International Journal of Plant & Soil Science

Volume 35, Issue 19, Page 741-752, 2023; Article no.IJPSS.105437
ISSN: 2320-7035

Evaluation of Morphological Characteristics, Yield Potential, and Essential Oil Composition of *Ocimum sanctum* Genotypes for Crop Improvement

Mirudhula S. [a], Nalina L. [b*], Kokila Devi E. [c], Bini Sundar S. T. [a] and Meenakshi P. [d]

[a] Department of Medicinal and Aromatic Crops, HC&RI, TNAU, Coimbatore, India.
[b] Controller of Examinations, TNAU, Coimbatore, India.
[c] Department of Plant Biotechnology, CPMB&B TNAU, Coimbarore, India.
[d] Department of Biochemistry, TNAU, Coimbatore, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i193606

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105437

Original Research Article

Received: 17/06/2023
Accepted: 21/08/2023
Published: 25/08/2023

ABSTRACT

Ocimum sanctum, also known as Holy Basil, is an aromatic herb with a long history of use in traditional medicine. It is native to tropical and subtropical regions of Asia and is now cultivated worldwide. Plants have erect, much-branched sub-shrub with simple opposite green or purple leaves that are strongly scented and hairy stems and leaves has a strong, characteristic aroma that occurs mainly because of the volatile oils present.

**Corresponding author: E-mail: nalina@tnau.ac.in;*

In this experiment, 30 genotypes of *Ocimum sanctum* were evaluated for morphological, yield and quality traits. At nursery stage, germination percentage, seedling shoot length and seedling root lengths were recorded. Among the accessions. *OS*-22 exhibited the highest germination percentages (82%), Seedling shoot and root length were highest in *Os*-18 and *OS* 21 (35 cm and 11 cm) respectively. In the main field, the accessions were characterized for qualitative traits *viz* growth habit, leaf colour and stem colour. The accessions were grouped into two, based on growth habit. Based on stem and leaf colour the accessions were grouped into five and four groups respectively. In case of quantitative traits, plant height achieved maximum in the accession *OS* 22 (88cm) followed by *OS* 17(75cm). The accessions *OS*-15 and *OS*-22 exhibited more extensive plants spread, while *OS*-21 and *OS*-13 had higher number of primary branches. Accessions *OS*-20 and *O S*-23 recorded more number of leaves (409 and 422) and the accessions *O S*-22 and *OS*-11 recorded highest fresh leaf weight (370.2 g & 301.67 g). The essential oil recovery and oil yield was highest in the accession *OS* 20 (green type) followed by *OS* 22 (purple type). Characterization of oil in GCMS revealed that the key component was eugenol, which showed highest content in accession *Os*-20 (46 %). This study can be used for further crop improvement studies and breeding programs.

Keywords: Ocimum sanctum; eugenol; essential oil; GC-MS.

1. INTRODUCTION

Ocimum sanctum, commonly known as holy basil, comes under the genus *Ocimum* belongs to the family.Lamiaceae and has rich historical use in traditional medicinal systems, particularly in Ayurveda [1]. This aromatic plant holds profound significance in various cultures. The therapeutic potential of *Ocimum sanctum* has been recognized for its extensive health benefits [2]. The herb's multifaceted pharmacological actions encompass the ability to counteract physical, chemical, metabolic, and psychological stress [3]. It offers protection against chemical stress like pollutants and heavy metals, as well as physical stressors such as exertion, ischemia, and exposure to extreme conditions [4]. Moreover, it has been shown to p*o*sitively impact metabolic parameters, including blood glucose, blood pressure, and lipid levels. Its anxiolytic, anti-depressant, and cognitive-enhancing properties contribute to its reputation consider as genic herb [5]. It exhibits a broad-spectrum antimicrobial activity. It is rich in diverse metabolites, including essential oils, flavonoids, phenolic compounds, and terpenes. [6] The key compound, eugenol, is responsible for its distinct aroma and many of its medicinal effects, including antioxidant, anti-inflammatory, and antimicrobial activities [7]. Other significant metabolites such as caryophyllene, linalool, and ursolic acid further contribute to tulsi's adapt genic and stress-relieving properties. Collectively, these metabolites interact to provide a range of health benefits, encompassing immune system modulation, cardiovascular support, and cognitive enhancement [8].

Originating from the Indian subcontinent, *Ocimum sanctum* is identifiable by its potent aroma, petite leaves and vibrant green or sometimes purple coloration. Typically, it assumes the form of a compact, bushy annual herb, reaching heights of up to 18 inches. Leaves are in vibrant green, regal purple, or captivating red shades, exhibiting ovate, lanceolate, or oblong shapes and varying in size from small (1-2 cm long) to large (5-10 cm long) [9]. Stem enchant with hues of green, purple, or red, while flowers showcase the elegance of white, the softness of pink, or the majesty of purple, with forms ranging from tubular to bell-shaped Among the different variants of *Ocimum sanctum*, "sri tulsi" and "krishna tulsi" stand out, distinguished by the colour of their leaves [10]. Morphological variation in holy basil is thought to be due to a combination of genetic and environmental factors. Hence, the research was conducted to identifiy a genotype with high yield, oil recovery along with unique morphological traits [6].

