plant- anti- rheumatic, anti-paralytic, anti- gonorrhoeic, in aphthae of children, seminal weakness; seed- anti-cephalalgic, in neuralgia (Husain *et al.*, 1992). In Ethiopia, the leaves are used for the treatment of headache. In Madagaskar, the herb or shoot is put in boiled water and the resulting vapour is inhaled for the treatment of blocked nose (nose) and headache. In Homoeopathy, the fresh mature leaves are used in constipation, nasal catarrh, cough and fever. They are also used in gonorrhoea with difficult urination and burning sensation and sometimes pus in the urine (Anonymous, 2003).

Major Chemical Constituents: Essential oil from leaves and flowers contains alpha - and beta-pinene, camphene, alpha- terpinene, delta-3-carene, myrcene, 1,8- cineole, p-cymene, limonene, camphor, linalool, alpha - terpineol, thymol, methyleugenol, methyl isoeugenol, caryophyllene, humulene, alpha-selinene, clovene, longifolene and a sesquiterpene alcohol, gratissimol. A variety rich in eugenol is also known as 'Clocimum' developed by CSIR-IIIM, Jammu. Seed mucilage contains pentoses, hexoses, uronic acids and lipids (Husain *et al.*, 1992; Anonymous, 2003).

Biological Activity: Essential oil- anti-bacterial, antifungal; plant- spasmolytic, diuretic, CNS active (Husain et al., 1992).

4. ***Ocimum kilimandscharicum*** Guerke.; Kapur Tulsi; Lamiaceae.

Description: Erect aromatic perennial evergreen undershrub; leaves ovate- oblong-elliptic, margin serrate, apex acute, narrowed at the base, green and pubescent; flowers whitish arranged in verticillasters, stamens much exserted; fruits one seeded and indehiscent (Fig 10.).

Status: Grown for experimental/medicinal purposes.

Flowering and Fruiting: August-November.

Parts Used: Aerial parts.

Medicinal Uses: Decamphorised oil-insecticidal (Husain *et al.* 1992). In Rewanda (Central Africa), the plant is used in traditional medicine to cure eye infection (Anonymous, 2003).

Major Chemical Constituents: Essential oil contains camphor, pinene, limonene, terpinolene, myrcene, alpha- phellandrene, linalool, camphene, p-cymene, borneol and alpha- selinene (Husain *et al.*, 1992).

Biological Activity: Essential oil- anti-bacterial, antifungal; aerial part- CVS and CNS active, spasmolytic (Husain *et al.*, 1992).

5. ***Ocimum tenuiflorum*** L.; Holy Basil, Tulsi; Lamiaceae.

Description: Erect annual herbs or under-shrubs; leaves 2.5-5 cm long, elliptic-oblong or ovate-oblong, entire or crenate-serrate, obtuse or acute at both ends; flowers purplish-pink, whorled, in racemes, often forming panicles; nutlets broadly ellipsoid and smooth.

Status: Commonly cultivated in gardens but seen as escape throughout. CIM-Kanchan, CIM-Ayu (green type) and CIM- Angana (purple type) varieties have developed by CSIR-CIMAP, Lucknow with an essential oil yield potential about 55 kg/ha, 110kg/ha and

91kg/ha, respectively (Kothari *et al.*, 2001; Lal *et al.*, 2003; Lal *et al.*, 2008). The CIM-Kanchan, CIM-Ayu (Fig 11.) and CIM- Angana (Fig 12.) herb contain essential oil content of 0.37%, 0.72% and 0.56%, respectively. Methyl eugenol (70%), beta- caryophyllene (15.7%) and beta- elemene (7%) in CIM- Kanchan, eugenol (83%) and beta- elemene (7.4%) in CIM- Ayu and eugenol (40%), beta- elemene (14%), beta- caryophyllene (9%) and germacrene-D (16.6%) in CIM-Angana are the major chemical constituents present in its essential oils.

Flowering and Fruiting: August- December

Parts Used: Aerial parts

Medicinal Uses: Leaves- expectorant; juice of leaves- diaphoretic, antiperiodic, in catarrh and bronchitis; dropped into the ear for earache, infusion of leaves- stomachache, in gastric disorders of children and in hepatic affections; dried leaves- powdered and used as snuff in ozaena; seeds- demulcent, given in disorders of the genitor-urinary system; root-decoction as a diaphoretic in malarial fevers; fresh roots, stems and leaves- bruised and applied to the bites of mosquitoes; plant- in snake - bite and scorpion- sting (Husain *et al.*, 1992).

Major Chemical Constituents: Major constituents of essential oil are eugenol, beta-elemene, carvacrol, nerol, eugenol methylether, caryophyllene, terpinen-4-ol, decylaldehyde, γ - selinene, alpha- and beta-pinene, camphor; leaves-ursolic acid, apigenin, luteolin, apigenin-7-O-glucuronide, luteolin-7-O-glucuronide, orientin, molludistin, rosmarinic acid, cirsilineol, gallic acid, its methyl and ethyl esters, protocatechuic acid, vanillic acid, caffeic acid, chlorogenic acid, 4-hydroxybenzoic acid, vanillin, 4-hydroxybenzaldehyde (Husain *et al.*, 1992 ; Rastogi and Mehrotra, 1998).

Biological Activity: Ursolic acid may have antiallergic potential (Rastogi and Mehrotra, 1998); leaves- hypoglycaemic, spasmolytic; plant- adaptogenic (Husain *et al.*, 1992).

