IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume 7 | Issue 2 | July, 2012 | 266-270

RESEARCH ARTICLE

Analysis of combining ability in tulsi (*Ocimum sanctum* L.)

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SUMMARY

Combining ability analysis was conducted for yield and its component traits in tulsi (*Ocimum sanctum L.*) Both additive and non-additive gene effects were present. Mean square due to lines, testers and line x tester were also found significant for all the characters. The crosses EC-338785 x IC-381552, EC- 388890 x IC – 381552, EC -388788 x IC – 112607, EC – 312264 x IC – 112607, EC – 388891 x IC – 369153 and EC- 174527 x IC– 369153 were found the best crosses combiners for most of the seed yield fresh and dry herbage yield. Nine lines of tulsi *viz.,* (EC – 338785, EC – 3888895, EC – 388890, EC – 3287838, EC – 388788, EC – 312264, EC – 388891, EC – 112548, EC - 174527)crossed with five tester *viz.,* (IC – 112607, IC – 210757, IC – 381552, IC – 369153, EC - 338773) in line x tester design. The line EC – 388890, EC – 387838, EC – 312264 and EC – 312284 were found as good general combiners for seed yield. Whereas EC – 312264 and EC – 388895 found for number of primary branches. The line EC – 388895, EC – 387838, EC – 388890 and tester IC – 381552, IC – 369153 were found best combiner for early flowering. The line EC – 388895, EC – 312264, EC – 388891 and EC – 174527 and IC – 210757 and IC – 369153 were found best combiners for spike. In respect of number of flowering for line EC – 838785 and tester IC – 112607 were good general combiners for this trait.

Key Words : Combining ability,Tulsi

How to cite this article : Singh, Neetu, Singh, S.K., Kumar, Devendra and Dwivedi, V.K. (2012). Analysis of combining ability in tulsi (*Ocimum sanctum* L.). *Internat. J. Plant Sci.*, **7** (2) : 266-270.

Article chronicle : Received : 08.02.2012; **Revised :** 24.04.2012; **Accepted :** 08.05.2012

Tulsi (*Ocimum sanctum* L) is a widely grown, sacred plant of India. It belongs to the Labiatae family. It is called Holy Basil in English. Basil is the English name of the aromatic plants of genus *Ocimum*.tulsi is a branched fragrant and erect herb ataining a height of about 75 to 90cm at maturity. These are aromatic because of the presence of a kind of scented oil in them. The essential oils of *Ocimum* are mainly the mono-tarpens, sesqitarpens and phenols with their alcohols, esters and aldehydes and other *Ocimum* species are mostly connected with taxonomical, cytogestical, chemical and pharmaceutical evaluations of the *Ocimum* species. The nature and magnitude of various types of gene effects (additive and non-additive) involved in the expression of quantitative traits can be worked out by various biometrical technique available. The material undertaken for the investigation, the line x tester approach for combining ability analysis outlined by Kempthrone (1957) was adopted to ascertain the best combiner parental lines and their specific cross combinations on the basis of gca and sca effects, respectively. Thus, information generated will be utilized as guidelines for the development of hybrids in *Ocimum* (tulsi).

Combining ability is most effective tool for identifying the appropriate parents for hybridization. It is necessary to select the cross combinations with high degree of specific combining ability (SCA) and preferably the parents involved with high general combiners ability (GCA) effects. Therefore, the present investigation was under taken to study the combining ability of parents and cross combinations for yield and its components intulsi.

MATERIALS AND METHODS

Nine diverse genotypes namely EC- 338785, EC – 388895,

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EC- 3688890, EC – 387838, EC – 388788, EC – 312264, EC – 388891, EC – 112548, EC – 174527 crossed with five tester oftulsi *viz.,* (IC – 112607, IC 210757, IC – 381552, IC – 369153, EC – 338773) in line x tester fashion and resulted 45 f_1 hybrids. The 45 f_{1s} along with parents were grown in randomized block design with three replications. Data were recorded for eleven qualitative traits. The experimental trial conducted at Agriculture Research farm of C.C.R. (PG) College Muzaffarnagar, with using common agricultural practices. Five competitive plants were selected to observe the data for eleven characters. The data were subjected to analysis of variance (Panse and Sukhatame, 1967) and combining ability analysis (Kempthrone, 1957).