2. MATERIALS AND METHODS

Seeds of *Ocimum sanctum* accessions were collected from different parts of Tamil Nadu and the experiment was conducted in RBD with three replication and 30 treatments in the year 2022-23. Seeds were raised in nursery. Seeds germinated after 10 to 14 days of sowing. In the nursery, observation on germination percentage, seedling shoot length and root length were recorded. Seedlings were transplanted to main field at a spacing of 45x 45cm. Regular cultural operations were followed [3]. In the main field, both qualitative (plant growth habit, leaf colour,

stem colour).Royal Botanical society colour chart was used for screening the germplasm. Quantitative parameters viz. plant height , plant spread ,number of primary branches , number of secondary branches, number of leaves per plant, fresh weight of leaves were recorded.

2.1 Essential Oil % Estimation

To extract essential oil fresh leaves were harvested and weighed, leaves were cut into small pieces and water was added with ration of 3:1 after adding water sample was boiled by maintaining temperature ranging from 70 to 80^0 c it takes around 3hours for distillation by condensation process oil get collected in upper layer of water and they are seprated and collected in tube [11].

Essential oil was distilled and oil recovery and oil yield were calculated.

2.2 Gas Chromatography and Mass Spectroscopy

essential oil of high yielding accessions were analyzed using a Perkin-Elmer (Italy) gas chromatograph (Model 8500) equipped with flame ionization detector (FID), GP-100 printer-plotter and an electronic integrator using BP-1 (SGE, USA) (25 m × 0.5 mm i.e. × 0.25mm film thickness) capillary column coated with polydimethylsiloxane. Nitrogen was used as carrier gas at 10 psi inlet pressure with a flow rate of 0.4 ml/min (linear velocity 14 cm/s). Temperature was programmed from 60 to 220 ◦C at a ramp rate of 5 ◦C/min with a final hold time of 10 min , Identification of individual compounds was achieved by comparing their mass spectra with a relevant database, and quantification was done based on peak areas [12].

2.3 Statistical Analysis

The experiment was carried out in randomized block design with 3 replications and 30 treatments, each genotype is considered as one treatment. The mean performance and ANOVA was calculated using SPSS software.

3. RESULTS AND DISCUSSION

In this study, thirty germplasm accessions of Tulsi (*Ocimum sanctum*) were collected and evaluated for morphological, yield and quality traits. In the nursery, germination percentage (ranged from 5% to 95%). The accession *OS*12 exhibited the highest germination percentage 95%, followed by *OS*20 (75%. However, the accessions *OS*10 and *OS*-3 had much lower germination rates, at 5% and 10%, respectively (Fig. 4). Significant variations was observed for seedling shoot and root length. Shoot length ranged from (8cm to 35 cm). The accession *OS*18 and *OS*16 recorded highest lengths 35cm and 30cm respectively, the accession *OS*10 recorded the lowest shoot length (8cm). Root length ranged from 3cm to 11cm) It was highest in *OS*21 and *OS*22 (11 cm and 10 cm) respectively and lowest in OS7 and *OS*19.Variation was observed for growth habit, stem and leaf colour. Owing to the ease of cr*o*sspollination, morph types, chemo types and genotypes are available in this genus [13]. The accessions were grouped into two based (Fig. 1) on growth habit viz. [14], erect and spreading. Erect growth habit was observed in 26 accessions and spreading habit was observed in 4 accession.Based on stem colour the accessions were grouped into 5 (Fig. 2) (Table 2), Brilliant purple colour was observed in 4 accession. Light purple stem colour was observed in 8 accession were under, Yellowish green stem colour was observed in 6 accession .Deep purple colour of stem was recorded in 7 accessions. Viz., Dark green was recorded in 3 number of accessions. Based on leaf colour the accessions were grouped into 4 in which accession are grouped under vivid yellowish green colour leaf (Fig. 3). Accession were grouped under dark green leaves. Light olive green was observed in 5 accession [6]. Observations in the main field after 45 days (Table 3) of transplanting revealed significant variations for growth and yield parameters. Plant height (ranged from 15cm to 88cm), the accession *OS*22 recorded the maximum height (88cm, while *OS*8 and *OS*4 had lower height 22.1cm and 23cm, respectively. Plant spread (ranged from 10cm to 62cm) the accessions *OS*15 and *OS*18 recorded highest spreads at 58cm and 59cm, respectively. Number of primary branches ranged from 3 to 22 with *OS*21 having more primary branches [4], followed by *OS*22 with 15 branches. *OS*6 had the fewest primary branches [15]. The number of secondary branches ranged from 9 to 76 the accession *OS*20 having the more number of secondary branches 72, and *OS*6 having the fewest 9 [16]. Further the accession were grouped based on statistical analysis and are arranged in a group based on least significant difference .totally 18 groups were classified and those which have similar characters are arranged in same group and its said to be on par with each other (Table 4) Yield observation like number of leaves per plant also varied significantly, with *OS*20 and

*OS*22 having the more number of leaves 422 and 409, respectively, while *OS*9 had the fewest leaves 65. Leaf yield ranged from 115g to 371.5g, with *OS*20 producing the highest yield at 371.5g and *OS*10 producing the lowest yield at 115g.among the accessions *OS*20 recorded more plant height, number of primary branches, secondary branches which in turn resulted in high leaf yield. The genetic improvement of the crop depends m*os*tly on the nature and relative magnitude of genetic variance components concerned with yield and yield related attributes yield [17] of essential oil recovery % ranged from (0.01 to 1%l) were accession *Os*20, *OS*22 observed 0.9 and 0.85% of essential oil (Fig. 5) [18,19].

