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Vikram Jambhale
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Vilas Awari
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Adheer Aher
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Kiran Shinde
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Gaurav Pagire
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Corresponding Author:
Gaurav Pagire
Medicinal and Aromatic Plant Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra, India

Assessment of genetic variability in *Ocimum* spp.

Vikram Jambhale, Vilas Awari, Adheer Aher, Kiran Shinde and Gaurav Pagire

Abstract
The investigation on "Assessment of genetic variability in *Ocimum* spp." was conducted on 27 genotypes of *Ocimum* spp. to know the variability, interrelationship among yield and its components, their direct and indirect effects on dry leaves weight and genetic divergence of various *Ocimum* spp. genotypes. Observations were recorded for days to 50 percent flowering, plant height, number of primary branches per plant, number of secondary branches per plant, number of inflorescences per plant, length of inflorescence, number of flowers per inflorescence, plant spread, 1000 seed weight, green leaves weight per plant, dry leaves weight per plant. Green leaves weight per plant exhibited highest range of variability followed by plant height, dry leaves weight per plant, number of secondary branches, number of inflorescences per plant, number of flowers per inflorescence, days to 50 percent flowering. The variability was lowest for 1000 seed weight, length of inflorescence, number of primary branches. Dry leaves weight showed strong significant and positive correlation with green leaves weight, plant spread, number of secondary branches, number of primary branches, plant height, number of inflorescences per plant and number of flowers per inflorescence. Dry leaves weight showed significant negative correlation with days to 50 percent flowering at both genotypic and phenotypic level. Path coefficient analysis revealed that green leaves weight had highest direct effect on dry leaves weight followed by number of primary branches, number of secondary branches, plant height and plant spread. These direct effects are mainly responsible for positive association of these character with dry leaves weight. number of inflorescences, length of inflorescence, and 1000 seed weight had negative direct effect on dry leaves weight. The D^2 statistics showed that there was adequate diversity among the genotypes. Based on D^2 values 27 genotypes studied were grouped into three clusters. Based on inter cluster distance and cluster means the genotypes *viz*., lavang tulsi, ran tulsi, AB-10, sabja tulsi, OS-8, OS-5, Krishna tulsi were identified for their use in hybridization program.

Keywords: *Ocimum* spp., genetic variability and heritability, correlation studies, path coefficient analysis, genetic divergence

Introduction
Since the dawn of civilization, Ocimum is more valuable aromatic medicinal plant. It is a rich source of numerous naturally occurring essential oils and aromatic compounds since it is a polymorphic group of economically important herbs (Khosla *et al*., 2000) [3]. Because of its stimulant, carminative, and antispasmodic qualities, sweet basil is used in folk medicine (Marotti *et al*., 1996) [4]. It has anti-fever and anti-malarial effects as well. As a result, the plant's infusion is used to treat gouty joints, cephalalgia, and bad breath. Basil extracts are also known for their ability to relieve throat, earache, and ringworm irritation. Anticancer, antioxidant, anti-inflammatory, and anti-stress properties are all found in *Ocimum sanctum*. The Tulsi plant can inhibit the growth of pathogenic microbes including bacteria, fungi, and viruses. Sabja is the name of another Ocimum genus species (*Ocimum basilicum*). Basil is a tropical plant native to Central Africa and Southeast Asia. The area under cultivation and average yield of Ocimum in India is low. One of the reasons for less growing and low yield is lack of genotypes suited to a particular region. In Ocimum, the selection is based on herbage yield, oil yield and oil quality along with their component characters which would prove very useful. Evaluation of the genotypes is required across different agro-climatic regions to know their performance in terms of yield and its attributing characters. Based on this, promising genotypes can be selected and employed in breeding programmes. For any heritable improvement, genetic variability is critical. When selecting good genotypes from a germplasm, understanding genetic variability, its nature, and degree is helpful. Wide genetic variability that exists in the available germplasm provides ample scope for further improvement. Keeping this in view, the present investigation was done to know the

variability among different characters in *Ocimum* spp. genotypic correlation coefficient provides a measure of genotypic conjugation between character. While the method of partitioning the correlation in to direct and indirect effects by path coefficient analysis suggested by Wright (1960) [9] provides useful information on the relative trait in the selection criteria. genetic diversity among the parents, which is heritable is a pre-requisite for any successful breeding programme. The proper choice of parent in breeding programme is of paramount importance. Genetic divergence among the parents plays vital role in cultivar improvement because, crosses involving genetically diverse parent is likely to produce high heterotic effect and more variability in segregation generation, which can be exploited for the improvement.