RESULTS AND DISCUSSION

The analysis showed significant differences among the parents and hybrid for all the traits indicating large genetic diversity among parents and hybrids. A perusal of Table 1 revealed the significant difference due to general and specific combining ability for all the traits under study. This represents that both additive and non-additive gene effects were important for the expansion of these traits. Similar results were also reported by Blank *et al.* (2004).

The lines EC-388895, EC-388890, EC-387838 and testers IC-381552 and EC-338773were found good combiners for days to 50 per cent flowering. EC-338785 X IC-381552 ,EC-338785 X IC-369153 ,EC-388895 X IC-381552 , EC-388895 X EC-338773 ,EC-388890 X EC-338773, EC-387838 X EC-338773,EC-312264 X IC-112607, EC-312264 X IC-381552, EC-388891 X IC-369153,EC-112548 X IC-112607,EC-174527 X IC-112607 had significant negative sca effects .These crosses had the specific combination for earliness.

Non-additive gene action was found to be more important in the expression of plant height as reported by Altinnbas (1998) and Pajic (1985). The lines EC-388890, EC-387838, EC-312264, IC-112607 and EC-338773 were the best combiner for the plant height and also reflected high mean performance for this trait. The crosses *viz.,* EC-338785 X IC-112607, EC-338785 X EC-338773, EC-388895 X IC 210757, EC-388890 X IC-381552, EC-387838 X IC-369153, EC-312264 X IC-210757,EC-112548 X IC-381552, and EC-174542 X EC-338773 exhibited high positive sca effects for plant height.These crosses indicated the importance of non additive gene action .The lines EC-388895, EC-312264 ,and EC- 338773 had positive significant gca effects for number of primary branches per plant . The crosses EC-338785 X IC-369153, EC-388895 X IC-369153 , EC-388890 X IC-210757, EC-388788 X IC-381552, EC-312264 X IC-381552, EC-38890 X IC-210757 and EC-388891 X EC-338773 had good specific combining ability. These crosses showed non-additive nature of gene action (Table 3).

Number of spike per plant indicated the importance of non additive gene action in the inheritance of this trait the result of non additive nature of gene action with those of Pajic(1985).The line EC-388895,EC-312264,EC-388891 and EC-174527, IC-210757 had positive significant gca were found to be good combiner for more number and these line may be used to improve more number of spike .For the trait spike length had EC-312264, EC-388891, EC-112548, IC-381552, IC-210757 and IC-369153. The crosses EC-388890 X IC-210757, EC-388890 X IC-112607 ,EC-387838 X IC-112607, EC-388788 X IC-381552 ,EC-312264 X IC-210757, EC-388891 X IC-369153 and EC-112548 X EC-338773 had higher sca and showing non-additive gene effects.

In respect of number of flowering the line EC-838785

Table 1 : Analysis of variance (ANOVA) for different characters of *Ocimum sanctum* L.

Characters	Mean square due to		
	Replication	Treatment	Error
No. of primary branches	11.57	8.82**	1.89
Days of 50% flower	25.66	30.20**	0.62
Spike per plant	3.04	33.40**	1.09
Spike length (cm)	5.16	25.86**	0.25
No. of flowers whorls per spike	8.24	29.01**	1.19
Plant height (cm)	53.34	150.55**	1.98
Fresh herbage yield (g)	11.00	3378.88**	44.45
Dry herbage yield (g)	0.78	220.76**	0.69
Seed yield per plant (g)	8.29	33.60**	2.49
1000-seed weight (mg)	0.029	0.190**	0.026

* and** indicate significance of values at P=0.05 and 0.01, respectively

and tester IC-112607 were good general combiner for fresh and dry herbage yield,the good general combiner were EC-388895, EC-388890, EC-387838 and IC-210757 and EC-338773.