Since the yield of *OS*20 (Fig. 6) and *OS*22 (Fig. 7) is more due to various factors. This essential oil were subjected to screening of major secondary metabolites like eugenol percentage in *OS*20 is (46%) *OS*22 (20%), caryophyllene in *OS*20 (10%) and *OS*22 (30%), eucalyptol in *OS*20(2%) and *OS*22 (0.17%), Methyl eugenol in *OS*20 (51.78%) and *OS*22 (34%), elemene in *OS*20 (6.8%) and *OS*22 (11.6%), and germacrene D in *OS*20 (5.3%) and *OS*22 (7.2%) [20,21]. The compound alpha-terpinol in *OS*20 (5%) and it was absent in *OS*22.chemical comp*o*sition of essential oil mainly depends on soil and climatic condition on the location, growing season and maturity stage however plants subjected to present study were cultivated at the same location under same soil and climatic conditions and harvested at the same age [3]. Therefore variability of essential oil comp*o*sition could be considered as variation between two morphotyes [6]. Considering all these observations, it is evident that *Os*20 performed exceptionally well in terms of morphological characteristics, yield, and containing a higher percentage of secondary metabolites, indicating valuable medicinal and pharmacological properties.

Table 1. List of germplasm accessions in Ocimum sanctum

S.NO	Accession number	Place collected	Latitude (^{o} N)	Longitude (^{o} E)
1	*OS*-1	Tiruchirappali	10.7905	78.7047
2	*OS*-2	Dindigul	10.3624	77.9695
3	*OS*-3	Pudukkottai	10.3833	78.8001
4	*OS*-4	Madurai	9.9252	78.1198
5	*OS*-5	Salem	11.6643	78.1460
6	*OS*-6	Erode	11.3410	77.7172
7	*OS*-7	Dharmapuri	12.1211	78.1582
8	*OS*-8	Thanjavur	10.7870	79.1378
9	*OS*-9	Ariyalur	11.1401	79.0786
10	*OS*-10	Namakal	11.2194	78.1678
11	*OS*-11	Karur	10.9601	78.0766
12	*OS*-12	Vellore	12.9165	79.1325
13	*OS*-13	Thiruvallur	13.1231	79.9120
14	*OS*-14	Perambalur	11.2342	78.8807
15	*OS*-15	Viluppuram	11.9401	79.4861
16	*OS*-16	Theni	10.0079	77.4735
17	*OS*-17	Musiri	10.9549	78.4439
18	*OS*-18	kulithalai	10.9426	78.4172
19	*OS*-19	Neyveli	11.5390	79.4794
20	*OS*-20	Coimbatore	11.0168	76.9558
21	*OS*-21	Kanyakumari	8.0844	77.5495
22	*OS*-22	Tirunelveli	8.7150	77.7656
23	*OS*-23	Krishnagiri	12.5266	78.2150
24	*OS*-24	Sivagangai	9.8433	78.4809
25	*OS*-25	Virudhunagar	9.4218	77.8367
26	*OS*-26	Ramanathapuram	9.3639	78.8395
27	*OS*-27	Thoothukudi	8.7642	78.1348
28	*OS*-28	Thiruvarur	10.7661	79.6344
29	*OS*-29	Chennai	13.0827	80.2707
30	*OS*-30	Thuraiyur	11.1519	78.5951

Table 2. Qualitative characterization of Ocimum sanctum genotypes

Plant habit	Genotypes
Spreading	*Os-1,Os-2,Os-3,Os-4,Os-5, Os-7,Os-8,Os-9,Os-11,Os-12,Os-13,Os-14,Os-15,Os-16,Os-18,Os-19,Os-20,Os-21,Os-22,Os-23,Os-25,Os-26,Os-27,Os-28,Os-29,Os-30*
Erect	*Os-6,Os-10, Os-17, Os-24*
Stem colour	
Yellowish green	*Os-1,Os-4, Os-13, Os-16, Os-26, Os-28, Os-30, Os-26, Os-21*
Brilliant purple	*Os-2, Os-8, Os-15, Os-22*
Light purple	*Os-3, Os-5, Os-7, Os-10, Os-12, Os-19, Os-21, Os-24*
Dark Green	*Os-9, Os-20, Os-29*
Deep Purple colour	*Os-6, Os-11, Os-14, Os-17, Os-18, Os-23, Os-27*
Leaf colour	
Vivid yellowish green	*Os-1, Os-4, Os-5, Os-7, Os-8, Os-10, Os-12,Os-15, Os-16, Os-21, Os-23, Os-24, Os-26*
Light olive green	*Os-2, Os-3, Os-6, Os-18, Os-20, Os-25, Os-30*
Dark green	*Os-9, Os-11, Os-14, Os-19, Os-28*
Brilliant yellow green	*Os-27, Os-29*
Deep purple	*Os-13, Os-17, Os-22*

