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COMBINING ABILITY STUDIES IN LINSEED

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ABSTRACT

A field experiment was conducted at Latur (M.S.) during rabi season of 2013-14 to study the general and specific combining ability in linseed (Linum usitatissimum L.) through L x T analysis with five lines and five testers including ten traits viz; days to first flowering, days to 50% flowering, days to maturity, plant height, branches /plant, capsules /plant, seed /capsule, 1000 seed weight, oil content and seed yield. Based on the general combining ability effects of parents OL-98-13-1 was a good general combiner for seed yield, days to first flowering, and days to 50% flowering. RLC-133 was found to be good general combiner for days to first flowering, days to 50% flowering, plant height, seed per capsules. Among males, SHARDA was good general combiner for seed yield and T-397 also had significant GCA effects for 3 characters viz. days to first flowering, 1000 seed weight and oil content. The cross combinations of OL-98-13-01 x LMS-210-01-27, RL-292-02 x T-397, NL-97 x SHARDA, SLS-89 x SHARDA and OL-98-13-01 x SHARDA, exhibited positive and significant SCA effects hence recommended for yield improvement.

Key words: General combining ability, specific combining ability, linseed, line x tester

INTRODUCTION

Linseed, (*Linum usitatissimum* L. (n=15), also called flax is an important oilseed crop grown for both seeds and fibers, belongs to the family Linaceae having 14 genera and over 200 species. It is cool season crop and requires moderate to cool temperature during the growing season.The choice of suitable parents for evolving better varieties/hybrids is a matter of concern to the plant breeders. For these purpose, the combining ability is a powerful tool to discriminate good as well as poor combiners for choosing appropriate parental materials for a particular character in the plant breeding programme. At the same time, it also provides information about the nature of gene action involved in the inheritance of grain yield and its component characters. In a systematic breeding programme, selection of parents with desirable characteristics having good general combining ability effects for grain yield and its components and high estimates of specific combining ability effects are essential. These estimates will help in formulating sound, efficient and effective breeding procedure to bring about rapid and purposeful improvement in this crop. Most of these papers reveal significant effects of both general combining ability (GCA) and specific combining ability (SCA) but with a prevalence (greater or smaller, depending on the trait) of GCA effects. Many researchers studied the combining ability in linseed (El – Kady and Abo – kaied 2010). The present study was undertaken to identify good combiners from selected genotypes and to estimate the general and specific combining ability effects in linseed (*Linum usitatissimum* l.).

MATERIALS AND METHODS

The field experiment was conducted at the Experimental farm, Oilseeds Research Station Latur during *Rabi*-2013-14. The material consisting of five line and five testers crossed in a line X testers mating design resulting in twenty five hybrids with two standard checks *viz;* RLC-4 and NL-260. Twenty five hybrids and their ten parents were sown in rows with spacing 30 cm between row and 15 cm between plants in row during October- 2013. The experiment was laidout in randomized block design with two replications. A fertilizer schedule of 25 kg N + 50 kg P_2O_5 ha^{-1} was followed along with the recommended cultural operations and plant protection measures. Observations were recorded on days to first flowering, days to 50 % flowering, days to maturity, plant height branches /plant, number of capsule/plant, number of seed/capsule, 1000 seed weight, oil content and seed yield /plant. The analysis of variance for combining ability was done by the method developed by Kempthorne (1957) on five randomly selected plants.

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RESULT AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed the presence of significant differences due to lines, testers and lines x testers for most of the characters studied indicating the existence of variability among parents and hybrids. The testers contributed a major share of variance for all the characters. The estimates of GCA and SCA variances are useful to infer the type of gene action and the relative importance of the character in breeding programme. The estimates of components of variance for GCA were larger in magnitude than sca for all the characters indicating predominance of additive gene action (Sarvanan *et al.*, 2000 and Rauf *et al.* 2005).

