The Pharma Innovation Journal 2022; 11(12): 3387-3392

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 3387-3392

www.thepharmajournal.com
Received: 07-09-2022
Accepted: 15-10-2022

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Diallel analysis for estimation of combining ability for some quantitative traits in linseed (*Linum usitatissimum* L.)

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Abstract
The research consisted of fifteen diverse parents of linseed (*Linum usitatissimum* L.) which were crossed following diallel mating design (Griffings 1956) [4] Model I Method II to generate one hundred and five crosses (excluding reciprocals). These 105 F_1s were evaluated in randomized block design having three replications during *rabi* 2021-22 at the farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. The data were recorded on five observational plants for nine quantitative characters *viz.,* days to 50% flowering, days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight (g), seed weight plant^{-1} (g), alternaria blight infestation (%), bud fly infestation (%) to estimate general combining ability of parents, specific combining ability of crosses for yield and yield contributing traits and to select potential parents and crosses for linseed breeding programme.
The analysis of variance revealed highly significant mean squares for all the characters studied indicating presence of considerable genetic diversity among genotypes which allows further estimation of experimental material. Analysis of variance for combining ability revealed that mean squares due to GCA and SCA were significant for all the characters studied. The predictability ratio ranged from 0.49 to 0.81. Based on mean performance and GCA effects of parental lines, the genotypes Kota Barani-3, TL 99, Indira Alsi-32, Neela were found to be the best general combiners for seed yield plant^{-1}, 1000 seed weight, number of capsules plant^{-1}. The crosses PKV NL 260 × Indira Alsi-32, Kota Barani 4 × Arpita, PKV NL 260 × Neela, Mutant-2 × TL 99, Mau Azad Alsi-2 × TL 99, JLS 79 × Pratap Alsi 1, Neela × Mutant-4, JLS 95 × Mau Azad Alsi-2, JLS 9 × Mau Azad Alsi-2, JLS 95 × Kota Barani 3, JRF 2 × Kota Barani 3, JLS 95 × Kota Barani 4, Neela × JRF 2 possessed negative SCA effects along with high and significant or non significant mean performance for seed yield plant^{-1}, 1000 seed weight, number of capsules plant^{-1}. These crosses possesses desirable GCA effects for the parents involved in the cross. These crosses therefore found to be the best crosses which can be forwarded to the next generation for their use in varietal breeding programme in linseed.

Keywords: Linseed, analysis of variance, combining ability, predictability ratio, GCA effects, SCA effect

Introduction

Linseed (*Linum usitatissimum* L.) is an annual autogamous diploid (2x=2n=30, genome size-370 Mb) oilseed crop belonging to Linaceae family growing during *rabi* season in India. It has been mainly cultivated for fibre (Flax fiber) and seed oil (Linseed) or both (dual purpose linseed). Every part of linseed plant is utilized commercially either directly or indirectly after processing. Its seed is good source of fat (41%), Protein (20%), dietary fibre (28%). Seed contain oil ranging from 35-45%. Flax is gluten free. Linseed is unique among the oilseeds as it is widely available herbal source of 75% polysaturated fatty acids, 57% Alpha-linolenic (ALA) an omega-3 fatty acid and 16% linoleic acid (LA) an omega-6 essential fatty acid. Omega 3 and omega 6 fatty acid act as brain tonic which known to cure the diseases like cardiovascular disease (CVD_s) diabetes, cancer, major depression (Ekka *et al.* 2017) [2].
Combining ability analysis is a powerful tool to select elite parents and best specific crosses for yield parameters and also to understand the nature of gene action involved in inheritance of various traits. Thereby it provides the opportunity for the use of these combiners in hybridization programme. Isolation of parental lines of good combining ability makes the pathway easy, towards success. Keeping in view above fact this work executed to evaluate 15 genotypes and their 105 F_1s.

Materials and Methods

The experimental material required for present study comprised of 15 genetically diverse genotypes used to develop diallel set excluding reciprocals and the 105 crosses thus formed were sown in RBD with three replications following spacing of about 30 cm × 5 cm during *rabi* 21-22 at the farm of AICRP on linseed and Mustard, College of Agriculture, Nagpur. Recommended cultural practices and plant protection measures were adopted as and when found necessary. Observations were recorded on five randomly selected plants for nine quantitative characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight (g), seed weight plant^{-1} (g), bud fly infestation (%), Alternaria infestation (%). Combining ability analysis was performed according to procedure suggested by Griffings (1956) [4] Method II Model I (fixed effect).