Materials and Methods

The experimental material used for the study of variability which are of 27 genotypes obtained from the Aromatic and Medicinal Project Department of Botany MPKV, Rahuri, MH, India. Following are the genotypes used for study of variability in *Ocimum* spp. by using all standard statistical parameters.

Table 1: List of twenty-seven genotypes of *Ocimum* spp.

Sr. No.	Genotype	Sr. No.	Genotype
1	OS-1	15	OB-3
2	OS-2	16	OB-4
3	OS-3	17	OB-5
4	OS-4	18	OB-6
5	OS-5	19	AB-2
6	OS-6	20	AB-7
7	OS-7	21	AB-8
8	OS-8	22	AB-10
9	Karpoora tulsi	23	AB-6
10	Sabja tulsi	24	AB-1
11	Lavang tulsi	25	Krishna tulsi
12	Ran tulsi	26	Laxmi tulsi
13	OB-1	27	Angana (C)
14	OB-2		

Results and Discussion

The results obtained from the present study entitled "Assessment of genetic variability in *Ocimum* spp.*"* are presented as below

Table 2: Analysis of variance for eleven characters in *Ocimum* spp.

Sr. No.	Character	Replication	Genotypes	Error
	DF	2	26	52
1	Days to 50% Flowering	2.230	775.591**	0.348
2	Plant height (cm)	85.361	644.455**	12.249
3	Number of primary branches per plant	0.487	10.759**	0.134
4	Number of secondary branches per plant	5.222	701.978**	3.137
5	Number of inflorescences per plant	62.131	453.757**	22.225
6	Length of Inflorescence (cm)	0.123	6.018**	0.069
7	Number of flowers per inflorescence	127.635	368.000**	7.824
8	Plant spread (cm)	28.197	173.565**	10.349
9	1000 seed Weight (g)	0.008	1.003**	0.007
10	Green leaves weight per plant (g)	732.033	11030.024**	1274.636
11	Dry leaves weight per plant (g)	7.961	915.391**	102.907

*, ** Significant at 5 % and 1 % probability respectively

Table 3: Mean performance of yield contributing characters in *Ocimum* spp.

Sr. No.	Genotypes	Days to 50% flowering	Plant height (cm)	No. of primary Branches per plant	No. of secondary branches per plant	No of inflorescence per plant	Length of inflorescence (cm)	No of flowers per inflorescence	Plant spread (cm)	1000 Seed Weight (g)	Green Leaves Weight per Plant (g)	Dry Leaves Weight per Plant (g)
1	OS-1	46.46	78.89	15.66	74.13	115.00	9.69	74.26	67.53	1.88	363.89	62.89
2	OS-2	46.53	76.48	14.50	68.20	112.93	8.83	71.53	68.47	1.93	259.73	45.82
3	OS-3	47.06	72.85	16.26	79.16	128.46	8.76	69.86	83.59	1.87	358.32	60.81
4	OS-4	48.40	70.36	14.30	60.23	103.16	8.45	68.93	66.45	1.90	347.69	61.91
5	OS-5	45.86	73.92	15.33	73.10	114.23	9.48	64.60	72.97	1.84	414.81	82.38
6	OS-6	45.66	69.48	16.03	85.03	103.36	7.66	65.26	71.97	1.92	333.96	60.09
7	OS-7	47.13	64.16	17.40	92.56	121.60	7.54	57.13	72.16	1.82	370.88	65.24
8	OS-8	45.26	83.40	16.43	88.56	135.26	9.39	75.33	70.47	1.77	406.30	81.74
9	Karpoora tulsi	47.13	67.84	17.60	96.56	88.13	12.46	90.80	79.50	1.77	371.63	69.34
10	Sabja tulsi	46.13	108.81	17.63	92.26	132.80	11.52	87.36	82.68	3.22	417.62	86.22
11	Lavang tulsi	47.20	129.84	22.30	112.96	138.33	11.22	93.33	89.96	2.00	500.12	109.43
12	Ran tulsi	45.86	106.57	15.26	71.86	130.53	9.40	74.46	88.43	1.98	489.39	108.23
13	OB-1	79.86	87.57	15.73	73.73	109.33	12.19	81.40	78.31	2.76	310.95	54.34
14	OB-2	77.66	85.15	15.16	70.83	102.60	11.60	75.60	70.52	2.86	313.17	52.14
15	OB-3	79.40	94.31	17.16	84.30	112.53	11.12	94.26	74.90	3.49	363.99	69.02
16	OB-4	76.66	86.22	14.10	60.73	112.20	10.88	75.80	65.72	2.94	346.97	66.20
17	OB-5	79.26	86.52	14.06	62.16	110.43	9.87	75.06	63.87	2.92	312.93	52.96
18	OB-6	77.86	94.52	17.86	85.23	135.20	11.40	69.03	71.30	2.89	359.38	62.44