Table 1: Analysis of variance for combining ability for different characters including parents in Linseed

Source	d.f.	Days to first flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches / plant	Capsule / plant	Seeds / Capsule	1000 Seed weight (g)	Oil content (%)	Seed yield/ plant (g)
Replications	1	1.157	1.428	3.214	41.657	0.057	4.628	0.700	0.009	0.010	0.000
Crosses	24	9.111**	3.586*	14.663**	59.570**	0.430	97.208**	1.620**	0.692**	0.826**	1.734**
Lines	4	6.650**	16.600**	1.850	44.350*	1.650**	409.150**	0.750	0.2965*	1.278**	1.242**
Testers	4	15.850**	8.900**	1.000	62.650**	0.400	111.000*	0.500	2.248**	0.556**	1.217**
Line x Tesrer	34	6.657**	3.095*	14.855**	29.007*	0.480	120.362**	2.070**	0.653**	1.078**	1.513**
Error	34	1.245	1.516	3.243	13.127	0.263	31.363	0.5823	0.1251	0.066	0.079

The estimates of gca effects of lines and testers are presented in Table 2. Among the lines, OL-98-13-01, NL-97 and RL-292-02 were found to be the best general combiner for seed yield. The lines OL-98-13-01 had significant GCA effects for the characters namely days to first flowering, days to 50% flowering and plant height Hence, they were considered as good general combiners for exploiting early maturity along with short strature. The line, NL-97 had significant GCA effects for the characters *viz.*, plant height and days to first flowering. While, RLC-133 was best general combiner for days to 50 per cent flowering, days to first flowering, plant height. Likewise, the line RL-292-02 was the general combiner for number of capsule per plant. Among testers Sharda was found to be best general combiner for seed yield and T-397 also had significant GCA effects for 3 characters *viz.* days to first flowering, 1000 seed weight and oil content. Similar results were followed by Goral *et al.* (2006) and Singh *et al.* (2008).

Table 2: Estimates of general combining ability (GCA) of lines and testers in linseed

Parents	Days to first flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches /plant	Capsule /plant	Seeds/ capsule	1000-Seed weight (g)	Oil content (%)	Seed yield/ plant (g)
Lines										
OL-98-13-1	1.080**	0.880*	-1.340*	-4.180**	0.240	2.200	0.280	-0.018	0.110	0.588**
NL-97	0.980*	0.580	0.460	4.920**	-0.060	1.000	0.080	-0.299	0.150	0.233*
RLC-133	-1.520**	-1.020*	1.060	3.420**	-0.060	0.200	-0.520*	-0.187	-0.112	-0.147
RL-292-02	0.180	-0.620	-0.540	1.720	-0.260	-3.700*	-0.020	0.223	-0.017	0.202*
SLS-89	-0.720	0.180	0.360	-5.880**	0.140	0.300	0.180	0.283*	-0.130	-0.877**
S.E.(Gi)	0.3529	0.389	0.569	1.145	0.162	1.771	0.241	0.111	0.081	0.089
S.E.(Gi-Gj)	0.499	0.550	0.808	1.620	0.229	2.504	0.341	0.158	0.115	0.126
CD (P=0.05)	0.728	0.803	1.175	2.364	0.334	3.655	0.498	0.230	0.168	0.184
CD (P=0.01)	0.987	1.089	1.593	3.204	0.453	4.953	0.675	0.312	0.228	0.250
Testers										
T-397	0.780*	- 0.120	0.460	1.920	0.040	3.400	-0.220	0.233*	-0.252**	0.091
JLC-9	1.480**	-0.220	-0.140	0.320	-0.160	-1.700	0.080	0.405**	0.345***	-0.314**
LMS-210-01-27	-0.120	-0.620	1.260*	-1.080	-0.160	-2.400	-0.220	-0.141	-0.100	-0.274**
GS-61	-0.320	0.780	0.760	-0.480	0.040	0.900	0.080	-0.231	-0.030	-0.072
SHARDA	-1.820	0.180	-2.340	-0.680	0.240	-0.200	0.280	-0.264	0.038	0.568**
S.E.(Gi)	0.352	0.389	0.569	1.145	0.162	1.771	0.241	0.111	0.081	0.089
S.E.(Gi-Gj)	0.499	0.553	0.808	1.620	0.229	2.504	0.341	0.158	0.115	0.126
CD (P=0.05)	0.728	0.803	1.175	2.364	0.334	3.655	0.498	0.230	0.168	0.184
CD (P=0.01)	0.987	1.089	1.593	3.204	0.453	4.953	0.675	0.312	0.228	0.250

**and ** indicated significance at 5 and 1 per cent level respectively*

Perusal of specific combining ability data (Table 3) indicated that 3 crosses *viz*., RLC 292-02 x GS-61, RL 292-02 x T-397 and RL-292-02 x JLC-9 recorded significant negative sca effects for days to 50% flowering. The hybrid OL-98-13-01 x Sharda depicted highest significant desirable sca effect for days to maturity followed by RL-292-02. Hence, they were considered as good cross combinations for exploiting early maturity. The estimates of sca effects revealed that 4 out of 25 crosses exhibited significant negative sca effects for plant height.

