Variability Studies in French Basil (*Ocimum basilicum* L.)

NS Panwar[1*], VK Dwivedi[2] and SS Malik[1]
[1] *National Bureau of Plant Genetic Resources, New Delhi-110 012, India*
[2] *Janta Vedic College, Baraut, Baghpat-250 611, Uttar Pradesh, India*

Variability studies conducted in 30 *Ocimum* genotypes (20 exotic and 10 indigenous) in two environments during *kharif* (rainy season) 2004 and 2005 revealed highly significant variation for all the characters studied. More fresh herbage yield per plant was recorded in the genotypes namely IC333332, EC338785, EC128730 and EC388788. However, high essential oil yield per plant was extracted from genotypes IC110267 and EC388890. The pooled data analysed at phenotypic level revealed that fresh herbage yield per plant had highest positive direct effect with essential oil yield per plant and maximum direct negative effect in essential oil content. The essential oil yield per plant had the highest direct positive effect at phenotypic level on essential oil content followed by fresh herbage yield per plant whereas maximum negative effect was observed in number of flower-whorls per spike and days to seed maturity. The above genotypes performed well in respect of fresh herbage and essential oil yield per plant which could be considered for incorporation in breeding programme to develop an improved variety coupled with high yield potential to enhance the production and productivity.

Key Words: Variability, Path coefficient, Essential oil yield, Fresh herbage yield, *Ocimum basilicum*, Plant traits

Introduction

French basil (*Ocimum basilicum* L.), an annual aromatic herb, belongs to family Lamiaceae having 160 species of *Ocimum* (Balyan and Pushpangadan, 1988). The genus *Ocimum* is widely distributed and extensively cultivated throughout India (Pushpangadan and Bradu, 1995; Verma *et al.*, 1998 and Pandey and Chowdhary, 2002). The diversity in this genus is observed in the tropical rain forests of Africa with the largest 59 reported species followed by the subtropical regions of Africa (19 species), Arabia and Brazil (11 species each), India, Ethiopia and Madagascar with 9, 8 and 7 species, respectively (Pushpangadan and Bradu, 1995). Its aromatic leaves are used fresh and dried as salad dressing, vegetables, flavouring in sauces, vinegar and confectionary products. The essential oil of basil is used to flavour foods, dental and oral products, in fragrances and in traditional rituals and medicines (Guenther, 1949; Simon *et al.*, 1984). Essential oil contains biologically-active constituents that are insecticidal (Deshpande and Tipnis 1977; Chavan and Nikam, 1982; Chogo and Crank 1981), nematicidal (Chatterjee *et al.*, 1982), fungistatic (Reuveni *et al.*, 1984) and antimicrobial properties (Ntezurubanza *et al.*, 1984).

Basil is propagated through seeds. Research work on variability and association of contributing characters for fresh herbage and essential oil yield in this crop is meagre. Present study was undertaken to estimate the variability present in population and direct and indirect effect of contributing characters on fresh herbage and essential oil yield in indigenous and exotic genotypes of French basil.

Materials and Methods

French basil genotypes (20 exotic, 10 indigenous accessions) were procured from National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India (Table 1). The accessions were grown in a Randomized Block Design (RBD) with three replications at NBPGR Experimental Farm, Issapur, New Delhi, India and Research Farm, Janta Vedic College, Baraut, District Baghpat, Uttar Pradesh, India representing two environments during *Kharif* (rainy season) 2004 and 2005. The nursery was raised during second week of June and 30-day-old seedlings were transplanted. Three rows of each accession having 10 plants per row were transplanted with row to row and plant to plant distance at 45 cm and 30 cm, respectively. Observations were recorded on five randomly selected competitive plants in each genotype for sixteen traits *viz.* number of primary branches per plant, lamina length (cm), lamina width (cm), leaf-stem ratio, days to flower initiation, number of spikes per plant, spike length (cm), number of flower-whorls per spike, plant height (cm), fresh herbage yield per plant (g), dry herbage yield per plant (g), days to seed maturity, seed yield per plant (g), 1000-seed weight (g), essential oil content (%), essential oil yield per plant (ml) at full-bloom stage. The year wise data was pooled for both the years for both the locations separately, statistically