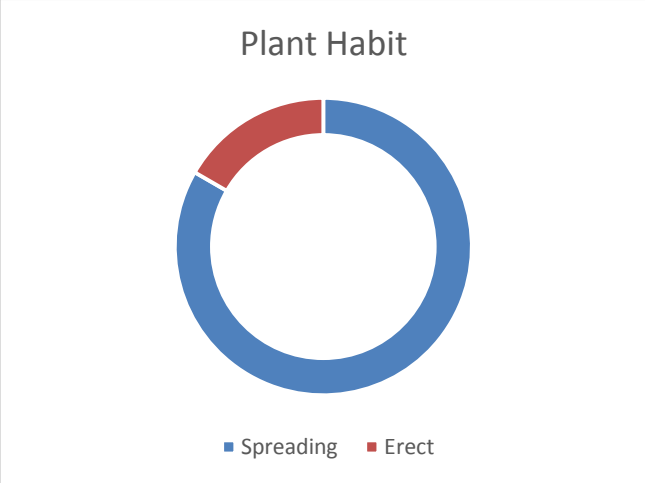

Fig. 1. Plant habit of *O. sanctum*

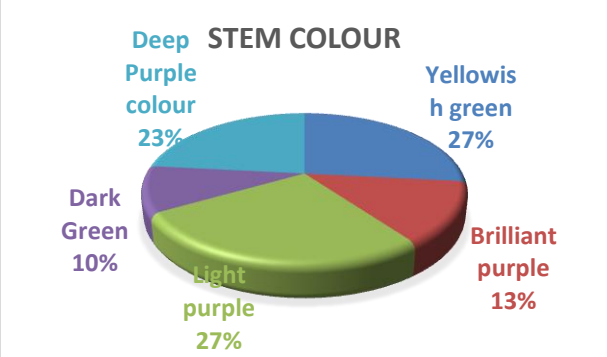

Fig. 2. Varations among stem colour *O. sanctum*

Table 3. morphological parameters of *Ocimum sanctum* genotypes

Accession name	Germination %	Shoot length (cm)	root length(cm)	Plant height (cm)	Plant spread (cm)	No of primary branches	No of secondary branches	No of leaves	Leaf fresh wt. (g)	Oil recovery percentage
OS-1	50.41	18.12	5.00	29.40	24.75	9.00	18.00	75	302.67	0.25
OS-2	29.93	23.30	6.12	39.40	31.23	14.00	31.00	98	210.30	0.20
OS-3	10.10	22.22	4.21	27.36	22.13	9.00	27.00	69	333.00	0.01
OS-4	40.72	19.12	5.52	23.21	20.51	8.00	16.00	88	227.31	0.10
OS-5	19.88	29.52	9.00	56.53	44.55	10.00	25.00	150	215.33	0.50
OS-6	29.88	25.30	4.41	36.42	25.88	3.00	9.00	121	290.71	0.05
OS-7	9.79	15.12	3.33	33.63	22.19	7.00	28.00	89	183.92	0.03
OS-8	19.55	20.30	6.00	22.10	15.43	5.00	10.00	97	222.13	0.10
OS-9*	20.17	17.20	10.12	47.66	41.24	11.00	33.00	160	235.67	0.40
OS-10	4.92	8.15	4.01	15.62	10.22	9.00	18.00	65	115.78	0.02
OS-11	49.69	32.22	7.20	50.55	46.15	10.00	20.00	189	354.67	0.54
OS-12	95.73	27.15	9.33	61.24	51.97	15.00	35.00	210	283.67	0.23
OS-13**	77.60	34.33	5.20	55.12	57.79	9.00	27.00	250	211.25	0.36
OS-14	59.52	29.01	6.12	46.42	50.79	13.00	26.00	291	297.62	0.59
OS-15	64.74	30.25	7.55	57.80	64.27	19.00	29.00	198	369.32	0.45
OS-16	70.01	32.23	8.52	62.43	58.65	20.00	48.00	269	274.67	0.39
OS-17	49.78	25.10	6.30	73.44	33.29	10.00	22.00	150	335.95	0.16
OS-18	83.52	35.31	9.20	78.33	61.30	21.00	33.00	215	367.33	0.62
OS-19	45.16	18.21	3.12	34.24	20.80	8.00	16.00	101	337.15	0.09
OS-20**	72.58	33.11	8.33	57.52	45.58	19.00	45.00	325	433.70	0.85
OS-21	78.45	24.22	11.01	67.41	51.98	22.00	35.00	269	280.91	0.59
OS-22**	82.92	27.32	9.20	84.30	46.18	15.00	21.00	356	371.52	0.90
OS-23*	90.51	22.10	5.30	73.13	23.26	21.00	36.00	158	282.57	0.31
OS-24	40.18	20.22	6.41	28.62	25.71	11.00	15.00	198	216.01	0.11
OS-25	45.30	16.20	8.20	36.41	20.42	12.00	12.00	120	253.02	0.23
OS-26	71.96	23.30	5.15	38.45	45.81	9.00	15.00	164	314.00	0.25
OS-27	41.58	25.15	6.23	36.34	25.25	10.00	20.00	99	233.66	0.30
OS-28	53.31	22.12	9.00	33.11	14.73	13.0	19.00	222	301.67	0.50
OS-29	28.71	28.30	6.10	46.71	18.13	7.00	31.00	133	235.71	0.22
OS-30	19.28	15.12	4.15	37.30	19.46	11.00	22.00	167	217.50	0.03