Table 3: Estimates of specific combining ability (SCA) for 10 characters in Linseed

Crosses	Days to first flowering	Days to 50 % flowering	Days to maturity	Plant height (cm)	Branches /plant	Capsule/ plant	Seed/ capsule	1000 seed weight (g)	Oil content (%)	Seed yield/ plant (g)
OL-98-13-01 X T-397	0.720	0.020	0.340	-0.820	0.160	6.100	-0.380	0.010	0.217	-0.438*
OL-98-13-01 X JLC-9	0.520	0.620	2.440	-1.720	-0.140	-3.300	-1.180*	0.078	-0.455*	0.222
OL-98-13-01 XLMS-210-127	0.120	-0.480	3.040*	3.180	0.360	1.400	1.620**	0.934**	0.690**	0.592**
OL-98-13-01 X GS-61	-0.680	1.120	0.040	-0.420	0.160	-2.900	-0.180	-0.336	-0.750**	0.120
OL-98-13-01XSHARDA	-0.680	-1.280	-5.860**	-0.220	-0.140	-1.300	0.120	-0.688*	0.252	-0.495*
NL-97 X T-397	-1.180	0.820	0.540	1.080	-0.040	2.800	-0.180	0.211	-0.123	0.237
NL-97 X JLC-9	-0.380	-0.580	-1.860	-2.820	-0.340	2.400	-0.480	0.269	0.230	0.522*
NL-97X LMS- 210-01-27	0.720	0.820	-2.260	5.580 *	-0.340	-0.900	-0.680	-0.515	-0.050	0.347
NL-97 X GS-61	1.920 *	-0.580	-0.760	1.480	0.460	-1.700	-0.480	-0.525*	0.580**	-1.075**
NL-97 X SHARDA	-1.080	-0.480	4.340 **	-5.320 *	0.260	-2.600	1.820**	0.558	-0.638**	-0.030
RLC-133 X T-397	2.320**	-0.080	-1.060	-3.920	0.460	3.100	0.420	-0.331	-0.986**	0.597**
RLC-133 X JLC-9	2.120*	0.520	-0.460	2.680	0.160	-0.300	-0.380	0.287	0.617**	-0.768**
RLC-133 X LMS-210-01-27	-1.780*	1.420	-0.860	-2.420	0.160	-1.100	-0.080	0.713**	-0.638**	0.902**
RLC-133 X GS-61	-2.580**	-0.980	-0.860	1.480	-0.540	7.600	0.620	-0.147	1.042**	-0.750**
RLC-133 X SHARDA	-0.080	-0.880	3.240 *	2.180	-0.240	-9.300 *	-0.580	-0.524*	-0.036	0.020
RL-292-02 X T-397	-2.380 **	-1.480	1.040	-2.220	0.160	-2.000	0.920	0.139	-0.241	0.498*
RL-292-02 X JLC-9	-2.580 **	0.120	0.640	2.380	0.360	9.600 *	0.620	-0.503	0.622**	0.678**
RL-292-02 X LMS-210-127	1.020	0.520	1.740	-5.220	-0.140	0.800	-0.080	-0.657*	0.317	-0.832**
RL-292-02 X GS-61	2.720 **	0.620	0.240	-0.320	0.160	-1.500	-0.880	0.753**	-0.678**	0.161
RL-292-02 X SHARDA	1.220	0.220	-3.660 **	5.380	-0.540	-6.900	-0.580	0.266	-0.021	-0.504*
SLS-89 X T-397	0.520	0.720	-0.860	5.880 *	-0.740	-10.000 *	-0.780	-0.031	1.132**	-0.893**
SLS-89 X JLC-9	0.320	-0.680	-0.760	-0.520	-0.040	-8.400 *	1.420 *	-0.133	-1.015	-0.653**
SLS-89 XLMS-210-01-27	-0.080	-2.280 *	-1.660	-1.120	-0.040	-0.200	-0.780	-0.477	-0.320	-1.008**
SLS-89 X GS-61	-1.380	-0.180	1.340	-2.220	-0.240	-1.500	0.920	0.253	-0.240	1.545**
SLS-89 X SHARDA	0.620	2.420 *	1.940	-2.020	1.060 **	20.100 **	-0.780	0.386	0.442*	1.010**