Some of the best cross combination for number of flower per plant were EC-388890 X IC-381552, EC-387838 X IC-112607, EC-388788 X EC-338773, EC-312264 X EC-338773,EC-112548 X EC-338773 and EC-174527 X IC-210757. It is interested to note that parental line EC-388890,EC-388788,EC-312264,EC-112548 having negative gca value but in combination with IC-210757,IC-381552 and EC-338773 showed positive sca effects. In case of fresh and dry herbage EC-338785 X IC-381552, EC-388895 X IC-369153, EC-388890 X IC-381552 , EC-388788 X IC-112607, EC-312264 X IC-112607, EC-388891 X IC-369153 and EC-112548 X IC-369153 had significant and positive sca effects and were considered as good specific combiners. But in case of seed yield per plant EC-338785 X IC-381552, EC-388890 X IC-381552, EC-388788 X IC-112607, EC-312264 X IC-112607,EC-388891 X IC-369153 and EC-174527 X IC-369153 had the positive and high sca effects and identified as good combiner while EC-174527 , IC-112607 and IC-369153 had highly significant gca effects. For the 1000 seed weight, the crosses EC-388895 X EC-338773, EC-387838 X IC-112607, EC-388890 X IC-112607, EC-112548 X IC-210757, and EC-112548 X EC-338773 had positive and significant sca values.

EC- 388890 was the best general combiner for the traits *viz.,* no. of primary branches, days of 50 per cent flowering, no.of spikes per plant, plant height, fresh herbage yield and seed yield.

It is important to mention here that the parents which showed good GCA effects for yield per plant also indicated significantly positive GCA effects for dry herbage yield, fresh herbage yield, plant height, days to 50 per cent flower and number of primary branches (Table 2).

On the basis of significantly desirable SCA effects, out of 45 crosses, 9 for yield, 6 for dry herbage yield, 13 for fresh herbage yield, 7 for plant height, 11 for number of flowers whorls per spike, 9 for spike length, 7 for spike per plant, 5 for days to 50 per cent flowers were found to be desirable specific cross combination.

Table 2 : Estimate of GCA effects for yield and its components traits in *Ocimum sanctum* L.

Sr. No.	Genotypes	No. of primary branches	Days to 50% flower	Spike per plant	Spike length (cm)	No. of flowers whorls per spike	Plant height (cm)	Fresh herbage yield (g)	Dry herbage yield (g)	Seed yield per plant (g)	1000-seed weight mg)
	Female parent (lines)										
1.	EC-838785	0.51	-0.24	-0.20	-0.64**	2.02**	-5.96**	-6.44*	0.43	-0.41	0.04
2.	EC-388895	0.58**	-0.64**	0.60**	-0.53**	0.51	-2.56**	6.710**	1.25**	0.19	-0.16**
3.	EC-388890	-0.22	-1.58**	-1.76**	-0.58**	-0.19	5.44**	14.44**	3.39**	1.25**	0.03
4.	EC-387838	-1.02	-1.64**	-1.71**	-0.38**	0.21	3.30**	7.90**	2.03**	1.05**	-0.01
5.	EC-388788	-0.36	0.02	-0.50**	0.03	-0.30	6.17**	-1.50	-0.46	0.19	0.08*
6.	EC-312264	0.71**	0.96**	0.82**	1.23**	-2.57**	3.17**	-0.56	-0.17	0.72*	0.03
7.	EC-388891	-0.56	-0.11	0.81**	0.48**	0.19	0.97**	-14.83**	-2.96**	-0.55	0.05
8.	EC-112548	0.11	0.96**	0.35*	0.25**	-0.37	-4.63**	-13.83**	-2.58**	-1.75**	-0.17**
9.	EC-174527	0.24	2.29**	0.60**	0.16	0.49	-5.90**	-4.76*	-0.93*	-0.68**	0.11**
	SE±	0.29	0.18	0.16	0.11	0.25	0.28	1.27	0.17	0.31	0.03
	Male parent (tester)										
1.	IC-112607	-0.58*	1.44**	-1.71**	-1.80**	1.68**	2.91**	-2.21**	-3.71**	-0.87**	0.00
2.	IC-210757	-0.61*	-0.23	2.21**	0.57**	0.36	0.02	24.24**	4.76**	1.09**	0.13**
3.	IC-381552	0.09	-1.04**	0.10	1.65**	0.00	-4.46**	-7.43**	-0.58	-0.21	-0.09*
4.	IC-369153	-0.21	-1.86**	1.40**	0.42**	-2.16**	-2.35**	-17.91**	-3.91**	-1.13**	-0.13**
5.	EC-338773	1.31**	1.70**	-2.10**	-0.84**	0.11	3.87**	10.31**	3.43**	1.12**	0.09**
	SE±	0.21	0.12	0.22	0.08	0.18	0.20	0.90	0.12	0.22	0.02

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3: Estimate of SCA effect for yield and its component of *Ocimum sanctum* L.