* *Author for correspondence: E-mail: nspanwar2002@yahoo.co.uk*

Table 1. List of French basil genotypes and their places of collection

S. No.	Genotypes	Country/ Area	S.N.	Genotypes	Country/ Area
1.	EC174527	Germany	16.	EC388893	USSR
2.	EC128730	Hungary	17.	EC388891	USSR
3.	EC312264	Poland	18.	EC388896	USSR
4.	EC338785	USA	19.	EC388887	USSR
5.	EC387838	USA	20.	EC388889	USSR
6.	EC338788	USA	21.	IC211313	India
7.	EC338794	USA	22.	IC344638	India
8.	EC338782	USA	23.	IC333332	India
9.	EC338772	USA	24.	IC336833	India
10.	EC344638	USA	25.	IC201236	India
11.	EC338773	USA	26.	IC326735	India
12.	EC338775	USA	27.	IC338959	India
13.	EC338776	USA	28.	IC326711	India
14.	EC388890	USSR	29.	IC326732	India
15.	EC388895	USSR	30.	IC110267	India

IC – Indigenous Collection EC – Exotic Collection

analysed and presented in Table 2 and 3. The differences between genotypes for these characters were tested for significance by using Analysis of Variance (Panse and Sukhatme, 1967). The phenotypic correlation coefficients were partitioned into direct and indirect effects of contributing traits on fresh herbage yield and essential oil yield per plant as suggested by Wright, 1921 and Dewey and Lu (1959) and Pilania *et al.*, (2005).

The herbage was harvested at full-bloom stage and chopped into tiny pieces. The chopped material was hydro-distilled for 3 hours using Clevenger's apparatus for extraction and estimation of essential oil content and yield (Pareek *et al.*, 1982). The essential oil was dried over anhydrous sodium sulphate to remove the moisture.

Results and Discussion

The efficiency of selection largely depends on the magnitude of genetic variability present in the genotype in a plant breeding programme. Genotype EC 338775 was significantly superior over other accessions in respect of number of primary branches per plant followed by EC388788, IC336833, EC387838, IC333332, EC388895, EC338794, EC338772, EC338773 and IC326711 which did not differ significantly among themselves. The accessions EC338785 and EC128730 were statistically at par and significantly superior over other accessions in respect of leaf lamina length. Genotypes EC338775 and EC338776 had significantly more lamina width as compared to other genotypes. The accessions EC 388893 and EC338775 were statistically at par and significantly superior over other accessions in respect to leaf-stem ratio. The genotypes IC326711 was significantly superior over other genotypes. Genotypes namely, IC336833, EC387838 and EC338794 had significantly more number of spikes per plant and did not differ significantly among themselves. The accessions EC338785 and EC388890 were statistically at par and significantly superior over other accessions in respect of spike length. The least spike length as compared to other accessions was recorded in EC338794. Genotype IC338785 showed significantly more number of flower-whorls per spike as compared to rest of the genotypes. The EC338785 was significantly superior over other accessions in respect of plant height. The genotypes IC333332, EC338785, EC128730 and EC387888 yielded significantly more fresh herbage yield. The genotypes *viz*. IC333332, EC338785 and EC128730 yielded significantly more and did not differ significantly among themselves**.** Genotypes EC388887 and IC326711 took significantly more number of days to seed maturity when compared with rest of the genotypes and EC388890, IC338959, EC388788 and EC388893 were significantly at par and took less days to seed maturity as compared to others. The genotype EC388891 and EC 388785 yielded significantly more as compared with other genotypes. The accession IC326711 was significantly superior to other genotypes. The essential oil content was recorded high in IC326732, IC110267, EC388890 and EC388893 which did not differ significantly among themselves. Significantly more essential oil yield were recorded in IC110267 and EC388890 as compared to rest of genotypes.

