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Combining ability and gene action studies for yield and yield contributing traits in linseed (*Linum usitatissimum* L.)

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ABSTRACT
Combining ability and gene action were worked out for nine characters in ten genotypes and their 25 crosses in Linseed (Linum usitatissimum L.) through line x tester design along with two standard checks NL-97 and RLC-4. The analysis of variance revealed that the parents and hybrids included in the investigation exhibited significant differences between treatments for all the character indicating the presence of considerable amount of variability. The SCA variances (δ^2 SCA) were higher than GCA variance (δ^2 GCA) for all the nine characters except the traits days to 50% flowering and number of branches per plant. The character number of branches per plant show additive type gene action. The GCA effects of tester EC-90705 was desirable for days to 50 % flowering, number of branches per plant, number of capsules per plant and 1000 seed weight. The tester EC-41595 was good general combiner for plant height, number of capsules per plant, 1000 seed weight and seed yield per plant. Tester EC-99015 was desirable for best combiner number of capsules per plant and seed yield per plant, and the tester EC- 90710 was desirable good combiner for oil content. Majority of their crosses EC-41636 x EC-90710 and EC-41730 x EC-41595 were showed highly significant SCA effects for component characters of number of capsule per plant, 1000 seeds weight, oil content and per se performance for days to 50% flowering and days to maturity and seed yield per plant respectively.
Key words: *Combining ability, Line x Tester, and linseed.*

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INTRODUCTION

Linseed (*Limum usitatissimum* L.) is one of the oldest oilseed cup cultivated by man for its seed and fibre. It belongs to the genus *Limum* of the family Linaceac. The somatic chromosome number of the cultivated species is 2n = 30. According to [7] linseed was probably native of Southwest Asia consisting of India, Afghanistan and Turkey. Most of the investigators are of opinion that wild flax *Linum ongutfolium* is the progenitor of *Linum* L. The genus *Limum* has nearly 290 species spread over the temperate and warm temperate zones of the northern hemisphere, most abundantly in Europe and Asia. *Linum ustatisimum* L is the only widely cultivated species although L. *angusnjfolium Hads.* (n-30) has been grown in some areas.

Commercially grown linseed crops are grouped into two main types i.e. fibre linseed and seed linseed, the former is generally referred to as long stalked flax and the latter as crown linseed Long stalked flax is grows for fibre and cultivated as a spring crop on primarily silt or clay loams in a moist and warn climate.

The plants grown commercially for oilseed purposes are often referred to as linseed. The oil extracted from the linseeds (40-45 %) is used for a variety of industrial purposes such as linoleum, paint vanish and printer ink. Since linseed oil is high in linolenic fatty acid content (45-60 %), it makes a very effective drying agent. The plants grown commercially for high quality fibers are referred to as the fibre flax crop. Fibers obtained from the stem are known for their length, strength and are used for sewing threads, button threads, fish and sieve lines. Every paint of the linseed plant is utilized commercially either directly or after processing.

Linseed is unique among oilseeds as it has a high content of onega-3 fatty acid, alpha-linolenic acid (AL.A). Flax seed contains 35 to 45 % oil with the ALA making up about 57 % of the total tatty acids. Onega-3 fatty acids lowers levels of triglycerides in the blood, thereby reducing heart diseases, and also show promise in the battle against inflammatory diseases such as rheumatoid arthritis. Linolenic acid (LA) an omega-6 essential fatty acid is also found in linseed.

MATERIAL AND METHODS

The present investigation was conducted a Research Farm, Oilseed Research Station Latur. During 2013 and parents are evaluated for estimation of GCA and SCA with based on their suitability of nature for ten parents were selected and crossed in Line x Tester fashion design. Majority their 25 crosses along with their parents and two checks *viz.,* RLC-4 and NL-97 were evaluated in random block design with two replications. All the parental material was planted during *Rabi*-2013 by adopting a spacing of 30 cm between rows and 10 cm between plants within a row. Two set of parental lines were sown at an interval of three days to ensure synchrony in flowering for crossing, the desired flower buds.

