Research Article

www.ekinjournal.com

Ekin
Journal of Crop Breeding and Genetics

10(2):94-104, 2024

Ekin International biannual peer-reviewed journal

Morphological Characterization of Different *Ocimum* spp. Germplasm Lines under Semi-Arid Region of Haryana

Vijay Kumar C TALAWADE[1,2] **Krishan KUMAR**[2,3] **Ishwar SINGH**[4] **Rajesh Kumar ARYA**[2*]

[1] University of Agricultural Sciences, Raichur-584133 Karnataka, India
[2] Department of Genetics and Plant Breeding, C C S Haryana Agricultural University, Hisar-125004 Haryana, India
[3] Ram Dhan Singh Seed Farm, CCS Haryana Agricultural University, Hisar-125004 Haryana, India
[4] ICAR-National Bureau of Plant Genetic Resouces, New Delhi, India

[*] Corresponding author e-mail: rakarayogi@gmail.com

Citation:
Talawade VKC., Kumar K., Singh I., Arya RK., 2024. Morphological Characterization of Different *Ocimum* spp. Germplasm Lines under Semi-Arid Region of Haryana. Ekin J. 10(2):94-104.

Received: 05.05.2024 ***Accepted: 01.06.2024*** ***Published Online: 30.07.2024*** ***Printed: 31.07.2024***

ABSTRACT

Knowledge about the genetic variation among the various plant traits enables the plant breeders to effectively utilize the available germplasm lines for the development of elite genotypes. The experimental material comprising of 40 germplasm lines of Tulsi (*Ocimum* spp.) received from National Bureau of Plant Genetic Resources, New Delhi were characterized for different morphological traits viz. leaf colour, leaf shape, leaf pubescence, stem colour, stem pubescence, petiole colour, flower colour, calyx colour, calyx pubescence, seed colour, plant height, inflorescence length and fresh herbage yield. The investigation was carried out in the Research Area of Medicinal, Aromatic and Potential Crops Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* 2022 and 2023. Among the various categories of different traits/descriptors, the maximum number of germplasm lines were observed for leaf lamina colour-green (25 germplasm lines), leaf shape-elliptical (40), stem colour-green (28), stem pubescence-pubescen t(5), petiole colour-green (36), flower colour-white(27), calyx colour-green (25), calyx pubescence-pubescent (13), seed colour-dull black (35). Plant height ranged from 70 cm (EC 388895) to 119 cm (IC 381185) and inflorescence length from 9.3 cm (IC 75730 and IC 381185) to 24 cm (IC 387838 and EC 469904). Maximum fresh herbage yield per plant was found for the genotype EC 388890 (1250 g) and minimum for IC 387838 (290 g). The study revealed that sufficient genetic variability was present among different germplasm lines. This genetic variability may further be exploited for crop improvement programme to develop improved varieties using appropriate breeding methodology.

Keywords: Tulsi germplasm, morphological characterization, genetic variability

Introduction

The genus *Ocimum* is represented by 66 species across the world. *Ocimum* is a versatile aromatic and most important genus of the family Lamiaceae due to its immense use in traditional system of medicine, perfumery and pharmaceutical industry (Simpson and Conner, 1986). All the aromatic plants belonging to the genus *Ocimum* are collectively called Basil. In India, so far about 9 species of *Ocimum* (*Ocimum tenuiflorum* L., *O. basilicum* L., *O. gratissimum* L., *O. kilimandscharicum* L., *O. micranthum* L., *O. campechianum* L., *O. americanum* L., *O. minimum* L. and *O. citriodorum* L.) have been reported of which the last three are exotic species (Balyan and Pushpangadan, 1988). The *O. basilicum* is known by various names such as 'Sweet Basil', 'Common Basil' or 'French Basil'. The *O. canum* species with a peculiar mint smell is known as 'Mint Basil'. The camphor containing species *O. kilimandscharicum* is commonly called 'Camphor Basil'. The species *O. canum* having borneol smell is known as 'Hoasy Basil' and the species *O. gratissimum* with high contents of eugenol is known as 'Spice Basil'. Hindus worship the plants of *O. sanctum* hence it is popularly known as 'Sacred

Basil' or 'Holy Basil'. The genus *Ocimum* exhibits a range of chromosome numbers, including various haploid chromosome numbers (12, 13, 16, 20, 24, 32, 36 and 38) in addition to the basic chromosome number. According to Carovic et al*.,* (2010), the basic chromosome number for *Ocimum* species is x=12. Moreover, *O. basilicum* and *O. americanum* are known to be tetraploid (2n=4x=48) and hexaploid (2n=6x=72), respectively (Sobti and Pushpangadan, 1979).

The *Ocimum* species showcase remarkable morphological diversity owing to significant variations in their leaf size, shape, colour and pubescence, which have evolved over the centuries of cultivation. They are highly branched and can grow to a height ranging from 60-150 cm. Their stems and twigs are quadrangular in shape. The leaves are simple and have petioles and appear in a range of shapes from elliptical to ovate and have either entire or serrated margins. The leaves of these plants also bear sessile glands which secrete strongly scented volatile oils with aromatic flavours. The plants have small flowers that are white or purple in colour. These flowers are hermaphrodite and zygomorphic in nature. They are arranged in whorls on racemose inflorescence. The flowers have didynamous stamens and a style with bifid stigma. After the successful process of entomophilous pollination, the corolla naturally detaches and gives way to the development of four round seeds inside the bilabiate calyx. The seed's shape varies from elliptical to globose and becomes mucilaginous when wetted (Pushpangadan and Bradu, 1995).