Fresh Herbage Yield per Plant as Dependent Variable at Phenotypic Level

Results pertaining to direct and indirect effects of fifteen contributing characters on fresh herbage yield per plant at phenotypic level are presented in Table 4. The highest direct positive effect of essential oil yield was recorded with fresh herbage yield followed by dry herbage yield, seed yield, days to seed maturity, lamina width, number of flower-whorls per spike, number of primary branches, plant height and number of spikes. The maximum direct negative effect on fresh herbage yield was observed with essential oil content followed by days to flower initiation, spike length, lamina length, leaf-stem ratio and 1000-seed weight.

Lamina length showed positive correlation with fresh herbage yield and had negative direct effect. The positive correlation was due to indirect positive effect through essential oil yield followed by dry herbage yield and essential oil content. The positive correlation between dry herbage yield and fresh herbage yield was observed and

Table 2. Mean performance of 30 *Ocimum* genotypes for 16 characters in overall pooled data of Issapur and Baraut locations

SN	Genotypes	No. of primary branches per plant	Lamina length (cm)	Lamina width (cm)	Leaf stem ratio	Days to flower initiation	No. of spikes per plant	Spike length (cm)	No. of flower whorls per spike	Plant height (cm)	Fresh herbage yield per plant (g)	Dry herbage yield per plant (g)	Days to seed maturity	Seed yield per plant (g)	1000-seed weight (g)	Essential oil content (%)	Essential oil yield per plant(ml)
1.	IC – 110267	11.33	5.35	2.82	0.86	62.18	55.13	14.41	12.90	46.41	321.76	70.57	157.58	22.01	1.22	0.22	0.71
2.	EC – 338785	10.63	5.89	2.97	1.14	66.82	55.32	23.91	15.28	81.70	344.92	75.71	163.58	43.59	1.64	0.15	0.50
3.	EC – 388890	11.92	5.23	2.68	1.21	60.70	67.67	22.91	14.03	58.65	326.92	70.48	153.58	29.18	1.39	0.22	0.70
4.	EC – 388895	12.18	5.01	2.59	1.13	61.90	69.73	17.08	11.87	57.90	298.92	64.88	155.42	27.24	1.47	0.17	0.50
5.	EC – 388893	11.53	4.83	2.59	1.67	60.85	67.55	15.65	12.65	55.07	238.83	52.84	154.83	34.00	1.32	0.22	0.53
6.	EC – 387838	12.38	5.28	2.90	0.86	61.17	81.27	15.89	12.08	54.28	320.00	70.15	155.00	19.37	1.49	0.14	0.46
7.	EC – 388788	12.45	5.08	2.59	0.84	60.28	77.60	16.09	12.65	56.53	335.00	71.65	153.75	31.67	1.19	0.16	0.53
8.	EC – 338794	12.15	4.73	2.53	1.14	63.02	81.70	10.55	10.85	50.98	330.58	71.42	158.42	28.73	1.47	0.17	0.57
9.	IC – 326735	11.25	5.00	2.54	0.97	62.08	69.53	15.79	12.25	53.45	255.33	55.40	156.83	19.31	1.42	0.18	0.46
10.	IC – 333332	12.23	5.17	2.82	0.83	67.18	75.63	14.49	11.52	50.29	346.25	75.78	163.75	24.64	1.62	0.18	0.62