Preparations and Formulations: Jwara-samharaka rasa, Tribhuvanakriti rasa, Muktapanchamrita, Mahajwarankusha rasa, etc. (Sharma *et al.*, 2000-2001).

Conclusion

Studied districts of upper Gangetic plain are a rich source of basil biodiversity. Conservation of Basil's diversity is very important for its important essential oil constituents, used by pharmaceutical, flavour and fragrance industries for preparation of various medicines and health supplements. Keeping in view of these importance, CSIR-CIMAP has developed so many varieties viz. CIM- Saumya, CIM- Jyoti, CIM- Sharada, CIM- Surabhi, CIM- Ayu and CIM- Angana, etc. for commercial cultivation and sustainable use of its herb for various pharmaceutical industries.

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References

Anonymous. 2003. The Wealth of India-Raw Materials, Supplements 1-5. CSIR New Delhi.

Bahl, J.R., Garg, S.N., Bansal, R.P., Naqvi, A.A., Singh, V., Kumar, S. 2000. Yield and quality of shoot essential oil from the vegetative, flowering and fruiting stage crops of Ocimum basilicum cv Kusumohak. J. Med. Arom. Plant Sci. 22:743–746.

Darrah, H., 1980. The cultivated basils. Thomas Buckeye, Independence, M.O.

Dwivedi, S., Tajuddin, Yaseen, M., Singh, K., Naqvi, A.A., Singh, A.P., Kumar, S. 1999. Registration of new variety Vikarshudha of Ocimum basilicum. J. Med. Arom. Plant Sci. 21:373–374.

Harley, R.M., Heywood, C.A. 1992. Chromosome numbers in tropical American labiatae. In: Advances in Labiatae Science (eds. R.M. Harley and T. Reynolds). Royal Botanical Garden, Kew, pp. 211-246.

Husain, A., Virmani, O.P., Popli, S.P., Misra, L.N., Gupta, M.M, Srivastava, G.N., Abraham, Z., Singh, A.K. 1992. Dictionary of Indian medicinal plants. CIMAP, Lucknow.

Jain, S.K., Rao, R.R. 1977. Handbook of Field Herbarium Methods. New Delhi.

Kothari, S.K., Bhattacharya, A.K., Singh, C.P., Singh, K., Syamsundar, K.V., Ramesh, R., Kumar, S. 2001. A new methyl eugenol-rich and short duration strain of Ocimum tenuiflorum. J. Med. Arom. Plant Sci. 22/4A and 23/1A:385-388.

Kumar, S., Bahl, J.R., Bansal, R.P., Khanuja, S.P.S., Darokar, M.P., Shasany, A.K., Garg, S.N., Naqvi, A.A., Sharma, S., Singh, A., Ram, G. 1999. Registration of a new variety Kusumohak of Ocimum basilicum. J. Med. Arom. Plant Sci. 21:46.

Lal, R.K., Khanuja, S.P.S., Agnihotri, A.K., Misra, H.O., Shasany, A.K., Naqvi, A.A., Dhawan, O.P., Kalra, A., Bahl, J.R., Darokar, M.P. 2003. High yielding eugenol rich oil producing variety of Ocimum sanctum-'CIM-Ayu'. J. Med. Arom. Plant Sci. 25: 746–747.

Lawrence B.M. 1988. In: Lawrence B.M., Mookheyee B.D., Willis B.J. (eds): Developments in Food Sciences, Flavors and Fragrances: a World Perspective. Elsevier, Amsterdam.

Maheshwari, M. L. 1995. Quality and chemistry of essential oils. In Advances in horticulture: Medicinal and aromatic plants, edited by K. L. Chadha and R. Gupta, 145–197. Kirti Nagar, Delhi, India: Malhotra Publishing House.

Paton, A. 1992. A synopsis of Ocimum L. (Labiatae) in Africa. Kew Bul.47:403-435.

Paton, A., Harley, M.R., Harley, M.M. 1999. Ocimum: an overview of classification and relationships. In: Basil: the genus Ocimum (eds. Hiltunen R., Holm Y.). Harwood, Amsterdam, pp. 1–38.

Parakasa Rao, E. V. S., Puttanna, K., Ganesha Rao, R. S., Ramesh, S. 2007. Nitrogen and potassium nutrition of French basil (Ocimum basilicum Linn.). J. Spices Arom. Crops 16:99–105.

Pushpangadan, P., Bradu, B.L. 1995. Basil. In Chadha, K.L. & Rajendra Gupta, eds, Advances in Horticulture Vol. 11- Medicinal and Aromatic Plants. Malhotra Publishing House, New Delhi.

Rastogi, R.P., Mehrotra, B.N. 1998. Compendium on Indian Medicinal Plants. 6 vol. CDRI, Lucknow and NISC, New Delhi.

Sharma, P.C., Yelne, M.B., Dennis, T.J. 2000-2001. Database on Medicinal Plants used in Ayurveda. 3 Vols. CCRAS, New Delhi.

Simon, J.E., Quinn, J., Murray, R.G. 1990. Basil: a source of essentials, In: New Crops, Timber. Press, Portland, pp. 484-489.

Singh, K., Singh, A., Tajuddin, Singh, V.P., Yaseen, M. 1998. Prospects of large scale cultivation and production of Indian basil oil in India. Pafai J. 20: 29-31.

Varshney, S.C. 1997. Trends in essential oil production in India. In: Abstract of Symposium on Future Trends in Essential Oil Industry in India on dated 28-29 September, 1997, at RRL, Jammu, pp.53.