Plants are the primary source of secondary metabolites and oils with therapeutic potential due to which people have relied on plant-based medicines for health care since the dawn of civilization. The therapeutic properties of *Ocimum* have been acknowledged since ancient times, not only in India but also in the ancient civilizations of China, West Asia, Europe and Africa. This recognition has elevated the status of *Ocimum* spp. to a highly valued medicinal and aromatic crop plants. Tulsi is a valuable natural source of various essential oils and fragrant compounds that hold great economic and medicinal significance. Its essential oils contain several notable chemicals including eugenol, methyl eugenol, thymol, linalool, methyl chavicol, camphor, citral, elimicin, sesquiterpene alcohols, linalyl acetate, geraniol, and methyl cinnamate (Khosla et al., 2000). The medicinal herb *O. basilicum* has generally been used to cure renal problems, warts, worms, cough, diarrhoea and headaches. Its oil is directly applied to the skin for treating acne and externally it can be used as an ointment for bug bites (Javanmardi et al., 2002). Its seeds are used in treatment of dysentery and chronic diarrhoea (Gangrade et al., 2000). Oil of *O. gratissimum* has been recommended for use in biological mosquito control because of its ability to repel insects. Leaves of *O. canum* are used to cure a variety of eye conditions, bronchitis as well as parasitic skin conditions (Naithani and Kakkar, 2002).

Materials and Methods

Experimental material: The study was carried out in the research area of the Medicinal, Aromatic and Potential Crops Section, Department of Genetics and Plant breeding, CCS Haryana Agricultural University, Hisar in the *Kharif* season of the years 2022 and 2023. The experimental material was comprised of 40 genotypes of Tulsi (*Ocimum* spp.). Among these, 38 genotypes were received from ICAR- National Bureau of Plant Genetic Resources (NBPGR), New Delhi and 2 genotypes from the germplasm pool maintained at the Medicinal, Aromatic and Potential Crops Section, which were characterized for morphological traits. The species to which each of the studied genotypes belongs is presented in Table 1.

Field layout of experiment: To conduct the experiment, all the 40 genotypes of Tulsi were grown in the Research Area of the Medicinal, Aromatic and Potential Crops Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* 2022 and 2023. Hisar is located in semi-arid sub-tropical region at 29°-10°N latitude and 75°-46°E longitude with elevation of 215.52 m above mean sea level.

Nursery preparation and Transplanting: To raise the healthy plants, nursery was prepared by sowing the seeds of all the 40 different genotypes on the raised beds separately. Light irrigation was given to the young seedlings as per requirement for good growth. Twenty days old young healthy seedlings of all the 40 different genotypes were transplanted in the Randomized Block Design (RBD) with three replications. One seedling per hill was transplanted at 10 cm spacing between the plants in two rows each of 3 m length with a row to row distance of 30 cm. A light irrigation was applied immediately after transplanting. All the required cultural practices were followed to raise the good Tulsi crop.

Recording of observations: The observations for all the 40 genotypes were recorded at appropriate plant growth stage i.e. from flowering to reproductive stage of the crop for the following 10 different qualitative traits: Stem colour, Stem pubescence, Leaf shape, Leaf colour, Leaf pubescence, Petiole colour, Flower colour, Calyx colour, Calyx pubescence and Seed colour. All the morphological observations were recorded at flowering stage. Under natural field conditions, the data for the different traits were recorded on five randomly selected plants from each genotype in each replication.

Results

The 40 genotypes of Tulsi (*Ocimum* spp.) taken for the present investigation was characterized for 10 different qualitative traits mentioned as below:

Stem colour

Based on stem colour, five different groups *viz.* dark green, green, light green, purple, and light purple (Figure 1) were observed among 40 different genotypes of Tulsi and all the genotypes were categorized accordingly (Table 2, Figure11a). Four genotypes exhibited dark green stem colour, 28 genotypes green stem colour whereas light green stem colour appeared only in one genotype. Purple stem colour was observed in five genotypes and two genotypes displayed light purple stem colour.

Stem pubescence

On the basis of the presence or absence of the hairs on the stem, Tulsi genotypes were classified as sparse pubescent and non-pubescent (Figure 2). Five genotypes were observed to have sparse pubescence whereas the remaining 35 genotypes had no pubescence (Figure 11b).

Leaf shape

Based on the leaf shape, Tulsi genotypes may be characterized into three groups such as elliptical, sub-ovate and ovate. But, in the present investigation only elliptical leaf shape (Figure 3) was observed for all the 40 genotypes (Figure 11c). None of the genotypes showed sub-ovate and ovate leaf shape.