11.	IC – 336833	12.42	4.99	2.74	0.68	60.57	82.18	13.81	12.07	46.06	287.00	62.54	154.33	12.05	1.27	0.19	0.54
12.	EC – 312264	11.70	4.95	2.72	0.72	63.80	73.87	13.62	12.73	53.28	321.67	70.20	159.58	19.11	1.40	0.17	0.55
13.	EC – 388891	11.62	5.11	2.61	0.99	66.30	69.33	17.66	12.93	58.18	264.92	56.24	163.50	44.65	1.53	0.21	0.56
14.	EC – 388782	11.97	4.88	2.65	0.80	66.47	68.65	14.54	12.50	51.55	313.25	68.42	162.83	29.34	1.47	0.19	0.58
15.	EC-128730	11.48	5.71	2.72	0.82	66.25	69.32	15.51	12.42	56.16	341.25	75.56	158.58	39.45	1.61	0.17	0.59
16.	EC – 338772	12.15	5.00	2.71	1.23	62.80	72.17	14.54	12.53	49.76	297.75	64.63	156.58	14.25	1.25	0.19	0.56
17.	IC – 344638	10.97	5.06	2.69	0.59	63.60	75.02	15.23	12.05	50.38	281.33	60.37	159.17	11.32	1.45	0.18	0.50
18.	EC - 174527	11.47	4.94	2.77	0.86	65.55	79.42	14.40	12.02	50.43	293.17	64.33	156.50	19.67	1.32	0.17	0.49
19.	EC – 387837	11.78	4.47	2.50	1.52	63.92	71.15	12.96	11.83	44.95	275.50	59.96	159.67	10.41	1.38	0.21	0.58
20.	IC – 201233	11.07	4.70	2.74	0.78	62.77	67.57	15.53	11.80	47.71	224.42	49.16	157.58	10.62	1.22	0.17	0.39
21.	EC – 388896	11.30	4.70	2.66	1.07	63.60	67.33	16.69	13.62	51.87	223.58	50.76	157.75	19.68	1.41	0.21	0.47
22.	EC – 338773	12.15	4.44	2.71	0.81	62.63	64.55	20.95	13.12	58.90	304.58	63.95	157.92	19.51	1.52	0.19	0.59
23.	IC – 326711	12.02	5.12	2.87	0.90	72.82	68.58	19.26	13.17	63.14	232.17	50.40	167.08	14.48	1.69	0.21	0.49
24.	EC – 338775	12.98	4.42	3.12	1.67	65.42	79.55	21.49	12.87	57.84	297.75	63.99	156.58	10.82	1.20	0.18	0.54
25.	EC – 338776	11.62	4.55	3.12	1.50	65.22	54.55	22.28	12.30	58.64	258.92	57.58	157.50	11.09	1.62	0.17	0.44
26.	IC – 211313	11.83	4.64	2.61	0.92	66.27	59.00	15.03	12.17	52.38	275.42	61.00	159.75	10.58	1.29	0.16	0.44
27.	IC – 326732	11.77	4.43	2.47	0.62	63.00	67.25	15.87	12.98	46.48	275.75	60.84	157.08	11.16	1.19	0.23	0.63
28.	EC – 388887	11.92	4.91	2.60	0.61	70.38	67.07	11.78	12.05	47.04	296.58	65.68	167.33	10.62	1.31	0.21	0.63
29.	EC – 388889	11.10	4.59	2.59	1.05	64.57	64.62	16.86	12.32	54.83	277.83	60.03	159.75	10.64	1.10	0.16	0.45
30.	IC - 338959	11.38	4.78	2.60	0.85	60.88	69.17	21.43	12.65	59.22	267.92	57.41	153.58	10.78	1.20	0.16	0.44
	Mean	11.76	4.93	2.71	0.99	64.10	69.72	16.54	12.54	54.14	290.98	63.40	158.51	20.67	1.39	0.18	0.53
	Min.	10.63	4.42	2.82	0.59	60.28	54.55	10.55	10.85	44.95	223.58	49.16	153.58	10.41	1.10	0.14	0.39
	Max.	12.98	5.89	2.60	1.67	72.82	82.18	23.91	15.28	81.70	346.25	75.78	167.33	44.65	1.69	0.23	0.71
	SEd.	0.26	0.12	0.06	0.02	0.68	2.12	0.63	0.30	1.36	7.05	1.83	1.22	0.43	0.01	0.01	0.03
	CD at 5%	0.52	0.24	0.12	0.04	1.36	4.24	1.26	0.60	2.72	14.10	3.66	2.44	0.86	0.02	0.02	0.06
	CD at 1%	0.68	0.31	0.16	0.05	1.78	5.55	1.65	0.79	3.56	18.47	4.79	3.20	1.13	0.03	0.03	0.08