** and ** indicated the significance at 5 and 1 per cent respectively*

The highest negative sca effect in case of the character plant height was manifested by Rl-292-2 x sharda followed by NL-97 x Sharda, RL-292-02 x LMS- 210-127 and SLS- 89 x JLC-9. From the total of 25 hybrids, only one hybrid (SLS-89 x Sharda) exhibited significant positive sca effects for branches per plant hence, this hybrid was best specific combiners for the trait branches per plant. The estimates of sca effects revealed that, two hybrids showed significant positive sca effects for number of casules *viz*., SLS-89 x Sharda and RL-292-02 x JLC-9. The estimates of sca effects varied from 1.180 (OL-98-13-01 X JLC-9) to 1.820 (NL-97 X Sharda). Among the hybrids tested, 3 hybrids *viz*., NL-97 x Sharda, OL-98-13-01 x LMS-210-127 and

Table 4: Information on best 5 crosses based on *per se* performance in Linseed

Cross	*Per se* performance Seed yield/ plant (g/pl.)	Heterosis				GCA effects		SCA effects	Significant heterosis in desired direction for other traits	Significant SCA in desired direction for other traits
		M.P (%)	B.P (%)	SC-1 NL-97 (%)	SC-2 RLC-4 (%)	Parent I (Female)	Parent II (Male)			
OL-98-13-01 X LMS-210-01-27	4.84	69.06**	48.54**	197.54**	85.96**	0.588**	-0.274**	0.592**	Days to first flowers, Days to 50% flowers, days to maturity, Seed yield / plant.	Days to maturity, Seed yield / plant No. of seed/ capsule, 1000 Seed weight, Seed yield / plant.
RL-292-02 X T-397	4.72	268.3**	260.31**	190.46**	81.54**	0.202*	0.091	0.498*	Days to first flowers, No. of capsule/ plant, 1000 Seed weight, Seed yield /plant.	Days to first flowers, Seed yield / plant.
NL-97 X SHARDA	4.70	116.34**	79.73**	189.23**	80.77**	0.233*	0.568**	-0.030	Days to first flowers, Plant height, Seed yield /plant.	Days to maturity, Plant height, No. of seed/capsule,
SLS-89 X SHARDA	4.63	95.15**	77.06**	184.92**	78.08	-0.877**	0.568**	1.010**	1000 Seed weight, Seed yield / plant.	Days to 50% flowers, No of branches/plant, No. of capsule/ plant, Seed yield / plant.
OL-98-13-01 X SHARDA	4.59	56.39**	41.01**	182.46**	74.54**	0.588**	0.568**	-0.495*	Days to first flowers, Days to 50% flowers, Days to maturity, Plant height, Seed yield / plant.	Days to maturity, 1000 Seed weight, Seed yield / plant.

** and ** indicated the significance at 5 and 1 per cent respectively*

SLS-89 x JLC-9 exhibited significant positive sca effects for seeds per capsule. For the character 1000 seed weight the hybrid ol-98-13-01 x LMS-210-127 exhibited highest estimates of sca effect followed by RL-292-2 x Gs-61, RLC-133 x LMS-210-01-27 and OL-98-13-01 x Sharda hence, these hybrids were best specific combinations for the trait this trait. Four crosses showed significant positive sca effects for oil content. Among them, SLS-89 x T-397 recorded highest estimates of sca effects followed by OL-98-13-01 x LMS-210-127, RL-292-02 x JLC-9 and RLC-133 x JLC-9. These hybrids were best specific combinations for the trait oil content. The estimates of sca effects for seed yield varied from -1.075 (NL-97 X GS-61) to 1.545 (SLS-89 X GS-61). Best five hybrids with respect to grain yield per plant based on significant positive sca effects were SLS-89 x GS-61, SLS-89 x Sharda, RLC-133 x LMS-210-01-27, RL-292-02 x JLC-9 and OL-98-13-01 x LMS-21-127. A total of seven crosses showed significant positive sca effects for seed yield.