19	AB-2	79.00	75.50	15.66	56.73	120.40	7.31	63.93	64.38	2.90	376.37	67.44
20	AB-7	79.00	72.68	18.20	90.03	115.86	10.39	58.00	77.19	3.09	383.38	67.94
21	AB-8	79.53	80.20	14.33	63.96	108.00	8.46	61.20	65.77	2.89	264.28	55.90
22	AB-10	77.86	85.48	19.63	111.23	120.93	10.79	63.60	82.06	2.83	490.15	106.43
23	AB-6	75.13	75.69	17.60	84.70	98.93	10.22	61.53	76.12	2.89	366.10	68.82
24	AB-1	77.73	79.14	15.43	57.33	105.53	10.42	62.60	67.07	2.83	306.31	54.34
25	Krishna tulsi	46.73	73.87	18.36	95.53	109.43	8.71	60.53	80.82	1.79	399.85	76.66
26	Laxmi tulsi	45.73	70.07	18.33	91.10	118.13	8.93	68.06	79.48	1.65	390.29	73.62
27	Angana (C)	47.33	96.61	16.36	79.56	108.36	10.06	91.33	85.52	2.02	424.10	96.26
	Mean	60.64	83.21	16.54	80.08	115.26	9.88	72.43	74.71	2.39	371.95	71.07
	S.E.	0.34	2.02	0.21	1.02	2.72	0.15	1.61	1.85	0.01	20.61	5.85
	CD.5%	0.96	5.73	0.60	2.91	7.72	0.43	4.58	5.27	0.04	58.49	16.62
	C.V.	0.97	5.20	2.21	2.22	4.09	2.66	4.86	6.30	1.12	9.59	14.27

Table 4: Genetic variability parameters for yield and yield contributing characters in *Ocimum* spp.

Sr. No.	Character	Mean	Range	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	ECV (%)	Heritability	GA	GA as % of mean
1	Days to 50% flowering	60.64	45.26-79.86	258.41	258.75	26.50	26.52	0.97	99.92	32.77	54.03
2	Plant height (cm)	83.21	64.16-129.84	210.73	222.97	17.44	17.94	4.20	94.51	29.06	34.92
3	No. of primary branches per plant	16.54	14.06-22.30	3.54	3.67	11.37	11.57	2.21	96.45	3.77	22.78
4	No. of secondary branches per plant	80.08	56.73-112.96	232.93	236.10	19.05	19.18	2.22	98.65	31.32	39.11
5	No. of inflorescence per plant	115.2	88.13-138.33	143.84	166.06	10.40	12.29	4.09	86.61	22.81	19.79
6	Length of Inflorescence (cm)	9.88	7.31-12.46	1.77	2.46	14.24	14.49	2.66	96.61	2.85	28.84
7	No of flowers Per inflorescence	72.43	57.13-94.26	120.06	127.88	15.12	15.60	3.86	94.03	21.86	30.18
8	Plant spread (cm)	74.71	63.87-89.96	54.40	64.74	9.87	10.76	4.30	84.02	13.91	18.61
9	1000 seed Weight (g)	2.39	1.65-3.49	0.33	0.335	24.09	24.12	1.12	98.50	1.18	49.58
10	Green leaves weight per plant (g)	371.9	259.73-500.12	3251.79	4526.42	15.33	18.08	9.59	71.84	99.55	26.76
11	Dry leaves Weight per plant (g)	71.07	45.82-109.43	270.83	373.73	23.15	27.20	14.27	72.46	28.85	40.59

Table 5: Estimates of genotypic (above diagonal) and phenotype correlation coefficients (below diagonal) among dry leaves weight and yield contributing character in twenty-seven genotypes of *Ocimum* spp.