Table 3. Analysis of variance (Mean Sum of Squares) for qualitative16 characters of 30 French basil genotypes

Source of variance	d.f.	No. of primary branches per plant	Lamina length (cm)	Lamina width (cm)	Leaf stem ratio	Days to flower initiation	No. of spikes per plant	Spike length (cm)	No. of flower whorls per spike	Plant height (cm)	Fresh herbage yield per plant (g)	Dry herbage yield per plant (g)	Days to seed maturity	Seed yield per plant (g)	1000-seed weight (g)	Essential oil content (%)	Essential oil yield per plant (ml)
Rep.	2	0.629	0.911	0.038	0.011	0.875	21.063	13.621	0.014	3.688	281	58.625	7.5	0.539	0.0004	0.0004	0.0068
Env.	3	34.724**	1.389**	3.579**	0.014**	28.542	3457.500**	78.148**	3.299**	123.333**	589.607**	341.050**	79.333**	511.990**	0.1785**	0.0013	0.2448**
Genotype	29	3.180**	1.481**	0.319**	1.050**	102.098**	673.128**	133.215**	7.961**	593.996**	151.236**	698.395**	164.724**	1308.368**	0.3014**	0.0067**	0.0731**
(En x G)	87	1.363**	0.269**	0.118**	0.014**	18.958**	129.793**	5.472**	1.672**	14.987*	172.810**	86.412**	6.337	8.101**	0.0031**	0.0013**	0.0153**
Error	232	0.406	0.09	0.019	0.002	2.768	27.059	2.36	0.551	11.093	298.279	20.031	8.865	1.092	0.0011	0.0007	0.0058

* Significant at 5% level; ** Significant at 1% level

Table 4. Direct and indirect effect of genetic variability at phenotypic level on fresh herbage yield in French basil