In majority of cases, the best specific combinations for different characters were either good x poor, average x average, average x good and *vice versa* general combiners. This suggested that information on GCA effects should be supplemented by SCA effects and hybrid performance of cross combinations to predict the transgressive type possibly made available in segregating generations. The GCA effects of the parents and SCA effect of their crosses indicated that the crosses between two high general combiners were not always best specific combiners. Compared to *per se* performance it is noticed that the combinations having high SCA effects also had high *per se* performance for most of the characters indicating close agreement between *per se* performance and SCA effects (Table 4). The combinations which exhibited high SCA effects for seed yield per plant also had significant and desirable SCA for one or other component characters. The cross OL-98-13-01x LMS-210-01-27 exhibited significantly high SCA effects for five characters *viz*., days to maturity, number of seed capsule, 1000 seed weight, seed yield per plant and oil content. Likewise, the best crosses identified for various yield contributing characters were RL-292-02 X T-397, NL-97 X Sharda, SLS-89 X Sharda and OL-98-13-01 X Sharda for days to first flowering, days to 50 per cent flowering and days to maturity. Similar results were also obtained by Mohammadi (2013). Crossess *viz.,* NL-97 x SHARDA, SLS-89 x T-397, RLC-133 x SHARDA, and SLS-89 x JLC-8 identified for plant height, branches per plant and capsule per plant. OL-98-13-01 x JLS-9, OL-98-13-01 x SHARDA, NL-97 x GS-61, RLC-133 x SHARDA and RL-292-02 x LMS-210-01-27 for seed per capsule and 1000 seed weight. While crosees NL-97 x GS-61, SLS-89 x LMS-210-01-27, SLS-89 x T-397, RL-292-02 x LMS-210-01-27, RLC-133 x T-397, OL-98-13-01 x GS-61 and RLC-133 x LMS-210-01-27 identified for seed yield per plant and oil content on the basis of SCA effects indicating suitability for exploitation for respective characters. Similar results were also obtained by Singh *et al.* (2008), Goral *et al.* (2008), Sood *et al*.(2011) and Kumar *et al*.(2013).

It is worthy to note that most of superior F1s crosses in their SCA effects for seed yield and most of yield components traits include at least one of their parents of high GCA effects for the same traits. These results are in general agreement with those previously reported by El-kady and Abo-Kaied (2009) and Mishra *et al.* (2013), where they observed significant positive and negative SCA effects for these traits in their respective studies.

REFERENCES

El-Kady, E. A. and Abo-Kaied, H. M. H. (2010) Diallel cross analysis for straw, seed yield and their components in flax. *Journal of Plant Production* **1**: 1219-1231.

El-Kady, E.A.and Abo-Kaied, H. M. H. (2009) Analysis of combining ability for some economical useful charecters in flax. Minufiya *Journal of Agricultural Research* **34**: 2145-2158.

Goral, H. and M. Ejsmond (2008). Combining ability analysis and heritability of yield components in linseed (*Linum usitatissimum* L.). [Polish] *Biuletyn Instytutu Hodowlii Aklimatyzacji Roslin*. **249**: 209-215.

Kempthorne, O. (1957) An introduction to genetic statics. *John Willey and sons* , Inc.New York.

Kumar, S., Kerkhi, S.A., Anuj Kumar and Singh, S.D. (2013) Combinig ability and heterosis analysis in linseed (*Linum usitatissimum* L.). *Annals Agricaltural Reaserch New Series* **34** (3): 197-204.

Mishra, R., Marker, S., Bhatnagar, V. and Mahto, D. (2013) Genetic analysis of some agronomic traits in flax (*Linum usitatisimum* L.). *Austrian Journal of Crop Science* **4**: 343-352.

Mohammadi A.A., Saeidi, G.and Arzani, A. (2013) Genetic analysis of some agronomic traits in flax (*Linum usitatissimum* L.). *Australian Journal of Crop Science* **4**(5): 343-352 (2010).

Rauf, S., Shah, K. N. and Afzal, I. (2005) A genetic study of some earliness related characters in cotton (*Gossypium hirsutum* L.). *Caderno de Pesquisa Ser. Bio., Santa Cruz do Sul***, 17**: 1: 81–93.

Sarvanan, T., Thriugnana, S. K. and Ganesan, J. (2000) Combining ability and heterosis for earliness characters in seasame (*Sesamum indicum* L.). *Seasame Safflower Newslett*. **15**: 713.

Singh, S.B., Marker, S. and Kaleem, M. (2008) Combining ability analysis for grain yield & its attributes in linseed. (*Linum Usitatissimum* L.*). Journal of Maharashtra Agricultural Universities* **33**(2): 184-186.

Sood, S, Kalia, N. R. and Bhateria, S. (2011) Combining ability and heterosis studies across environments in linseed (*Linum usitatissimum* L.). *Acta Agronomica Hungarica* **59**(1): 87–102.