Leaf colour

All the 40 Tulsi genotypes were categorized into four different groups (dark green, green, light green and purple) based on the colour of their leaves (Figure 4). Dark green leaf colour was observed for 8 genotypes, green leaf colour for 25 genotypes, light green leaf colour for 6 genotypes whereas only one genotype exhibited purple leaf colour (Figure 11d).

Leaf pubescence

On the basis of the presence or absence of the hairs on the leaf surface, Tulsi genotypes can be classified as sparse pubescent, dense pubescent and non-pubescent (Figure 5). In the present investigation, only two genotypes were observed to have sparse pubescence. Dense pubescent was not observed in any of the genotype whereas 38 genotypes showed non-pubescent characteristic for leaf pubescence (Figure 11e)

Petiole colour

Fourty Tulsi genotypes were classified into three different groups based on their petiole colour namely green, purple and purple green (Figure 6). Thirty-six genotypes exhibited green petiole colour, one purple petiole colour whereas three genotypes displayed purple green petiole colour (Figure 11f).

Flower colour

On the basis of flower colour, Tulsi genotypes were classified into three categories which included white, light purple and purple (Figure 7). Among the 40 genotypes, 27 genotypes exhibited white flower colour, 8 genotypes light purple flower colour and purple flower colour expressed in the remaining 5 genotypes (Figure 11g).

Calyx colour

Five categories of calyx colour (Figure 8) *viz.* green (25 genotypes), light green (2 genotypes), purple (6 genotypes), light purple (6 genotypes) and dark purple (1 genotype) were observed for the 40 Tulsi genotypes studied for the present investigation (Figure 11h).

Calyx pubescence

Tulsi genotypes can be classified as sparse pubescent, dense pubescent and non-pubescent based on the presence or absence of the hairs on the calyx. In the present investigation, 13 genotypes were observed to have sparse pubescence, whereas 27 genotypes showed non-pubescent characteristic for calyx pubescence (Figure 9). None of the genotypes exhibited dense pubescence on calyx (Figure 11i).

Seed colour

Four categories of seed colour (Figure 10) *viz.* black (1 genotype), dull black (35 genotypes), brownish black (1 genotype) and brown (3 genotypes) were observed for the 40 Tulsi genotypes studied in the present investigation (Table 1, Figure 11j).

The maximum number of germplasm lines observed leaf lamina colour-green (25 germplasm lines), non pubescent leaf (38), leaf shape-elliptical (40), stem colour-green (28), stem pubescence-pubescent (5), calyx colour-green (25), calyx pubescence-pubescent (13), petiole colour-green (36), flower colour-white (27) and seed colour-dull black (35).

Discussion

Knowledge about the genetic variation of the various plant characters enables the plant breeders to effectively utilize the available germplasm lines for the development of elite genotypes (Gowda et al., 2019; Singh et al., 2020; Arya et al., 2024). Morphological and cytological studies have helped in resolving the identity issues in many genera (Paton and Putievsky, 1996).

The experimental material of the present investigation comprising of 40 genotypes of Tulsi (*Ocimum* spp.) were characterized for 10 qualitative traits *viz.* stem colour, stem pubescence, leaf shape, leaf colour, leaf pubescence, petiole colour, flower colour, calyx colour, calyx pubescence and seed colour.

On the basis of stem colour, all the 40 Tulsi genotypes were categorized into five groups: green (28 genotypes), purple (5), dark green (4), light purple (2) and light green stem colour (1). Based on presence or absence of minute hairs on the surface of the stem, two categories were formed: sparse pubescence (5 genotypes) and non-pubescent (35). Regarding leaf shape, elliptical leaf shape was observed in all the 40 genotypes of Tulsi. Based on leaf colour, all the Tulsi genotypes were classified into four group: green (25 genotypes), dark green (8), light green (6) and purple leaf colour (1). On the basis of leaf pubescence, two categories were observed: sparse pubescent (2 genotypes) and non-pubescent (38). Genotypes were classified into three groups on the basis of petiole colour: green (36 genotypes), purple green (3) and purple petiole colour (1). Based on flower colour, three categories were formed *viz.* white (27 genotypes), light purple (8) and purple (5). Based on the colour of the calyx, the genotypes were classified into five groups: green (25 genotypes), purple (6), light purple (6), light green (2) and dark purple calyx colour (1). On the basis of presence or absence of minute hairs on the calyx surface, two categories were observed such as non-pubescent (27) and sparsely pubescent (13). Genotypes were classified into four groups based on seed colour *viz.* dull black (35), black (3), brownish black (1) and brown seed colour (1). The characterization of Tulsi genotypes based on qualitative traits has also been reported by Kumar et al., (2012a), Chhaya et al., (2013), Nassar et al., (2013), Malav et al., (2015) and Kumar et al., (2019). Yaldiz, and Camlica, (2021) also studies the agro-morphological and phenotypic variability of sweet basil genotypes for breeding purposes. The morphological characterization in different medicinal plants is carried by different researchers for their proper identification and further utilization in breeding programme (Arya et al., 2024; Singh et al., 2024).