S. No.	Characters	No. of primary branches per plant	Lamina length (cm)	Lamina width (cm)	Leaf stem ratio	Days to flower initiation	No. of spikes per plant	Spike length (cm)	No. of flower whorls per spike	Plant height (cm)	Dry herbage yield per plant (g)	Days to seed maturity	Seed yield per plant (g)	1000-seed weight (g)	Essential oil content (%)	Essential oil yield per plant (ml)	'r' Fresh herbage yield plant plant (g)
1	Number of primary branches per plant	**0.029**	0.004	-0.001	-0.002	0.001	0.003	0.002	-0.006	-0.003	0.037	-0.007	-0.005	0.000	-0.045	0.168	0.175
2	Lamina length (cm)	-0.005	**-0.021**	0.008	0.003	-0.006	-0.001	-0.004	0.006	0.009	0.125	0.006	0.033	0.000	0.103	0.137	0.394
3	Lamina width (cm)	-0.001	-0.005	**0.037**	-0.005	-0.013	0.000	-0.018	0.008	0.010	0.030	0.003	-0.002	0.000	0.179	-0.117	0.105
4	Leaf-stem ratio	0.003	0.004	0.009	**-0.020**	0.006	-0.001	-0.012	0.003	0.006	-0.046	-0.009	0.007	0.000	-0.041	-0.071	-0.164
5	Days to flower Initiation	-0.001	-0.002	0.010	0.002	**-0.050**	-0.002	-0.001	0.001	0.005	-0.008	0.043	0.000	-0.001	-0.063	0.019	-0.048
6	Number of spikes per plant	0.009	0.001	0.001	0.002	0.010	**0.010**	0.013	-0.010	-0.007	0.047	-0.008	-0.003	0.000	0.100	0.007	0.173
7	Spike length (cm)	-0.002	-0.002	0.017	-0.006	-0.002	-0.003	**-0.041**	0.016	0.020	-0.021	-0.006	0.008	0.000	0.078	-0.116	-0.060
8	Number of flower-whorls per spike	-0.006	-0.004	0.010	-0.002	-0.002	-0.003	-0.021	**0.030**	0.014	0.018	-0.001	0.017	0.000	-0.078	0.088	0.059
9	Plant height (cm)	-0.003	-0.007	0.013	-0.005	-0.009	-0.003	-0.030	0.015	**0.028**	0.046	0.006	0.028	-0.001	0.233	-0.150	0.163
11	Dry herbage yield per plant (g)	0.004	-0.009	0.004	0.003	0.001	0.002	0.003	0.002	0.004	**0.292**	0.001	0.024	0.000	0.276	0.350	0.957
12	Days to seed maturity	-0.004	-0.003	0.002	0.003	-0.043	-0.002	0.005	0.000	0.003	0.005	**0.050**	0.005	0.000	-0.036	0.015	-0.001
13	Seed yield per plant (g)	-0.002	-0.011	-0.001	-0.002	0.000	0.000	-0.005	0.008	0.013	0.113	0.004	**0.062**	-0.001	0.037	0.190	0.404
14	1000 seed weight (g)	-0.001	-0.007	0.010	-0.001	-0.022	-0.001	-0.008	0.003	0.012	0.047	0.019	0.028	**-0.001**	0.049	0.025	0.151
15	Essential oil content (%)	0.001	0.002	-0.007	-0.001	-0.003	-0.001	0.003	0.002	-0.007	-0.087	0.002	-0.003	0.000	**-0.924**	0.707	-0.314
16	Essential oil yield per plant (ml)	0.005	-0.003	-0.005	0.001	-0.001	0.000	0.005	0.003	-0.004	0.108	0.001	0.013	0.000	-0.689	**0.948**	0.381

Residual effect (P) = 0.0270

Table 5. Direct and indirect effect of genetic variability at phenotypic level on essential oil yield in French basil

S. No.	Characters	No. of primary branches per plant	Lamina length (cm)	Lamina width (cm)	Leaf stem ratio	Days to flower initiation	No. of spikes per plant	Spike length (cm)	No. of flower whorls per spike	Plant height (cm)	Fresh herbage yield per plant (g)	Dry herbage yield per plant (g)	Days to seed maturity	Seed yield per plant (g)	1000-seed weight (g)	Essential oil content (%)	Essential oil yield per plant (ml)
1	Number of primary branches per plant	**-0.001**	0.000	0.000	0.000	0.000	-0.005	-0.002	0.007	0.003	0.117	0.006	0.005	0.002	0.000	0.047	0.177
2	Lamina length (cm)	0.000	**0.001**	-0.003	0.001	0.003	0.001	0.005	-0.007	-0.011	0.263	0.019	-0.004	-0.013	-0.003	-0.107	0.144
3	Lamina width (cm)	0.000	0.000	**-0.014**	-0.001	0.006	0.000	0.020	-0.009	-0.011	0.070	0.004	-0.002	0.001	-0.002	-0.187	-0.123
4	Leaf-stem ratio	0.000	0.000	-0.003	**-0.003**	-0.003	0.002	0.013	-0.003	-0.007	-0.109	-0.007	0.006	-0.003	0.000	0.043	-0.075
5	Days to flower Initiation	0.000	0.000	-0.004	0.000	**0.024**	0.003	0.001	-0.001	-0.006	-0.032	-0.001	-0.028	0.000	-0.003	0.066	0.020
6	Number of spikes per plant	0.000	0.000	0.000	0.000	-0.005	**-0.018**	-0.014	0.011	0.008	0.115	0.007	0.005	0.001	0.001	-0.104	0.007
7	Spike length (cm)	0.000	0.000	-0.006	-0.001	0.001	0.006	**0.044**	-0.017	-0.024	-0.040	-0.003	0.004	-0.003	-0.001	-0.081	-0.123
8	Number of flower-whorls per spike	0.000	0.000	-0.004	0.000	0.001	0.006	0.023	**-0.033**	-0.016	0.040	0.003	0.000	-0.007	-0.001	0.081	0.093
9	Plant height (cm)	0.000	0.000	-0.005	-0.001	0.004	0.004	0.032	-0.017	**-0.032**	0.109	0.007	-0.004	-0.011	-0.003	-0.243	-0.158
10	Fresh herbage yield per plant (g)	0.000	0.000	-0.001	0.000	-0.001	-0.003	-0.003	-0.002	-0.005	**0.668**	0.042	0.000	-0.010	-0.001	-0.302	0.381
11	Dry herbage yield per plant (g)	0.000	0.000	-0.001	0.000	-0.001	-0.003	-0.003	-0.002	-0.005	0.639	**0.043**	-0.001	-0.010	-0.001	-0.288	0.369
12	Days to seed maturity	0.000	0.000	-0.001	0.001	0.021	0.003	-0.005	0.000	-0.004	0.000	0.001	**-0.033**	-0.002	-0.003	0.037	0.016
13	Seed yield per plant (g)	0.000	0.000	0.001	0.000	0.000	0.001	0.006	-0.009	-0.014	0.270	0.017	-0.002	**-0.025**	-0.003	-0.039	0.201
14	1000 seed weight (g)	0.000	0.000	-0.004	0.000	0.010	0.002	0.009	-0.004	-0.014	0.101	0.007	-0.012	-0.011	**-0.007**	-0.051	0.026
15	Essential oil content (%)	0.000	0.000	0.003	0.000	0.002	0.002	-0.004	-0.003	0.008	-0.210	-0.013	-0.001	0.001	0.000	**0.961**	0.746

