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Breeding for new chemotypes with stable high essential oil yield in *Ocimum*

R.K. Lal*

CSIR – Central Institute of Medicinal and Aromatic Plants, P.O. CIMAP, Lucknow, UP 226015, India

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ABSTRACT

The investigation was carried out to determine the stability and adaptability among 40 genetic stocks of basil belonging to six *Ocimum* species assembled from India and abroad for high oil yield by using AMMI analysis. Some new specific chemotypes were identified: one each high oil content (1.00%), oil yield 92.43 g/plot with high citral 76.62% (geranial = 46.59 + neral 30.03 = 76.62%) chemotype G 26; an ever green, cold tolerant with spreading habit recombinant developed between *Ocimum basilicum* and *O. kilimandscharicum* – G 34; one high linalool content in oil G 39 and two high oil (1.2%), 105.92 g/plot, 0.95% oil content and 95.20 g/plot oil yield with methyl chavicol chemotypes – G 14 (methyl chavicol = 55.00%), G 25 (methyl chavicol = 89.75%). Based on the AMMI model, these chemotypes showed the widest adaptability and stability due to its ability to tolerate wide environmental conditions over years.

1. Introduction

Ocimum (fam. Lamiaceae) is a genus of about 200 species of annual and perennial aromatic herbs and shrubs. Most species are native to the tropical and warm temperate regions of the old world, including India. The dry herb (leaves), *Ocimum* leaf tea, essential oil and its chemical derivatives (eugenol, methyl–eugenol, linalool, methyl chavicol, germacrene A and D, elemicin, ß-elmene, (Z)-ocimine) are exported to European countries in sizable quantity every year. The annual export of dry leaves herb, its products, essential oil and its derivatives chemical constituents of *Ocimum* are worth 10,000 tonnes (Lal et al., 2003, 2004, 2008). Peoples know the plant as Tulsi as Surasah in Sanskrit and Tulsi in Hindi. Due to anti oxidant and anti ageing effects of Tulsi, Hindus use fresh leaves in the Panchamrut/Charanamrut drink after puja. Tulsi is Divinity. It is regarded not merely as a utilitarian Godsend, as most sacred plants are viewed to be, but as an incarnation of the Goddess Herself. The classic Hindu myth, Samudramathana, the "Churning of the Cosmic Ocean," explains that Vishnu spawned Tulsi from the turbulent seas as a vital aid for all mankind. The Tulsi leaf, when eaten, can control thirst, and so was invaluable to weary travellers (Lal et al., 2008, 2013).

Apart from religious importance, the Tulsi has several medicinal properties. It is rich in carbohydrates, fibres, phosphorous, calcium, protein, iron, beta-carotene, vitamins B1 and B2 and in aromatic oils. It is good for colds and coughs, indigestion, stomach pain and diarrhoea. nausea, ulcers, ringworm and asthma can also be effectively treated with Tulsi. It is said to lower blood sugar, antimalarial activity in roots, anti cancer activity and increase lactation (Lal et al., 2003, 2004, 2008). The oil is used as anti-perspirant and as fly and mosquito repellent. CIMAP is actively involved in genetic enhancement of the *Ocimum* species following half sib selection and population improvement breeding approaches in view of traditional importance, together with the need for developing a better plant type having high herb, essential yield characters combined with a consistent high yield of phenyl propanoid eugenol and other economic important chemical constituents to formulate value added industrial products.

At CSIR-CIMAP, Lucknow, UP, India, available genetic stocks are belongs to six Ocimum species – *Ocimum sanctum* – Krishna and Shyam tulsi, *O. basilicum*, *O. kilimandscharicum*, *O. canum*, *O. gratissimum*, *O. tenuiflorum* and *O. basilicum*. In future, there will be possibility to develop highly adaptable and stable cultivars/varieties for high herb and oil yielding chemotypes with high specific needs chemical like eugenol, methyl–eugenol, methyl chavicol, linalool, elemicin, (Z)-ocimine etc. content with some others herbal products.