Conclusions

It may be concluded from present study that the sufficient morphological variability was present among different germplasm lines of Tulsi. The presence of genetic variation for different traits enables the plant breeders to utilize the germplasm lines EC 388890, IC 469938, IC 388785 and IC 328582 having maximum fresh herbage yield for the development of elite genotypes.

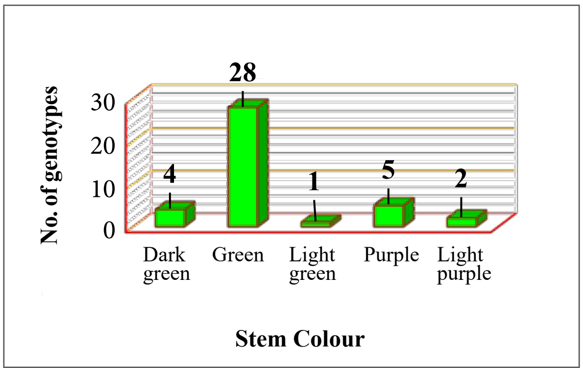

Figure 1. Classification of 40 Tulsi genotypes on the basis of stem colour.

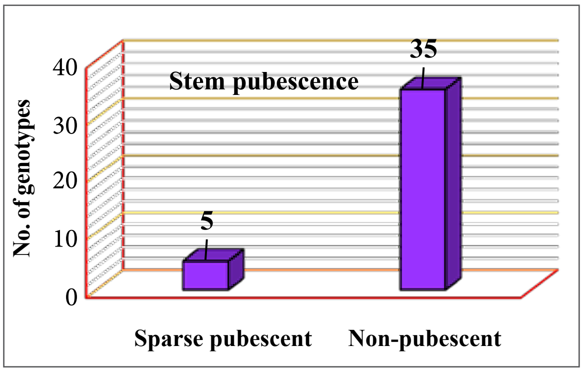

Figure 2. Classification of 40 Tulsi genotypes on the basis of stem pubescence.

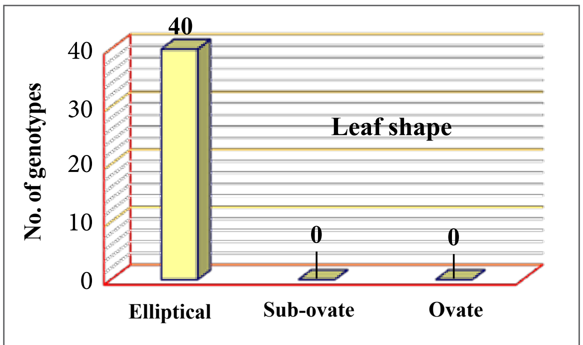

Figure 3. Classification of 40 Tulsi genotypes on the basis of leaf shape.

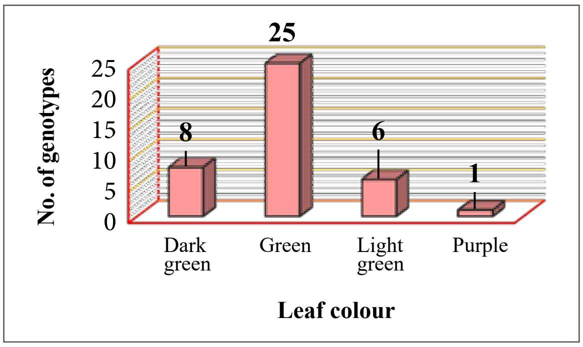

Figure 4. Classification of 40 Tulsi genotypes on the basis of leaf colour.

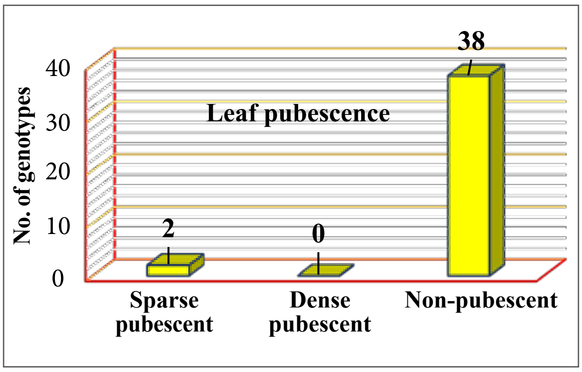

Figure 5. Classification of 40 Tulsi genotypes on the basis of leaf pubescence.

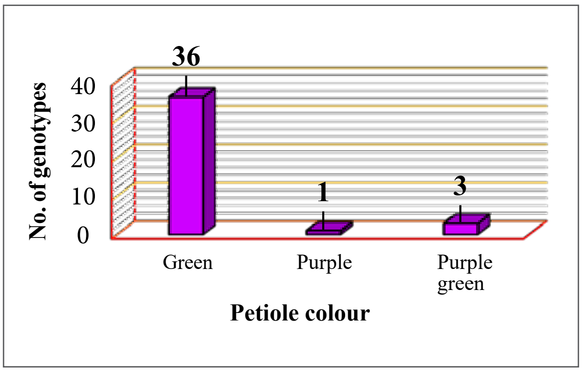

Figure 6. Classification of 40 Tulsi genotypes on the basis of petiole colour.