Residual effect (P) = 0.019

it also had positive direct effect. This positive correlation was partly due to indirect positive effect of this character via essential oil yield and essential oil content. Seed yield showed positive correlation and direct effect with fresh herbage yield. The positive correlation was due to indirect positive effect of this character via essential oil yield followed by dry herbage yield and essential oil content. Essential oil yield showed positive correlation and direct effect with fresh herbage yield. The positive correlation was partly due to indirect positive effect of this character through dry herbage yield. The residual effect values (0.0270) indicates that the characters studied covered the majority part of variability.

Essential Oil Yield per Plant as Dependent Variable at Phenotypic Level

The path coefficient analysis of essential oil yield per plant as dependent character is presented in Table 5. The results revealed that fresh herbage yield, spike length, dry herbage yield, days to flower initiation and lamina length had the highest direct positive effect on essential oil yield per plant. The maximum direct negative effect was observed for number of flower-whorls per spike, days to seed maturity, plant height, seed yield, number of spikes, lamina width, 1000-seed weight, leaf-stem ratio and number of primary branches.

The correlation and direct effect between fresh herbage yield and essential oil yield was positive. The positive correlation was partly due to indirect positive effect of this character through dry herbage yield. The correlation and direct effect between dry herbage yield and essential oil yield was observed. The positive correlation was partly due to indirect positive effect of this character through fresh herbage yield. The correlation and direct effect between essential oil content and essential oil yield was observed positive. The residual effect values (0.0190) indicates that the characters studied covered the majority part of variability.

Conclusions

It can be concluded from the findings that highly significant variations amongst the various characters existed in different genotypes of French basil under study. The overall pooled analysis of data showed that location had significant effect on all the sixteen characters except essential oil content. The interaction between genotype and environment was also pronounced for all the characters except days to seed maturity. This is apparent that four environments comprised of two cropping seasons at two locations had greatly influenced the variations in different characters and genotypes. Genotypes namely, IC333332, IC110267, EC388890, EC33885, EC128730 and EC387888 performed well in respect of fresh herbage and essential oil yield per plant when compared with other genotypes. These can be considered in any breeding programme. Like-wise the genotype IC128730 was having multiple desirable features like high fresh herbage yield, high dry matter and high 1000-seed weight. This genotype can also be exploited in *Ocimum* breeding programme.