The basic information on wide adaptability in *Ocimum* is lacking (Lal et al., 2004). Among the objectives of multiyear essential oil yield field trials are the establishment of adaptation strategies

* Correspondence to: Department of Genetics and Plant Breeding, Central Institute of Medicinal and Aromatic Plants, Lucknow, Uttar Pradesh, India.
Tel.: +91 0522 2718523; fax: +91 522 2343666.
E-mail addresses: rk.lal@cimap.res.in, rajkishorilal@gmail.com

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Table 1
List of genotypes/cultivar and their origin of basil.

S. No.	Code	Genotypes/cultivar	Botanical name	Origin
1	G1	French basil	*Ocimum basilicum*	Chennai, AP, India
2	G2	Vikarsudha	*Ocimum basilicum*	CSIR-CIMAP, Lucknow, UP, India
3	G3/OB4	Sweet basil	*Ocimum basilicum*	Gandhi Nagar, Gujarat, India
4	G4	French basil	*Ocimum basilicum*	Bangalore, Karnataka, India
5	G5/OB5	French basil	*Ocimum basilicum*	Mangalore, Karnataka, India
6	G6/OB12	French basil	*Ocimum basilicum*	Chandigarh
7	G7	Shyam tulsi (CIM Angana)	*Ocimum sanctum*	CSIR-CIMAP, Lucknow, UP, India
8	G8/OB8	Sweet basil	*Ocimum basilicum*	Singapore
9	G9/OB6	Sweet basil	*Ocimum basilicum*	Singapore
10	G10	Sweet basil (Kushmohak)	*Ocimum basilicum*	CSIR-CIMAP, Lucknow, UP, India
11	G11	Sweet basil	*Ocimum basilicum*	Košice, Slovak Republic
12	G12	Krishna tulsi (CIM Ayu)	*Ocimum sanctum*	CSIR-CIMAP, Lucknow, UP, India
13	G13/OB7	French basil	*Ocimum basilicum*	Mangalore, Karnataka, India
14	G14	Indian basil	*Ocimum basilicum*	Muzaffarpur, Bihar, India
15	G15	Indian basil (CIM Saumya)	*Ocimum basilicum*	CSIR-CIMAP, Lucknow, UP, India
16	G16	Holy Basil	*Ocimum sanctum*	Udaipur, Rajasthan, India
17	G17	Zanzibar basil	*Ocimum basilicum*	Tanzania
18	G18/OB3	Indian basil	*Ocimum basilicum*	Bareilly, Uttaranchal, India
19	G19/OB23	Sacred Basil (CIM Kanchan)	*Ocimum tenuiflorum* L.	CSIR-CIMAP, Lucknow, UP, India
20	G20/OB1	Indian basil	*Ocimum basilicum*	Lucknow, UP, India
21	G21/OB2	Indian basil	*Ocimum basilicum*	Lakhimpur (Kheri), UP, India
22	G22/OK19	Kapoor/camphor tulsi	*Ocimum kilimandscharicum*	CSIR-CIMAP, Lucknow, UP, India
23	G23/OS18	Shyam tulsi	*Ocimum sanctum*	Nasik, Maharashtra, India
24	G24/OB14	Holy Basil	*Ocimum sanctum*	Lucknow, UP, India
25	G25/AST1	Indian basil (sel-2)	*Ocimum basilcum*	CSIR-CIMAP, Lucknow, UP, India
26	G26	Hoary basil (Selection-1)	*Ocimum canum*	CSIR-CIMAP, Lucknow, UP, India
27	G27	Sweet basil	*Ocimum basilicum*	Trivandrum, Kerala, India
28	G28/OB17	Shyam tulsi	*Ocimum sanctum*	Lucknow, UP, India
29	G29	Hoary basil	*Ocimum canum*	Allahabad, UP, India
30	G30/OB9	French basil	*Ocimum basilicum*	Haridwar, Uttaranchal, India
31	G31/OB22	African basil.	*Ocimum gratissimum* L.	CSIR-CIMAP, Lucknow, UP, India
32	G32	Thai basil	*Ocimum basilicum var. thyrsiflora*	Thailand
33	G33	Shyam tulsi	*Ocimum sanctum*	Puralia, WB, India
34	G34	Hybrid	*O. basilicum* × *O. kilimandscharicum*	CSIR-CIMAP, Lucknow, UP, India
35	G35/OB21	Tree/van basil.	*Ocimum gratissimum* L.	Jammu (J&K), India
36	G36/OB11	Indian basil	*Ocimum basilicum*	Phagwara, Punjab, India
37	G37	Shyam tulsi	*Ocimum sanctum*	Barabanki, UP, India
38	G38/OB20	Clove basil.	*Ocimum gratissimum* L.	Shillong, Meghalaya, India
39	G39	Indian basil	*Ocimum basilicum*	Razaganj, UP, India
40	G40/OB10	Indian basil	*Ocimum basilicum*	Rishikesh, Uttaranchal, India