Name of character	Days to 50% flowering	Plant Height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No of inflorescence per plant	Length of inflorescence (cm)	No of flowers per inflorescence	Plant spread (cm)	1000 Seed Weight (g)	Green Leaves Weight / Plant (g)	Dry Leaves Weight / Plant (g)
Days to 50% flowering	1.000	0.028	-0.150	-0.304**	-0.201	0.326**	-0.167	-0.404**	0.862**	-0.369**	-0.341**
Plant height (cm)	0.027	1.000	0.365**	0.250*	0.571**	0.487**	0.644**	0.498**	0.274*	0.528**	0.600**
No. of primary branches per plant	-0.149	0.358**	1.000	0.913**	0.392**	0.281*	0.173	0.689**	-0.070	0.699**	0.620**
No. of secondary branches per plant	-0.304**	0.246*	0.912**	1.000	0.321**	0.272*	0.196	0.713**	-0.198	0.678**	0.624**
No of inflorescence per Plant	-0.196	0.557**	0.381**	0.314**	1.000	-0.063	0.084	0.342**	-0.031	0.596**	0.542**
Length of Inflorescence (cm)	0.323**	0.482**	0.278*	0.274*	-0.059	1.000	0.613**	0.315**	0.427**	0.135	0.143
No of flowers per Inflorescence	-0.165	0.642**	0.171	0.193	0.086	0.609**	1.000	0.400**	0.061	0.241*	0.293**
Plant spread (cm)	-0.393**	0.483**	0.672**	0.693**	0.328**	0.303**	0.385**	1.000	-0.243**	0.781**	0.785**
1000 seed weight (g)	0.862**	0.270*	-0.069	-0.197	-0.030	0.425**	0.060	-0.237*	1.000	-0.228*	-0.185
Green leaves weight per plant (g)	-0.348**	0.491**	0.659**	0.636**	0.519**	0.131	0.228*	0.727**	-0.214	1.000	0.963**
Dry leaves	-0.323**	0.565**	0.583**	0.585**	0.472**	0.139	0.277*	0.732**	-0.176	0.958**	1.000

weight per plant (g)											

*, ** Significant at 5 % and 1 % probability respectively

Table 6: Estimates of genotypic direct (diagonal) and indirect effects (above and below diagonal) of components characters on dry leaves weight in twenty-seven genotypes of *Ocimum* spp.

Name of character	Days to 50% flowering	Plant Height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No of inflorescence per plant	Length of inflorescence (cm)	No of flowers per inflorescence	Plant spread (cm)	1000 Seed Weight (g)	Green Leaves Weight / Plant (g)	Dry Leaves Weight / Plant (g)
Days to 50%flowering	0.096	0.009	0.054	-0.096	0.036	-0.051	0.009	-0.029	-0.026	-0.344	-0.341**
Plant height (cm)	0.003	0.342	-0.131	0.079	-0.103	-0.077	-0.034	0.036	-0.009	0.492	0.600**
No. of primary Branches per plant	-0.014	0.125	-0.358	0.289	-0.071	-0.042	-0.009	0.050	0.002	0.651	0.620**
No. of secondary Branches per plant	-0.029	0.086	-0.327	0.316	-0.058	-0.043	-0.010	0.052	0.006	0.632	0.624**
No. of inflorescence per plant	-0.019	0.195	-0.140	0.102	-0.181	0.010	-0.004	0.025	0.001	0.555	0.542**
Length of Inflorescence(cm)	0.031	0.167	-0.100	0.086	0.011	-0.156	-0.032	0.023	-0.013	0.126	0.143
No of flowers per Inflorescence	-0.016	0.220	-0.062	0.062	-0.015	-0.096	-0.053	0.029	-0.002	0.225	0.293**
Plant spread (cm)	-0.039	0.170	-0.247	0.226	-0.062	-0.049	-0.021	0.072	0.007	0.727	0.785**
1000 seed weight per plant (g)	0.083	0.094	0.025	-0.063	0.006	-0.067	-0.003	-0.018	-0.030	-0.212	-0.185
Green leaves weight per plant(g)	-0.036	0.180	-0.251	0.215	-0.108	-0.021	-0.013	0.057	0.007	0.932	0.963**

Residual effect = 0.172

Table 7: Distribution of twenty-seven genotypes of *Ocimum* spp. into different clusters.