The pooled analysis of both the locations revealed that essential oil yield had the highest positive effect on fresh herbage yield. The maximum direct negative effect was observed for essential oil content. The essential oil content followed by fresh herbage yield had the highest direct positive effect on essential oil yield and maximum direct negative effect was observed for plant height followed by number of flower-whorls per spike.

Acknowledgements

The authors are thankful to the Director, NBPGR, New Delhi, the Head, Plant Exploration and Germplasm Collection, the Head, Germplasm Evaluation and the Principal, Janta Vedic College, Baraut for providing facilities and suggestions from time to time.

References

Balyan SS and P Pushpangadan (1988) A study on the taxonomic status and geographical distribution of genus *Ocimum. PAFAI Journal* **10(2):** 13-19.

Chatterjee A, NC Sukul, S Laskal and S Ghoshmajumdar (1982) Nematicidal principles from two species of Lamiaceae. *J. Nematol*. **14:** 118-120.

Chavan SR and ST Nikam (1982) Mosquito larvicidal activity of *Ocimum basilicum* Linn. *Indian J. Med Res*. **75:** 220-222.

Chogo JB and G Crank (1981) Chemical composition and biological activity of the Tanzanian plant *Ocimum suave*. *J. Nat. Prod* **44(3):** 308-311.

Deshpande RS and HP Tipnis (1977) Insecticidal activity of *Ocimum basilicum* L. *Pesticides* **11:** 11-12.

Dewey OR and KH Lu (1959) A Correlation and Path Coefficient analysis of components crested wheat grass seed production. *Agron. J.* **51:** 515-518.

Guenther E (1949) *In:* The Essential Oils. VIII. Robert E. Krieger Publ. Co. Malabar, Florida. pp 399-433.

Ntezurubanza L, JJC Scheffer, A Looman and Svendsen A Baerhiem (1984) Composition of essential oil of *Ocimum kilimandscharicum* grown in Rwanda. *Planta Medica.* 385-388.

Pandey AK and AR Chowdhary (2002) Essential oil of *Ocimum basilicum* L. from Satura plateau of central India. *Indian Perfumer* **46(2):** 131-134.

Panse VG and PV Sukhatme (1967) Statistical Methods of Agricultural Workers. *ICAR Publication*, New Delhi, pp 152-155.

Pareek SK, ML Maheshwari and R Gupta (1982) Oil content and its composition at different stages of growth in *Ocimum sanctum* Linn. *Indian Perfumer* **26 (2-4):** 86-89.

Pilania DS, SK Pareek, Suneja Poonam and Kumar Ashok (2005) Characterization of French Basil (*Ocimum basilicum* L.) germplam for essential oil yield and quality under stress environment. *Indian Perfumer* **49 (1):** 49-55.

Pushpangadan P and BL Bradu (1995) *In:* Advances in Horticulture Vol. 11 Medicinal and Aromatic Plants (eds): K.L. Chadha and Rajendra Gupta (c) 1995 *Malhotra Publishing House*, New Delhi, India. 627-657.

Reuveni R, A Fleisher and E Putievsky (1984) Fungistatic activity of essential oils from *Ocimum basilicum* chemotypes. *Phytopath. Z.* **110:** 20-22.

Simon JE, LE Craker and A Chadwick (1984) Herbs: an indexed bibliography, 1971-1980. The scientific literature on selected herbs and aromatic & medicinal plants of the temperate zone. Archon Books, Hamden.

Verma PK, SN Gupta, M Khabiruddin and GD Sharma (1998) Genetic variability parameters for herb and oil yield in different *Ocimum* species. *Indian Perfumer* **42 (1):** 36-38.

Wright S (1921) Correlation and causation. *J. Agric. Res.* **20:** 557-585.