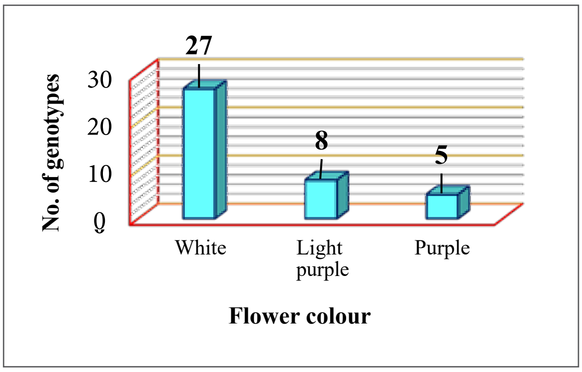

Figure 7. Classification of 40 Tulsi genotypes on the basis of flower colour.

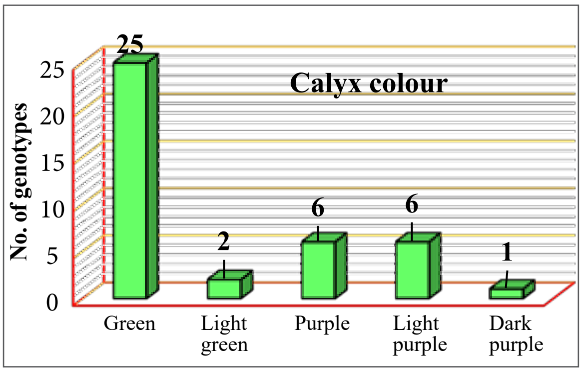

Figure 8. Classification of 40 Tulsi genotypes on the basis of calyx colour.

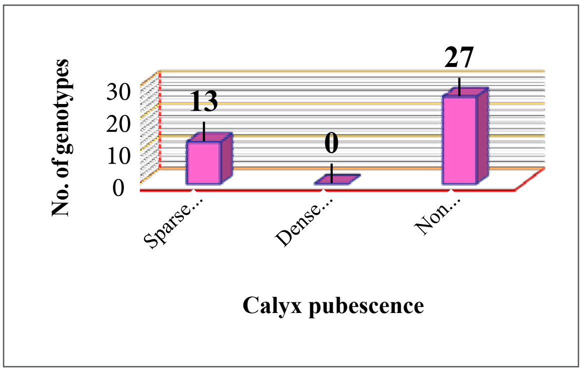

Figure 9. Classification of 40 Tulsi genotypes on the basis of calyx pubescence.

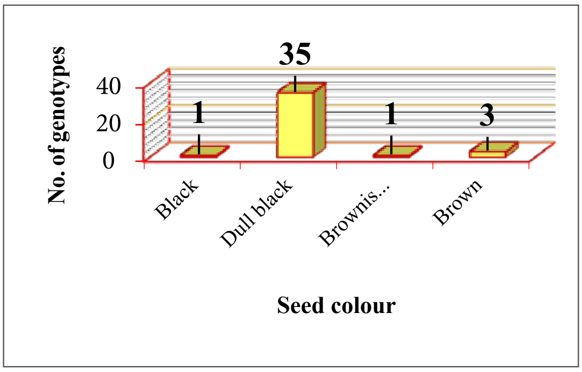

Figure 10. Classification of 40 Tulsi genotypes on the basis of seed colour.