Accession name	Germination %	Shoot length (cm)	root length(cm)	Plant height (cm)	Plant spread (cm)	No of primary branches	No of secondary branches	No of leaves	Leaf fresh wt. (g)	Oil recovery percentage
mean	48.6000	23.76	6.43	45.99	34.26	11.65	31.23	199.3	294.6	0.32
SEd	1.1412	0.40	0.14	2.34	0.85	0.26	0.60	4.99	6.12	0.0063
CD(.05)	2.2847	0.81	0.29	4.70	1.71	0.52	1.21	9.99	12.26	0.012

Table 4. Grouping of genotypes based on parameters by statistical analysis

Parameter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Germination %	*OS*12	*OS*23	*OS*13 *OS*18 *OS*22	*OS*22 *OS*18 *OS*21	*OS*20	*OS*16 *OS*26	*OS*15	*OS*14	*OS*28	*OS*1 *OS*11 *OS*17	*OS*19 *OS*25	*OS*19 *OS*27	*OS*4 *OS*24	*OS*2 *OS*6 *OS*29	*OS*5 *OS*8 *OS*9 *OS*30	*OS*3 *OS*7	*OS*10	
Shoot length	*OS*18	*OS*13	*OS*20 *OS*22	*OS*11 *OS*16	*OS*15	*OS*5 *OS*14	*OS*29	*OS*12	*OS*6 *OS*17 *OS*27	*OS*21	*OS*2 *OS*26	*OS*3 *OS*23 *OS*28	*OS*8 *OS*24	*OS*4	*OS*1 *OS*19	*OS*9 *OS*25	*OS*7 *OS*30	*OS*10
Root length	*OS*21	*OS*9 *OS*20	*OS*5 *OS*12 *OS*18 *OS*22 *OS*28	*OS*16 *OS*25	*OS*11 *OS*15	*OS*2 *OS*8 *OS*14 *OS*17 *OS*24 *OS*27 *OS*29	*OS*1 *OS*4 *OS*13 *OS*23 *OS*26	*OS*3 *OS*6 *OS*10 *OS*30	*OS*7 *OS*19									
Plant height	*OS*22	*OS*17 *OS*18 *OS*20	*OS*17 *OS*23 *OS*20	*OS*21	*OS*5 *OS*12 *OS*15 *OS*16	*OS*5 *OS*13 *OS*15 *OS*16	*OS*9 *OS*11 *OS*14	*OS*9 *OS*14 *OS*29	*OS*6 *OS*26 *OS*27 *OS*30	*OS*6 *OS*19 *OS*25 *OS*27 *OS*30	*OS*6 *OS*7 *OS*19 *OS*25 *OS*27 *OS*28	*OS*2 *OS*7 *OS*19 *OS*25 *OS*27 *OS*28	*OS*1 *OS*2 *OS*3 *OS*7 *OS*24 *OS*28	*OS*3 *OS*4	*OS*4 *OS*8	*OS*10		
Plant spread	*OS*15 *OS*22	*OS*16 *OS*18 *OS*20	*OS*s13	*OS*12 *OS*14 *OS*21	*OS*5 *OS*11 *OS*26	*OS*5 *OS*11	*OS*9	*OS*17	*OS*2	*OS*1 *OS*6 *OS*24 *OS*27	*OS*3 *OS*7 *OS*23	*OS*4 *OS*19 *OS*25 *OS*30	*OS*29	*OS*8 *OS*28	*OS*10			
No of primary branches	*OS*21 *OS*22	*OS*18 *OS*23	*OS*16 *OS*20	*OS*15	*OS*12	*OS*2	*OS*14 *OS*28	*OS*25	*OS*9 *OS*24 *OS*30	*OS*5 *OS*11 *OS*17	*OS*1 *OS*3 *OS*10	*OS*4 *OS*19	*OS*7 *OS*29	*OS*8	*OS*6			

Parameter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
										*OS*27	*OS*13 *OS*26							
No of secondary branches	*OS*20	*OS*22	*OS*12 *OS*21	*OS*2 *OS*18 *OS*23	*OS*16 *OS*28	*OS*15 *OS*28	*OS*25	*OS*9 *OS*26	*OS*5 *OS*17	*OS*3 *OS*7 *OS*13 *OS*29	*OS*3 *OS*13 *OS*14	*OS*24 *OS*30	*OS*11 *OS*27	*OS*1 *OS*10	*OS*4 *OS*19	*OS*6 *OS*8		
Leaf fresh weight	*OS*11	*OS*13 *OS*16 *OS*18 *OS*20 *OS*22	*OS*19	*OS*13 *OS*15 *OS*17 *OS*19	*OS*1 *OS*26	*OS*1 *OS*5 *OS*12 *OS*28	*OS*5 *OS*10 *OS*21 *OS*23	*OS*10 *OS*14 *OS*21 *OS*23	*OS*25	*OS*4 *OS*8 *OS* 27 *OS*29	*OS*4 *OS*7 *OS*27	*OS*4 *OS*7 *OS*24 *OS*30	*OS*2 *OS*7 *OS*24 *OS*30	*OS*16				
Oil recovery	*OS*20 *OS*22	*OS*19	*OS*14 *OS*21	*OS*11	*OS*5	*OS*28	*OS*15	*OS*9	*OS*16 *OS*17	*OS*13	*OS*23 *OS*27	*OS*1 *OS*26	*OS*12 *OS*25 *OS*29	*OS*2	*OS*18	*OS*4 *OS*8 *OS*24	*OS*6	*OS*7 *OS*10 *OS*30 *OS*3