All recommended agronomic practices were followed. Observation were recorded on five randomly selected plants for days to 50 percent flowering, days to maturity, plant height (cm), number of branches per plants, number of capsules per plants, number of seed per capsule, 1000-seed weight(g), oil content and seed yield per plant(g).

The analysis of variance was done as per standard method suggested by [9]. The Line x Tester analysis technique provides a systematic approach to assess the combining ability of parents and their crosses for different quantitative characters [2].

RESULT AND DISCUSSION

General combing ability:

The estimate of GCA revealed that of the parent was found to be consists of only good general combining ability for all the characters (Table.3). The female parent EC-98994 showed highest significant positive GCA for seed yield per plant (0.723), Number of capsule per plant (11.780) and 1000 seed weight. While, EC-41730 showed significant positive GCA effect for oil content (0.524), plant height (2.760). The female EC-112082 showed significant negative GCA effect for days to 50 percent flowering. Among the male parents EC-99015 showed significant GCA for seed yield per plant (0.417) and number of capsule per plant (4.980). However, EC-41595 was best general combiner and show significant GCA effect for seed yield per plant (0.549). The parent EC-90710 was best general combiner for oil content (0.644) also had significant GCA effects. Similar results on general combining ability were reported previously by [3], [11], [8]and [7].

Specific combing ability:

The estimate of SCA effects revealed that none of the crosses was found to be consistently superior for all the characters (Table.4) . The cross EC-41636 x EC-90710 (-1.48) followed by EC-98994 x EC-99015 (-1.38) were best cross combination showing significant negative SCA effect for days to 50 per cent flowering. Similarly results were also obtained by [14]. Out of the 25 crosses, six crosses sowed significant positive SCA effects. The cross combination EC-98994 x EC-41595 (7.440) was best positive effects for the character plant height. Similar results were also obtained by [15] and [3]. Amongst hybrid combinations, two crosses EC-41636 x EC-41595 (.750) and EC-41730 x EC-90705(0.760) showed significantly positive SCA effects for number of branches per plant. The similar results were also observed in the studies of [14], [10] and [3].

The crosses, EC-99020 x EC-2274(14.420) followed by EC-41636 x EC-90705 (9.420) and EC-41636 x EC-90705(9.420) showed significant SCA effect for number of capsule per plant. Similar results were found in the studies of [12] and [3]. The cross EC-99020 x EC-99015 (0.860) was highly significant positive SCA effect for number of seed per capsule that similar results were found in studies of [1] and [3]. Four crosses showed significant positive SCA effects and the cross EC-41636 x EC-99015 (0.718) was having highly positive significant SCA effect for the character 1000 seed weight. This similar result was found in studies of [14]. The cross EC-12082 x EC-99015 was having positive significant SCA effect for character of oil content. The desirable positive SCA effects for seed yield per plant were found in two cross combinations. Whereas the crosses EC-41636 x EC-90705 (0.989) and EC-41730 x EC- 41595 (0.537) were having significant SCA effect these similar result were obtained by [3], [5], *[11]* and [13].

Gene action:

The nine characters study exhibited non-additive gene action for all the characters except number of branches per plant such situation development of hybrids can be effectively done. Governing of such characters non-additive gene action was reported earlier by [8], [15].

Table.1: Variances for General and Specific Combining ability for different characters in Linseed.

Sr. No.	Character	δ² GCA	δ² SCA	δ² GCA/ δ² SCA
1	Days to 50% flowering	1.0692**	-1.1850	-0.9023
2	Days to maturity	0.1500	0.6936	0.2162
3	Plant height(cm)	4.2933	18.6102**	0.2307
4	No. of Branches /plant	0.1259**	0.0860	1.4652
5	No. of capsules /plant	69.2011**	88.6928**	0.7802
6	No. seeds /Capsules	0.0254	0.3270*	0.0777
7	1000 seeds weight (g)	0.1995**	0.2305**	0.8656
8	Oil content (%)	0.1437	0.5333**	0.2695
9	Seed yield / plant	0.1990**	0.2064**	0.639

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

Table. 2: Analysis of variance for combining ability for different characters including parents in Linseed.