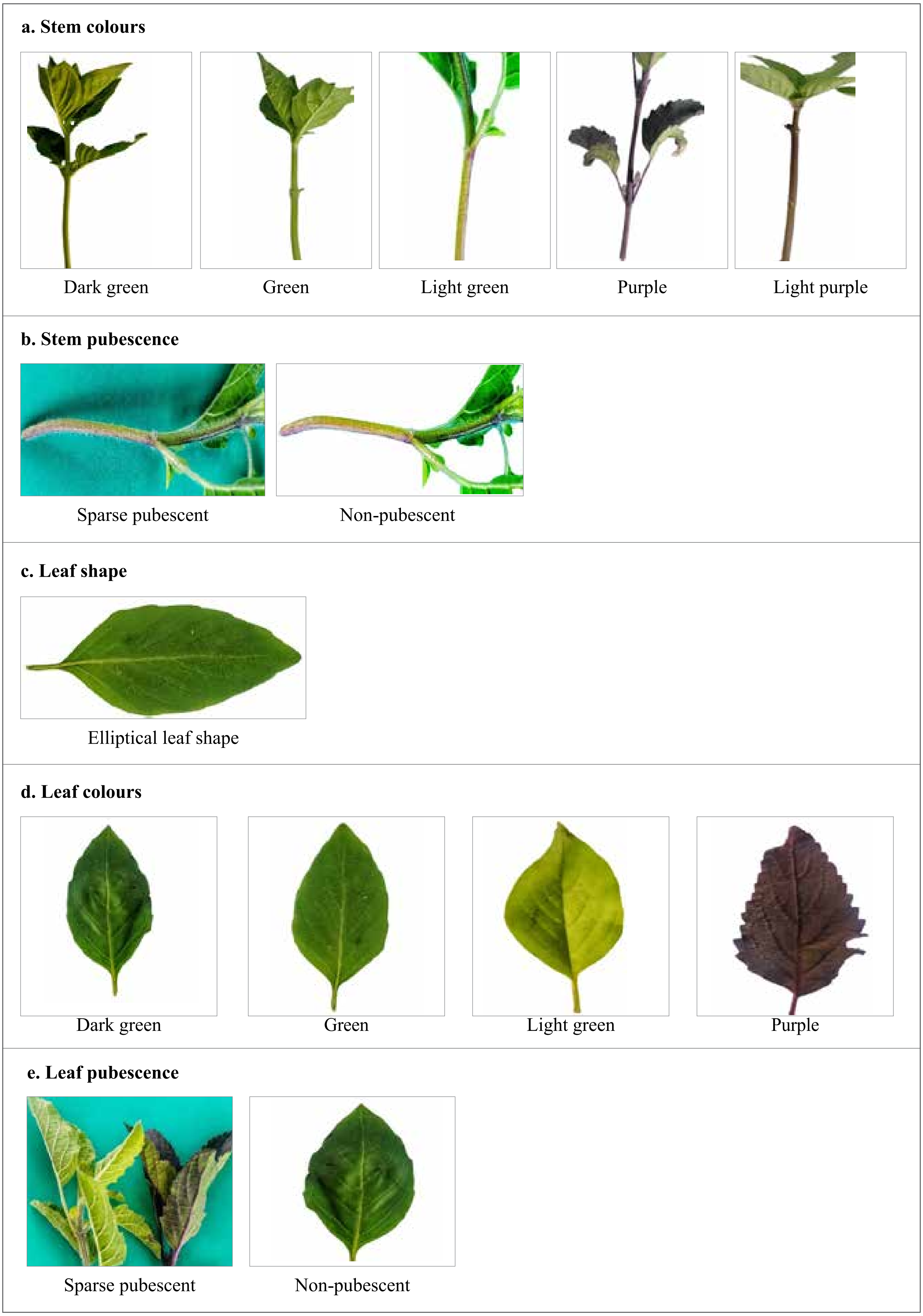

Figure 11. Figures represent morphological descriptors of various qualitative characters in *Ocimum* spp.

Continuing Figure 11

f. Petiole colours

Green Purple Light purple

g. Flower colours

White with light green shade White with light purple shade White with purple shade

h. Calyx colours

Green Light green Light pink Pink Dark Pink

i. Calyx pubescence

j. Seed colours

Black Dull black Brownish black Brown

Table 1. Species and source of 40 Tulsi genotypes used in present study.

Serial Number	Genotypes	Species	Source	Serial Number	Genotypes	Species	Source
1.	IC 44681	*Ocimum basilicum*	NBPGR	**21.**	EC 469904	*Ocimum basilicum*	NBPGR
2.	IC 387837	*Ocimum basilicum*	NBPGR	**22.**	EC 326771	*Ocimum basilicum*	NBPGR
3.	IC 369247	*Ocimum basilicum*	NBPGR	**23.**	EC 388893	*Ocimum basilicum*	NBPGR
4.	IC 387838	*Ocimum basilicum*	NBPGR	**24.**	EC 388887	*Ocimum basilicum*	NBPGR
5.	IC 388785	*Ocimum basilicum*	NBPGR	**25.**	EC 388895	*Ocimum basilicum*	NBPGR
6.	IC 469938	*Ocimum basilicum*	NBPGR	**26.**	EC 388896	*Ocimum basilicum*	NBPGR
7.	IC 326735	*Ocimum basilicum*	NBPGR	**27.**	EC 388782	*Ocimum basilicum*	NBPGR
8.	IC 312264	*Ocimum basilicum*	NBPGR	**28.**	EC 388737	*Ocimum basilicum*	NBPGR
9.	IC 110207	*Ocimum basilicum*	NBPGR	**29.**	EC 388889	*Ocimum basilicum*	NBPGR
10.	IC 338794	*Ocimum basilicum*	NBPGR	**30.**	EC 338772	*Ocimum basilicum*	NBPGR
11.	IC 336833	*Ocimum basilicum*	NBPGR	**31.**	EC 388788	*Ocimum basilicum*	NBPGR
12.	IC 201223	*Ocimum basilicum*	NBPGR	**32.**	EC 388890	*Ocimum basilicum*	NBPGR
13.	IC 328582	*Ocimum basilicum*	NBPGR	**33.**	NSV 38	*Ocimum basilicum*	NBPGR
14.	IC 338959	*Ocimum basilicum*	NBPGR	**34.**	RDV 45	*Ocimum basilicum*	NBPGR
15.	IC 333833	*Ocimum basilicum*	NBPGR	**35.**	Local 1	*Ocimum sanctum*	HAU
16.	IC 281185	*Ocimum basilicum*	NBPGR	**36.**	Local 2	*Ocimum tenuiflorum*	HAU
17.	IC 381552	*Ocimum basilicum*	NBPGR	**37.**	DOS 1	*Ocimum tenuiflorum*	DMAPR
18.	IC 436153	*Ocimum basilicum*	NBPGR	**38.**	IC 75730	*Ocimum basilicum*	NBPGR
19.	IC 381158	*Ocimum basilicum*	NBPGR	**39.**	IC 381185	*Ocimum basilicum*	NBPGR
20.	IC 326732	*Ocimum basilicum*	NBPGR	**40.**	EC 112548	*Ocimum basilicum*	NBPGR

Table 2. Classification of 40 Tulsi genotypes on the basis of morphological characters.