Sr. No.	Crosses	No. of primary branches	Days to 50% flower	Spike per plant	Spike length (cm)	No. of flowers whorls per spike	Plant height (cm)	Fresh herbage yield (g)	Dry herbage yield (g)	Seed yield per plant (g)	1000-seed weight (mg)
1.	EC-338785 x IC-112607	1.04	3.76**	3.89**	-0.27	0.31	7.89**	-10.99**	-3.25**	-1.99**	-0.24*
2.	EC-338785 x IC-210757	-0.92	-0.57	-6.43**	-0.87**	-1.10*	-7.22**	-41.10**	-11.45**	-4.29**	-0.04
3.	EC-338785 x IC-381552	-0.96	-2.76**	6.68**	-2.33**	0.86	-2.07**	55.56**	15.28**	6.34**	0.08
4.	EC-338785 x IC-369153	1.34**	-1.94**	-2.61**	2.04**	1.65**	-1.85**	-6.62*	-4.19**	-1.73*	0.12
5.	EC-338785 x EC-338773	-0.51	1.5**	-1.54**	1.43**	-1.72**	3.26**	3.16	3.61**	1.68*	0.07
6.	EC-388895 x IC-112607	-0.02	3.16**	4.76**	1.62**	2.46**	2.49**	-30.59**	-9.13**	-2.26**	-0.07
7.	EC-388895 x IC-210757	0.35	-2.5**	-3.56**	-0.15	1.91**	-4.62**	-15.37**	-4.53**	-1.22*	0.03
8.	EC-388895 x IC-381552	-1.69**	-1.69**	4.22**	-2.87**	1.10*	3.86**	20.63**	5.84**	1.07	-0.15
9.	EC-388895 x IC-369153	1.94**	3.13**	-3.41**	0.46	-4.10**	-2.25	0.44	0.13	0.00	0.02
10.	EC-388895 x EC-338773	-0.58	-2.10**	-2.00*	0.95**	-1.37*	0.53**	24.89**	7.69**	2.41**	0.17*
11.	EC-388890 x IC-112607	0.11	3.10**	2.65**	4.17**	2.05**	-3.51**	-20.66**	-2.84**	-1.66**	0.11
12.	EC-388890 x IC-210757	3.81**	-0.90	-0.53	3.27**	-0.06	-6.29**	-1.10	0.33	0.38	-0.16*
13.	EC-388890 x IC-381552	-0.56	-0.09	-2.76**	-3.19**	5.73**	3.53**	32.56**	7.43**	3.34**	-0.04
14.	EC-388890 x IC-369153	-293**	1.06**	-1.72**	-4.82**	-1.44*	5.08*	-35.96**	-9.17**	-4.07**	-0.03
15.	EC-388890 x EC-338773	-0.44	-3.16**	2.36**	0.57*	-6.28**	1.19**	25.16**	4.25**	2.01**	0.12
16.	EC-387838 x IC-112607	0.58	2.16	1.33*	4.40**	3.05**	2.62**	20.21**	5.18**	1.87**	0.34**
17.	EC-387838 x IC-210757	-1.72**	-0.84	2.08**	-1.90**	0.57	7.84**	5.43*	1.02	-0.09	-0.02
18.	EC-387838 x IC-381552	0.58	0.98	-3.81**	1.58**	-2.27**	-3.67**	11.76**	2.92**	1.87**	-0.14
19.	EC-387838 x IC-369153	-0.13	-0.54	1.23*	-0.08	2.22**	5.88**	-50.76**	-1279**	-5.20**	-0.16*
20.	EC-387838 x EC-338773	0.69	-1.76**	-0.83	-4.00**	-3.58**	-12.67**	13.36**	3.67**	1.54*	-0.02
21.	EC-388788 x IC-112607	0.24	-0.5	-1.54**	-0.81**	0.73	-1.58*	43.94**	13.84**	5.41**	-0.11
22.	EC-388788 x IC-210757	-1.05	0.16	0.54	1.15**	-2.18**	3.64**	21.83**	5.11**	2.44**	-0.11
23.	EC-388788 x IC-381552	1.58**	0.64*	-3.02**	3.37**	0.14	-3.87**	-1417**	-5.32**	-1.93*	0.11
24.	EC-388788 x IC-369153	-1.46*	1.79**	2.69**	-1.40**	-1.43**	-0.32	-17.69**	-4.73**	-2.67**	0.18*
25.	EC-388788 x EC-338773	0.69	-2.1**	1.33*	-2.31**	2.74**	2.13**	-33.91**	-8.90**	-3.26**	-0.07
26.	EC-312264 x IC-112607	-2.82**	-2.44**	-4.53**	-4.11**	1.80**	0.42	67.67**	14.78**	4.54**	0.01
27.	EC-312264 x IC-210757	-0.12	-0.44	4.22**	3.19**	-2.01**	3.98**	2.56	2.48	0.91	-0.42**
28.	EC-312264 x IC-381552	2.51**	-1.29**	-2.00**	-1.07**	-2.75**	-2.54**	-25.77**	-5.45**	-2.13**	0.19*
29.	EC-312264 x IC-369153	0.47	-0.47	3.37**	0.20	-0.82	1.01	-40.29**	-10.45**	-2.53**	0.20*
30.	EC-312264 x EC-338773	-0.04	4.64**	-1.06*	1.79**	3.78**	-2.87**	-4.18	-1.36	-0.79	0.02
31.	EC-388891 x IC-112607	0.78	-4.04**	-2.85**	-3.56**	-0.86	0.29	-56.39**	-14.36**	-4.19**	0.22**
32.	EC-388891 x IC-210757	0.15	2.63**	1.23**	-1.13**	0.49	0.18	8.16*	1.68	1.18	0.15*
33.	EC-388891 x IC-381552	-1.89**	1.44**	0.34	0.29	-2.12**	-0.01	-19.50**	-6.66**	-3.19**	0.03
34.	EC-388891 x IC-369153	-0.59	-2.41**	1.37**	3.82**	0.34	-1.45**	44.31**	12.01**	3.74**	0.04
35.	EC-388891 x EC-338773	1.56**	2.37**	-0.08	0.58*	2.14**	0.99	23.42**	7.33**	2.45**	-0.44**
36.	EC-112548 x IC-112607	0.11	-1.44**	-2.73**	-1.46**	-3.77**	-6.78**	-7.46**	-0.74	-0.33	-0.49**