Source	d.f.	Days to 50% flowering	Days to maturity	Plant height(cm)	No. of Branches /plant	No. of capsules /plant	No. seeds /Capsules	1000 seeds weight (g)	Oil content (%)	Seed yield / plant
Replication	1	6.914	0.057	11.200	0.700	1.728	0.096	0.194	0.00014	0.000
Treatments	34	16.120**	8.031*	45.464**	1.002**	353.151**	1.610**	1.147**	1.182**	0.742**
Parents	9	24.050**	9.688*	42.111**	0.916**	182.050**	0.494	1.416**	0.473	0.070
Parents *vs* crosses	1	139.955**	64.205**	123.480**	8.915**	1420.012**	27.601**	0.253	0.816	0.143
Crosses	24	7.986	5.070	43.471**	0.705	372.861**	0.946*	1.084**	1.463**	1.016**
L x T	16	3.632	5.032	41.567**	0.342	201.320**	1.080*	0.573**	1.340**	0.490**
Error	34	6.002	3.645	5.547	0.370	23.934	0.425	0.112	0.273	0.077

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

Table 3: Estimates of general combing ability (GCA) of Lines and Testers in Linseed.

Parents	Days to 50% flowering	Days to maturity	Plant height(cm)	No. of Branches /plant	No. of capsules /plant	No. seeds /Capsules	1000 seeds weight (g)	Oil content (%)	Seed yield / plant
Lines									
EC-99020	1.280	0.520	-1.240	0.540**	0.580	-0.260	0.281*	0.124	-0.008
EC-98994	-1.020	-1.080	-2.840**	0.040	11.780**	0.140	0.281*	-0.496**	0.723**
EC-41636	-0.320	-0.480	-1.140	0.240	3.780*	0.340	-0.294*	0.064	0.131
EC-12082	-1.720*	-0.080	2.460**	-0.760**	-6.420**	0.040	0.145	-0.216	-0.185*
EC-41730	1.780*	1.120	2.760**	-0.060	-9.720**	-0.260	-0.414**	0.524**	-0.663**
S.E.(Gi)	0.774	0.603	0.659	0.130	1.547	0.297	0.105	0.165	0.086
Tester									
EC-99015	0.980	0.120	-1.540*	0.040	4.980*	0.240	-0.528**	-0.376*	0.417*
EC-90705	-1.720*	0.020	-1.340	0.340*	8.880**	0.240	0.649**	0.104	0.181
EC-41595	0.580	-0.880	2.960**	0.040	3.880*	-0.360	0.549**	-0.456*	0.207*
EC-90710	0.380	0.120	-0.440	-0.160	-10.820**	0.040	-0.442**	0.644**	-0.584**
EC-2274	-0.220	0.620	0.360	-0.260	-6.920**	-0.160	-0.229*	0.084	-0.223*
S.E.(Gj)	0.774	0.603	0.659	0.130	1.547	0.297	0.105	0.165	0.086
S.E.(Gi-Gj)	1.095	0.853	0.932	0.184	2.187	0.291	0.149	0.234	0.124
CD@5%	1.599	1.246	1.360	0.269	3.193	0.426	0.218/	0.341	0.181
CD@1%	2.167	1.688	1.844	0.365	4.327	0.577	0.296	0.462	0.246

*and** indicated the significance at 5 and 1 percent respectively.

Table 4 : Estimate of specific combining ability (SCA) for 9 Characters of Linseed.