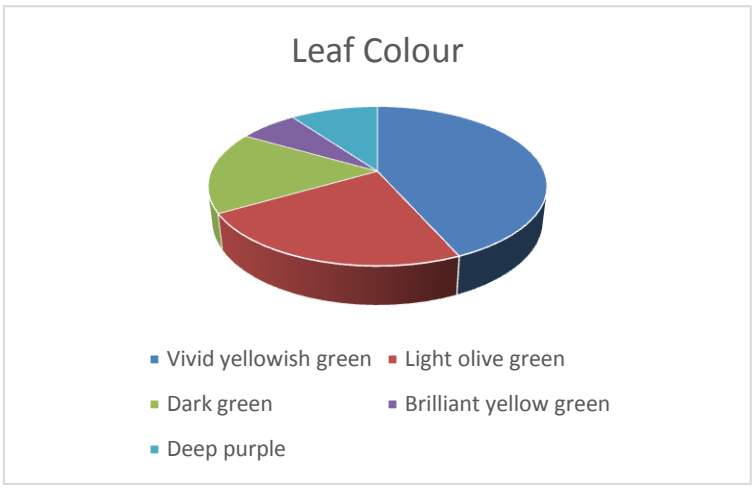

Fig. 3. Variation of leaf colour in *O. sanctum*

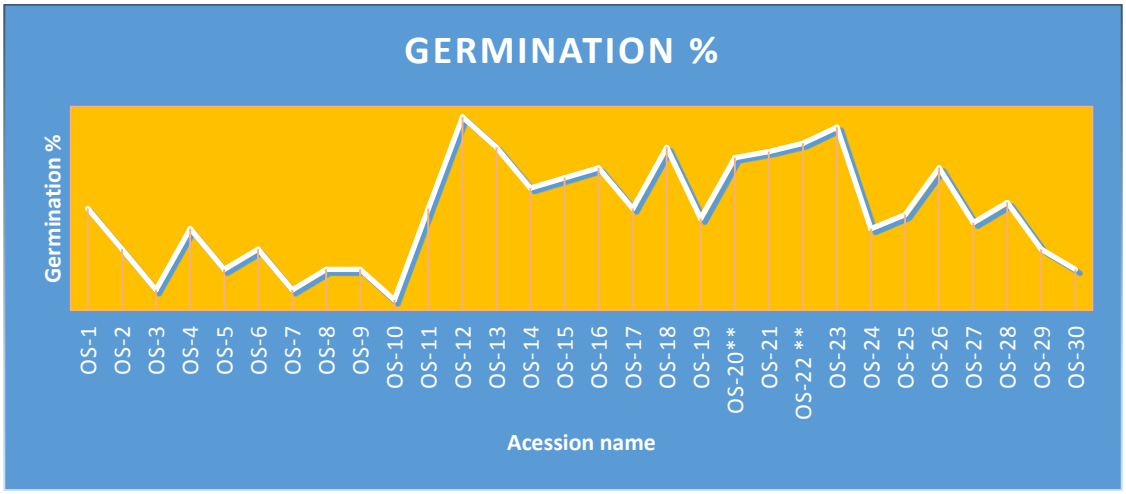

Fig. 4. Germination percentage of *O. sanctum* genotypes

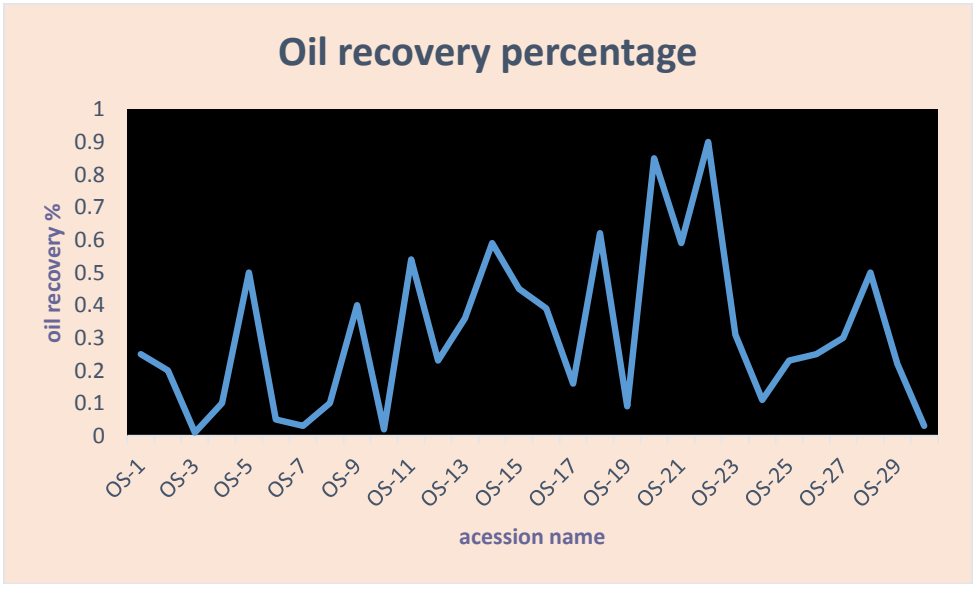

Fig. 5. Essential oil recovery percentage of *O. sanctum* genotypes

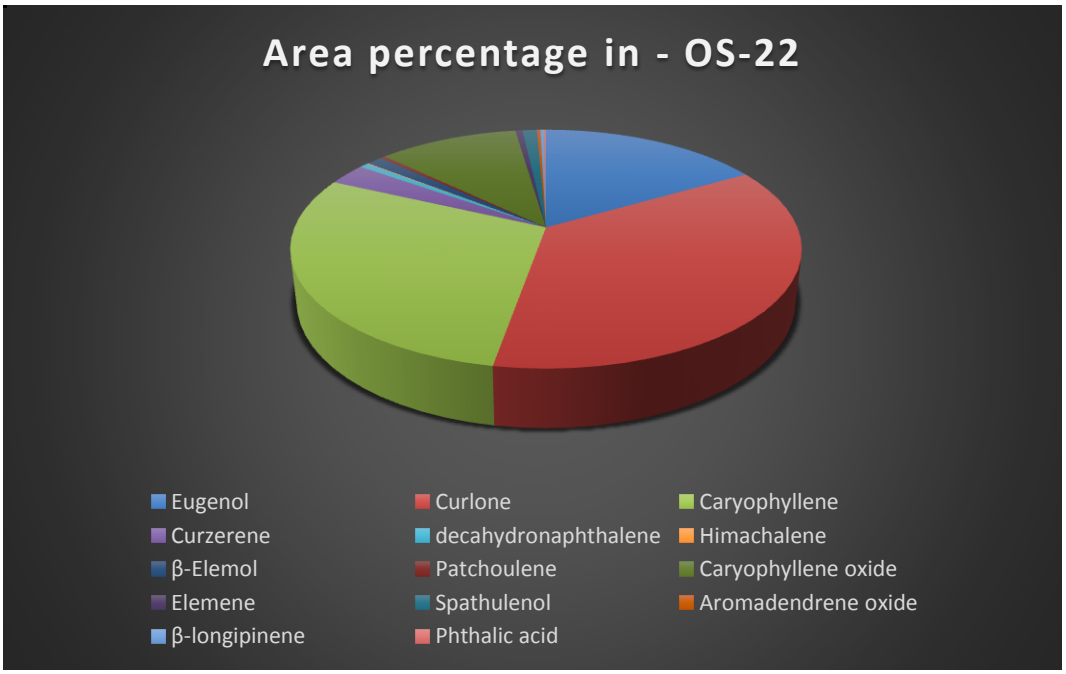

Fig. 6. Secondary metabolites and its area percentage through GC-MS in Os-20

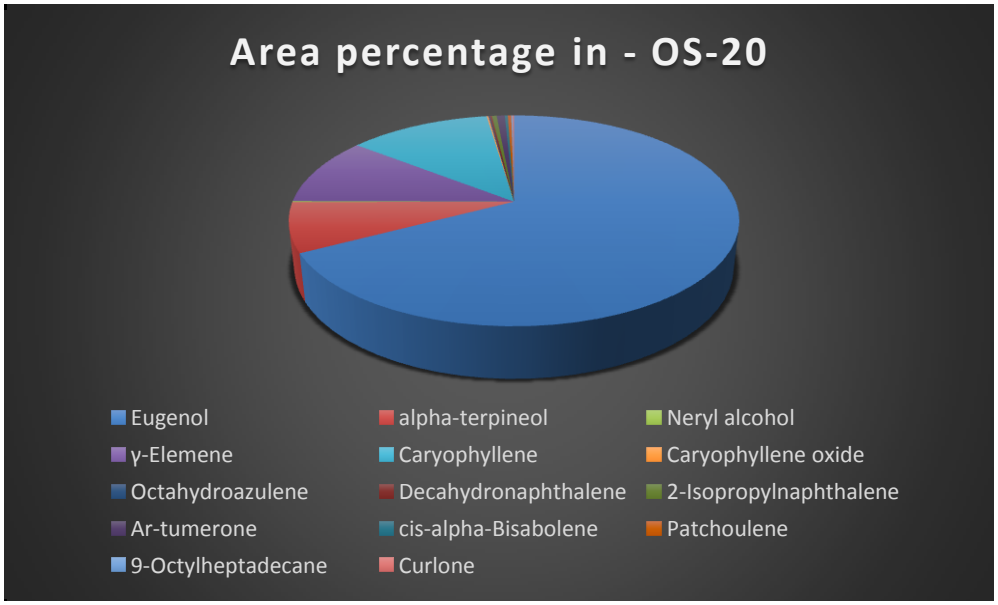

Fig. 7. Secondary metabolites and its area percentage through GC-MS in Os-22

4. CONCLUSION

Evaluated 30 *ocimum sanctum* genotypes for their morphological, yield, and quality traits. The findings highlighted significant genetic diversity, ranging from germination percentages to growth habits, stem colors, and essential oil composition. Notably, OS12 exhibited the highest germination rate at 95%, while OS20 and OS22 excelled in growth parameters and essential oil content. OS20 stood out for its exceptional morphological traits, yield, and higher secondary metabolite percentages, suggesting promising medicinal potential. The study underscores the importance of preserving this genetic diversity for sustainable agriculture and pharmaceutical applications, emphasizing the need for further exploration of the genetic mechanisms and utilization of *ocimum sanctum* diverse traits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERANCES

1. Cohen MM. Tulsi-Ocimum sanctum: A herb for all reasons. Journal of Ayurveda and Integrative Medicine. 2014;5(4):251
2. Hiltunen, Raimo, Yvonne Holm, eds. Basil: the genus Ocimum. CRC Press; 1999.
3. Kumar Vinod, Harish Chandra Andola, Hema Lohani, Nirpendra Chauhan. Pharmacological review on *Ocimum sanctum* Linnaeus: A queen of herbs. J of Pharm Res. 2011;4:366-368.
4. Shivananjappa, Mahesh, Manoj Joshi. Aqueous extract of tulsi (*Ocimum sanctum*) enhances endogenous antioxidant defenses of human hepatoma cell line (HepG2). Journal of Herbs, Spices & Medicinal Plants. 2012;18(4):331-48
5. Mahajan Nipun, Shruti Rawal, Monika Verma, Mayur Poddar, Shashi Alok. A phytopharmacological overview on *Ocimum* species with special emphasis on *Ocimum sanctum*. Biomedicine & Preventive Nutrition. 2013;3(2):185-192
6. Dharmadasa RM, Siriwardhane DA, Samarasinghe K, Rangana SH, Nugaliyadda L, Gunawardane I, Aththanayake AM. Screening of two *Ocimum tenuiflorum* L. (Lamiaceae) morphotypes for their morphological characters, essential oil composition and fruit fly attractant ability. World J. Agric. Res. 2015;3(1):1-4.
7. Manikandan P, Murugan RS, Abbas H, Abraham SK, Nagini S. *Ocimum sanctum* Linn. (holy basil) ethanolic leaf extract protects against 7, 12-dimethylbenz [a] anthracene-induced genotoxicity, oxidative stress, and imbalance in xenobiotic-metabolizing enzymes. Journal of Medicinal Food. 2007;10(3):495-502.
8. Joshi RK, Sharma AK. Determination of seasonal variation of volatile organic constituents of the leaves of traditional herb *Ocimum sanctum* Linn. Indian J. Pharm. Sci. 2021;83:750-7
9. Mondal S, Mirdha BR, Mahapatra SC. The science behind sacredness of Tulsi (*Ocimum sanctum* Linn.). Indian J Physiol Pharmacol. 2009;53(4):291-306.
10. Pattanayak Priyabrata, Pritishova Behera, Debajyoti Das, Sangram K. Panda. *Ocimum sanctum Linn*. A reservoir plant for therapeutic applications: An overview. Pharmacognosy Reviews. 2010;4(7):95.
11. Manaharan T, Thirugnanasampandan R, Jayakumar R, Kanthimathi MS, Ramya G, Ramnath MG. Purified essential oil from *Ocimum sanctum* Linn. triggers the apoptotic mechanism in human breast cancer cells. Pharmacognosy Magazine. 2016;12(Suppl 3):S327.
12. Salles Trevisan, Maria Teresa, Maria Goretti Vasconcelos Silva, Beate pfundstein, bertold spiegelhalder, robert wyn owen. Characterization of the volatile pattern and antioxidant capacity of essential oils from different species of the genus *Ocimum*. Journal of Agricultural and Food Chemistry. 2006;54(12): 4378-82.
13. Makri Olga, Spiridon Kintzios. *Ocimum* sp. (basil): Botany, cultivation, pharmaceutical properties, and biotechnology. Journal of Herbs, Spices & Medicinal Plants. 2008; 13(3):123-150.
14. Awasthi PK, Dixit SC. Chemical compositions of *Ocimum sanctum* Shyama and *Ocimum sanctum* Rama oils from the plains of Northern India. Journal of essential oil bearing plants. 2007; 10(4):292-6
15. Devi P. Uma, Ganasoundari A. Radioprotective effect of leaf extract of Indian medicinal plant *Ocimum sanctum*. Indian Journal of Experimental Biology. 1995;33(3):205-8.
16. Guenther E. Determination of physical and chemical properties. The Essential Oils. 1960;3:236-262.
17. Patel RP, Kumar RR, Singh R, Singh RR, Rao BR, Singh VR, Gupta P, Lahri R, Lal RK. Study of genetic variability pattern and their possibility of exploitation in Ocimum germplasm. Industrial Crops and Products. 2015;66:119-22
18. Khan A, Ahmad A, Akhtar F, Yousuf S, Xess I, Khan LA, Manzoor N. *Ocimum sanctum* essential oil and its active principles exert their antifungal activity by disrupting ergosterol biosynthesis and membrane integrity. Research in Microbiology. 2010;161(10): 816-23.
19. Laskar S, Majumdar SG. Variation of major constituents of essential oil of the leaves of ocimum-sanctum linn. Journal of the Indian Chemical Society. 1988; 65(4):301-2

20. Kovats ES. Gas chromatographic characterization of organic substances in the retention index system. Adv. Chromatogr. 1965;1:229-47

21. Ntezurubanza L, Scheffer JJ, Svendsen AB. Composition of the essential oil of *Ocimum gratissimum* grown in rwanda1. Planta Medica. 1987;53(05):421-3.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/105437