Clusters	No. of genotype included	Name of genotype
I	14	OS-1, OS-5, OS-2, OS-3, laxmi tulsi, Krishna tulsi, OS- 7, OS-6, OS-8, Angana, Ran tulsi, karpoora tulsi, OS-4, Lavang tulsi.
II	12	OB-4, OB-5, OB-2, OB-1, AB-8, AB-6, OB-6, AB-7, AB-1, AB-2, OB-3, AB-10
III	1	Sabja tulsi

Discussion

Range of Variability

Wide range of variability was found for almost all the character except 1000 seed weight. Green leaves weight per plant showed highest range of variability followed by plant height, dry leaves weight per plant, number of secondary branches, number of inflorescences per plant, number of flowers per inflorescence, days to 50 percent flowering. The variability was lowest for 1000 seed weight, length of inflorescence, number of primary branches.

Genotypic and Phenotypic Coefficient of Variation

Any heritable enhancement in crops plants is based on genetic diversity. The character dry leaves weight, days to 50 percent flowering and 1000 seed weight exhibited highest estimates of genotypic (GCV) and Phenotypic (PCV) coefficient of variation indicating good scope for their improvement through selection. This was in consonance with the results of Gowda *et al*. (2019) [5].

Heritability and Genetic Advance

All the traits in this analysis have a high heritability. High heritability coupled with high genetic advance as percent of mean was observed. Indicating that these traits could be prominently governed by additive gene action and selection of these traits could be more effective for desired genetic improvement. These were in consonance with the result of Khan *et al*. (2012) [2] and Lal (2017) [6] for plant height, green leaves weight, number of inflorescences per plant.

Correlation Studies

In the present investigation dry leaves weight showed strong significant and positive correlation with green leaves weight, plant spread, number of secondary branches, number of primary branches, plant height, number of inflorescences per plant and number of flowers per inflorescence. Dry leaves weight showed significant negative correlation with days to fifty percent flowering at both genotypic and phenotypic level.

Path Coefficient Analysis

Correlation coefficient along with effect provides basis for selection of superior genotypes from the diverse breeding programme. Dry leaves weight is the product of component traits. In the present study, path coefficient analysis revealed that green leaves weight had highest direct effect on dry leaves weight followed by number of primary branches, number of secondary branches plant height and south north

distance. These direct effects are mainly responsible for positive association of these character with dry leaves weight. number of inflorescences, length of inflorescence, and 1000seed weight had negative direct effect on dry leaves weight. Based on findings of the present investigation it could be enforced that the most desirable plant type in *Ocimum* spp. possess green leaves weight, number of secondary branches, number of primary branches, and plant spread. These findings agreed with reports of Pol *et al*. (2003) [7] for number of secondary branches.

Genetic Divergence

Higher heterotic effects are known to be produced by genetically different parents, resulting in desirable recombinants from the breeding material.

Diversity

The estimates of D values ranged from 21.37 to 76.65. this clearly indicates the presence of adequate diversity between genotype studied.

Cluster Formation

The more the genetic variety in the genotypes, the greater the divergence between the 2 clusters. It has also been noted that crosses involving parents with high divergence show a decrease in heterosis (Moll *et al*., 1964) [8]. Therefore, while selecting the parents by considering the genetic diversity and performance and cluster mean for the characters also need due consideration in the crop improvement programme.

In the present investigation twenty-seven genotypes were grouped into three clusters. The cluster I was the largest cluster comprising 14 genotypes, cluster II was 12 genotypes cluster III with one genotype. The highest statistical distance (D= 76.24) was found between the cluster II and III. Followed by the cluster I and II (D=75.18). This indicate that hybridization among the genotypes between these clusters would produce successful hybrid and desirable segregants in further generation. The intra cluster values was highest in cluster II had maximum intra cluster distance (28.05) followed by cluster I (21.37). Indicating that this cluster is more heterogeneous.

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