Sr .No.	Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of Branches /plant	No. of capsules /plant	No. seeds /Capsules	1000 seeds weight (g)	Oil content (%)	Seed yield / plant
1	EC-99020 x EC-99015	1.820	-0.220	6.340**	0.460	-8.980*	0.860	-.0.342	-1.024*	-0.468*
2	EC-99020 x EC-90705	0.020	1.3802	4.140**	0.160	-15.380**	0.360	-0.264	-0.604	0.048
3	EC-99020 x EC-41595	-0.280	1.280	-6.160**	-0.540	7.620*	-0.040	-0.139	0.856*	0.227
4	EC-99020 x EC-90710	-0580	-1.220	-1.760	0.160	2.320	-0.440	0.207	0.056	0.018
5	EC-99020 x EC- 2274	-0.980	-1.220	-2.560	-0.240	14.420**	-0.740	0.539*	0.716	0.177
6	EC-98994 x EC-99015	-1.380	-0.120	-2.060	-0.040	5.320	0.460	0.023	-0.504	0.066
7	EC-98994 x EC-90705	-0.680	-1.020	-1.260	-0.340	3.420	-1.040*	-0.294	-0.384	-0.103
8	EC-98994 x EC-41595	-0.980	-2.620	7.440**	-0.040	-2.580	0.560	0.201	0.576	0.276
9	EC-98994 x EC-90710	0.720	0.880	-0.160	0.160	1.120	0.160	0.427	0.176	0.142
10	EC-98994 x EC-2274	2.320	2.880*	-3.960	0.260	-7.280	-0.140	-0.356	0.136	-0.379
11	EC-41636 x EC-99015	0.420	0.780	-0.760	-0.240	-5.680	-0.740	0.718**	0.836*	-0.147
12	EC-41636 x EC-90705	1.620	0.880	0.540	-0.540	9.420*	0.760	0.156	-0.144	0.989**
13	EC-41638 x EC-41595	0.320	1.280	4.740**	0.760*	-1.580	-1.140*	-0.804**	-0.184	-0.927**
14	EC-41636 x EC-90710	-1.480	-0.720	-4.860**	-0.040	7.620*	0.460	-0.130	-0.184	0.354
15	EC-41636 x EC-2274	-0.880	-2.220	0.340	0.060	-9.780**	0.660	0.034	-0.324	-0.267
16	EC-12082 x EC90915	-1.180	-0.120	-0.860	0.260	7.520*	0.560	0.509	1.016*	0.320
17	EC-12082 x EC-90705	-0.980	0.480	-3.560	-0.040	-6.880	-0.440	0.277	0.736	-0.190
18	EC-12082 x EC-41595	1.220	0.380	-0.680	-0.240	-10.380**	0.160	0.417	-1.904**	-0.111
19	EC-12082 x EC-90710	1.920	0.380	4.540**	-0.040	4.320	-0.240	-0.517*	0.396	-0.0.185
20	EC-12082 x EC- 2274	-0.980	-1.120	0.740	0.060	5.420	-0.040	0.685**	-0.244	0.159`
21	EC-41730 x EC-99015	0.320	-0.320	-2.660	-0.440	1.820	-1.140*	-0.907**	-0.324	0.222
22	EC-41730 x EC-90705	0.020	-1.720	0.140	0.760*	9.420*	0.360	0.126	0.396	-0.742**
23	EC-41730 x EC-41595	-0.280	-0.320	-5.160**	0.060	6.920	0.460	0.326	0.656	0.537*
24	EC-41730 x EC-90710	-0.580	0.680	2.240	-0.240	-15.380**	0.060	-0.013	-0.444	-0.327
25	EC-41730 x EC-2274	0.520	1.680	5.440**	-0.140	-2.780	0.260	0.469	-0.284	0.312
	SE (±)	1.732	1.350	1.474	0.292	3.459	0.461	0.236	0.369	0.196

*and** indicated the significance at 5 and 1 percent respectively.

CONCLUSION

Looking overall performance of all parents based on general combining ability effects, EC-98994 among the female parent was the best combiner. Among the male parents EC-90705 had significant GCA effect for different yield and yield contributing characters. Likewise majority of their crosses identified for various yield contributing characters were EC-98994 x EC-41595 for number of branches per plant followed by EC-41730 x EC-90705 and EC-98994 x EC-2274. For seed yield per plant the cross EC-12082 x EC-90705 on the basis of SCA effect indicating suitability for exploitation of respective characters.

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