Characters: Stem colour	No. of Genotypes	Genotypes
Dark green	4	IC 369247, IC 381552, EC 388887, EC 388895
Green	28	IC 44681, IC 387837, IC 387838, IC 388785, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, EC 469904, EC 326771, EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, IC 436153, IC 381158, IC 326732, RDV 45, NSV 38, Local 1, Local 2
Light green	1	IC 336833
Purple	5	EC 388788, EC 388890, IC 75730, IC 381185, DOS 1
Light purple	2	EC 388893, EC 112548
Stem pubescence		
Sparse pubescent	5	IC 388785 , EC 469904, IC 75730, IC 381185, DOS 1
Non-pubescent	35	IC 44681, IC 387837, IC 369247, IC 387838, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 336833, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, IC 381552, EC 326771, EC 388893, EC 388887, EC 388895,EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, EC 388788, EC 388890, IC 436153, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, Local 1, Local 2
Leaf shape		
Elliptical	40	IC 44681, IC 387837, IC 369247, IC 387838, IC 388785, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 336833, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, IC 381552, IC 436153, IC 381158, IC 326732, EC 469904, EC 326771, EC 388893, EC 388887, EC 388895, EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, EC 388788, EC 388890, RDV 45, NSV 38, Local 1, Local 2, DOS 1, IC 75730, IC 381185, EC 112548
Sub-ovate	0	-None-
Ovate	0	-None-
Leaf colour		
Dark green	8	IC 369247, IC 381552, EC 388893, EC 388887, EC 388895, IC 75730, Local 1, DOS 1
Green	25	IC 44681, IC 387837, IC 387838, IC 388785, IC 326735, IC 312264, IC 110207, IC 336833, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, EC 469904, EC 326771, EC 388896, EC 388782, EC 388737, EC 388889, EC 388788, EC 388890, IC 381158, IC 326732, NSV 38, EC 112548
Light green	6	IC 469938, IC 338794, EC 338772, IC 436153, RDV 45, Local 2
Purple	1	IC 381185
Leaf pubescence		
Sparse pubescent	2	IC 388785, IC 381185
Dense pubescent	0	-None-
Non-pubescent	38	IC 44681, IC 387837, IC 369247, IC 387838, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 336833, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, IC 381552, EC 469904, EC 326771, EC 388893, EC 388887, EC 388895,EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, EC 388788, EC 388890, IC 436153, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, IC 75730, DOS 1, Local 1, Local 2

Continuing Table 2

Characters: Stem colour	No. of Genotypes	Genotypes
Petiole colour		
Green	36	IC 44681, IC 387837, IC 369247, IC 387838, IC 388785, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 336833, IC 201223,IC 328582, IC 338959, IC 333833, IC 281185, IC 381552, EC 469904, EC 326771, EC 388887, EC 388895, EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, EC 388788, EC 388890, IC 436153, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, Local 1, Local 2
Purple	1	IC 381185
Purple green	3	EC 388893, IC 75730, DOS 1
Flower colour		
White	27	IC 44681, IC 387837, IC 387838, IC 388785, IC 312264, IC 110207, IC 338794, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, EC 469904, EC 326771, EC 388887, EC 388895, EC 388782, EC 388737, EC 388889, EC 338772, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, Local 1, Local 2
Light purple	8	IC 369247, IC 469938, IC 326735, IC 381552, EC 388896, EC 388788, EC 388890, IC 436153
Purple	5	IC 336833, EC 388893, IC 75730, IC 381185, DOS 1
Calyx colour		
Green	25	IC 387838, IC 388785, IC 312264, IC 110207, IC 338794, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, EC 469904, EC 326771, EC 388887, EC 388895, EC 388782, EC 388737, EC 388889, EC 338772, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, Local 1, Local 2
Light green	2	IC 44681, IC 387837
Purple	6	EC 388893, EC 388788, EC 388890, IC 436153, IC 75730, DOS 1
Light purple	6	IC 369247, IC 469938, IC 326735, IC 336833, IC 381552, EC 388896
Dark purple	1	IC 381185
Calyx Pubescence		
Sparse pubescent	13	IC 44681, IC 369247, IC 388785, IC 469938, IC 312264, IC 338794, IC 381552, IC 75730, IC 381185, EC 469904, EC 388893, EC 338772, DOS 1
Dense pubescent	0	-None-
Non-pubescent	27	IC 387837, IC 387838, IC 326735, IC 110207, IC 336833, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, IC 436153, IC 381158, IC 326732, EC 326771, EC 388887, EC 388895, EC 388896, EC 388782, EC 388737, EC 388889, EC 388788, EC 388890, RDV 45, NSV 38, EC 112548, Local 1, Local 2
Seed colour		
Black	1	IC 44681
Dull black	35	IC 387837, IC 369247, IC 387838, IC 388785, IC 469938, IC 326735, IC 312264, IC 110207, IC 338794, IC 201223, IC 328582, IC 338959, IC 333833, IC 281185, IC 381552, EC 469904, EC 326771, EC 388893, EC 388887, EC 388895, EC 388896, EC 388782, EC 388737, EC 388889, EC 338772, EC 388788, EC 388890, IC 436153, IC 381158, IC 326732, RDV 45, NSV 38, EC 112548, Local 1, DOS 1
Brownish black	1	IC 336833
Brown	3	IC 75730, IC 381185, Local 2