Table 3 : Conted……

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37.	EC-112548 x IC-210757	-0.52	2.56**	-0.31	-1.70**	0.02	2.78**	16.43**	-0.67	-1.96**	0.51**
38.	EC-112528 x IC-381552	-0.22	1.04*	-0.54	1.25**	-1.86	3.26**	-26.24**	-8.10**	-3.33**	-0.21*
39.	EC-112548 x IC-369153	0.41	-0.81**	3.83**	-1.38**	1.04**	-0.19	37.58**	18.13**	7.93*	-0.06
40.	EC-112548 x EC-338773	0.22	1.36**	-0.26	3.30**	4.57**	0.93	-20.31**	-8.61**	-2.32*	0.25*
41.	EC-174527 x IC-112607	-0.02	-3.77**	-0.98	0.03	-5.76**	-1.84**	-10.99**	-3.49**	-1.39**	0.22*
42.	EC-174527 x IC-210757	0.01	-0.10	2.77**	-1.84**	2.36**	-0.29	-41.10**	6.04**	2.64**	0.06
43.	EC-174527 x IC-381552	0.64	1.71**	0.88	2.97**	1.15**	1.53**	55.56**	-5.92**	-2.06**	0.14
44.	EC-174527 x IC-369153	0.94	0.19	-4.75**	1.14**	2.54*	-5.92**	-6.62*	11.07**	4.53**	-0.32**
45.	EC-174527 x EC-338773	-1.58**	1.97**	2.09**	-2.30**	-0.29	6.53**	3.16	-7.70**	-3.72**	-0.10
	SE±	0.59	0.35	0.45	0.21	0.51	0.56	2.55	1.35	0.61	0.07

*and ** Indicate significance of value at P =0.05 and 0.01, respectively

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