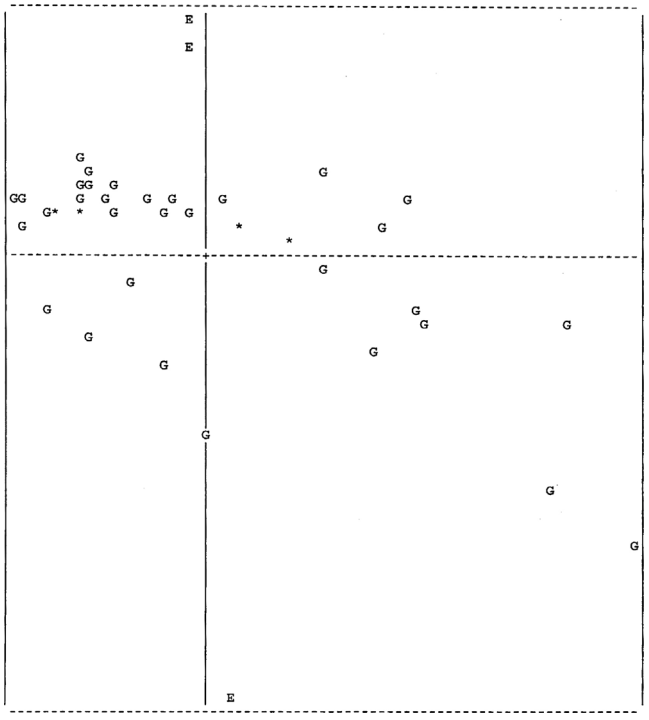

Fig. 1. Matamodel version 3.0 Mega-environments for AMMI 1 Model, cultivars, switch points, including hypothetical winners in *Ocimum* crop.

for *Ocimum* crop breeding programmes and definition of domains for cultivar recommendations. The adaptation strategy objectives focuses on responses of a set of genotypes to obtain indications and generate predictions relative to future breeding material that may be produced from the genetic base of which the tested genotypes are assumed to be a representative sample, while, for cultivar recommendation the most important information concern the response of, and comparison between, high yielding genotypes (Annicchiarico, 2002; Akçura et al., 2005; Lal, 2007, 2012). High yield stability usually refers to a genotype's ability to perform consistently, whether at high or low yield levels, across a wide range of years (Annicchiarico, 2002). Several biometrical methods including univariate and multivariate ones have been developed to assess stability (Akçura et al., 2005; Lal, 2010a,b). Between them the most widely used are the regression coefficient (Finlay and Wilkinson,

Table 2
ANOVA for model AMMI 1.

Source	d.f.	SS	MS	Probability
Treatments	119	167,241.31	1405.39	0.99
Genotypes	39	149,317.86	3828.66	0.47
Environments/years	2	2201.42	1100.71	0.75
G × E	78	15,722.03	201.56	1.00
IPCA1	40	13,707.80	342.70	1.00
Residual	38	2014.23	53.01	1.00
Error	120	454,273.29	3785.61	
Total	239	621,514.60	2600.48	

Grand mean = 38.53 g/plot oil yield.