References

Arya RK, Kumar V, Verma PK and Kumar P, (2024). Morphological characterization of lemon grass genotypes under semi-arid conditions of Haryana. Indian J. Plant Genetic Resources, 37(2):1-6.

Balyan SS and Pushpangadan P, (1988). A study on the taxonomical status and geographic distribution of the genus *Ocimum*. Perfumes and Flavours Association of India Journal10(2):13–19.

Carovic SK, Liber Z, Besendorfer V, Javornik B, Bohanec B, Kolak I and Satovic Z, (2010). Genetic relations among basil taxa *(Ocimum*) based on molecular markers, nuclear DNA content, and chromosome number. Plant Systematics and Evolution 285(1):13-22.

Chhaya A, Sharma NL and Gaurav SS, (2013). An analysis of basil (*Ocimum* sp.) to study the morphological variability. Indian Journal of Fundamental and Applied Life Sciences 3(3):521-525.

Gangrade SK, Mishra PK and Sharma RK, (2000). Variability in essential oil constituents of *Ocimum* species. Journal of Medicinal and Aromatic Plant Science 22:13-16.

Gowda M, Dorajeerao AVD, Madhavi M and Suneetha DS, (2019). A study on genetic variability for yield and its attributes in sweet basil (*Ocimum basilicum* L.). International Journal of Current Microbiology and Applied Sciences 8(6):2995-3003.

Javanmardi J, Khalighi A, Kashi A, Bais HP and Vivanco JM, (2002). Chemical characterization of basil (*Ocimum basilicum* L.) found in local accessions and used in traditional medicines in Iran. Journal of Agricultural and Food Chemistry 50(21):5878-5883.

Khosla MK, Bhasin M and Thappa RK, (2000). Essential oil composition of some improved species of *Ocimum*. Indian Perfumer 44(3):175-182.

Krishnamoorthy S, (1989). Indigenous essential oils: Recent developments and perfumery applications. Indian Perfumer 33:215-218.

Kumar N, Sharma KR, Sood M and Chandel S, (2019). Morphological characterization of Bhabri Tulsi (*Ocimum basilicum* L.). International Journal of Chemical Studies 7(6):2295-2298.

Kumar PK, Kumar MR, Kavitha K, Singh J and Khan R, (2012a). Pharmacological actions of *Ocimum sanctum*-review article. International Journal of advances in Pharmacy, Biology and Chemistry 1(3):2277-4688.

Malav P, Pandey A, Bhatt K C, Gopala Krishnan S and Bisht IS, (2015). Morphological variability in holy basil (*Ocimum tenuiflorum* L.) from India. Genetic Resources and Crop Evolution 62(8): 1245-1256.

Naithani V and Kakkar P, (2002). *Ocimum gratissimum, Ocimum canum* and *Ocimum kilimandscharicum*: a review. Journal of Medicinal and Aromatic Plant Science 24:441-455.

Nassar MA, El-Segai MU and Mohamed SN, (2013). Botanical studies on *Ocimum basilicum* L.(Lamiaceae). Research Journal of Agriculture and Biological Sciences 9(5):150-163.

Paton A and Putievsky E, (1996). Taxonomic problems and cytotaxonomic relationships between and within varieties of *Ocimum basilicum* and related species (Labiatae). Kew Bulletin 51(3):509-524.

Pushpangadan P and Bradu BL, (1995). Basil. In: Advances in horticulture, medicinal and aromatic plants, (Chadha, K. L., and Gupta, R., editors), Malhotra Publishing House, New Delhi 11:627-657.

Simpson BB and Conner OM, (1986). Economic botany: Plants in our world, McGraw-Hill Publishers, New York, 640pp.

Singh R, PK Verma, RK Behl, and RK Arya, (2024) Studies on identification of stable genotypes of lemongrass for semi-arid regions. *Ekin J.* 9(1):22-26.

Singh S, Lal RK and Singh B, (2020). Genetic variability in *Ocimum* L. germplasm: Medicinal and economic potential for value addition and product development. In Book: Botanical Leads for Drug Discovery (Singh, B. editor), Springer Publishers, Singapore 243-253.

Sobti SN and Pushpangadan P, (1979). Cytotaxonomical studies in the genus *Ocimum.* In: Taxonomy, Cytogenetics and Cytotaxonomy of Plants, (Bir S. S., editor), Kalyani Publishers, New Delhi 373-377.

Yaldiz G and Camlica M (2021). Agro-morphological and phenotypic variability of sweet basil genotypes for breeding purposes. Crop Science 61(1):621-642.