Results and Discussion

The results of analysis of variance for combining ability using diallel mating design (without reciprocals) are shown in Table 1. Where the mean squares due to GCA and SCA were highly significant for all characters studied indicating that, both additive and non additive controlling the inheritance of these traits. Similar results were reported by Suvarnlata *et al.* (2021) [10], Srivastava *et al.* (2007) [9] and Sedhom *et al.* (2016) [8]. Mahawar *et al.* (2021) [6], revealed that mean squares due to GCA and SCA were significant for seed yield plant^{-1} and all other component characters except number of secondary branches plant^{-1} and biological yield plant^{-1}.

The relative importance of GCA and sca in determining progeny performance obtained by calculating general predictability ratio on the basis of mean squares. The predictability ratio (GCA *Vs* SCA) ranged from 0.49 to 0.81. The closer the ratio to unity, the greater the predictability based on a general combining ability alone. Khan *et al.* (1999) [5], Mishra and Rai (1996) [7], Sedhom *et al.* (2016) [8], Mahawar *et al.* (2021) [6], have used relative magnitude of GCA vs SCA as index of relative role of additive and non additive variation which guides in the choice of breeding plan. Achila *et al.* (2022) [1] The ratio of gca variance to that of sca variance was less than unity for almost all the traits except omega-6, suggesting that these traits were governed by non-additive gene action. Ghige (2020) [3] calculated predictability ratio and found close to unity which indicated the predominance of additive genetic component for development of studied characters.

General and specifc combining ability

The combining ability analysis of Griffings (1956) [4] serves as important tool to identify potential parents with highest breeding value and best specific cross combination for desirable economic traits. The Additive portion of the total variance is included in the variance of general combining ability, whereas the non-additive fraction of total variance is included in the variance for specific combining ability, which is a consequence of dominance (intra-allelic interaction) and epistatic deviations (inter-allelic interaction). GCA effects of parents and SCA effects of crosses were worked out for all nine characters and have been presented in Table 4a and 4b respectively.

In linseed, positive GCA effects and SCA effects are desirable for all the traits studied except for days to 50% flowering, days to maturity, plant height, bud fly infestation and alternaria blight infestation for which negative GCA and SCA effects are desirable. The GCA effects of parents and sca effects of crosses were worked out for all nine characters for selection of parents and crosses for linseed breeding programme and have been presented in Table 2a and 2b respectively. Among the fifteen parents studied, parents Indira Alsi 32, Neela showed desirable GCA effects for seed yield plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, plant height, days to 50% flowering and bud fly infestation. Only two parents TL 99 and Arpita showed desirable, significant and negative GCA effect for days to maturity. Kota Barani 3 was found to be good general combiner for seed yield plant^{-1}, number of capsules plant^{-1}, 1000 seed weight. Number of branches plant^{-1}. Seven parents namely PKV NL 260, Neela, Indira Alsi 32, JLS 95, Mau Azad Alsi 32 found to be best general combiners for bud fly infestation. Hence Neela on crossing with JLS 95 and Mau Azad Alsi 2 can be used to produce transgressive segregants for yield and bud fly resistance in hybridization programme. The parent PKV NL 260 recorded the highest, significant and negative GCA effect for alternaria blight infestation.

Out of one hundred and five crosses, JRF 2 × Mau Azad Alsi-2 showed significant and negative SCA effect for days to 50% flowering. The crosses JRF 2 × Kota Barani 3, JLS 95 × Kota Barani 4 showed significant and negative SCA effects for seed yield plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, plant height, bud fly infestation. In addition to above traits JRF 2 × Kota Barani 3 showed significant and negative SCA effects for number of branches plant^{-1}.

Potentialities of varieties as parents and crosses to be forwarded to next generation in predominantly self-pollinated crop may be determined by comparing it's *per se* performance of F_1 values involving that parent, general combining ability and negative SCA effect along with high GCA of one or both diverse parents involved in the cross respectively. The cross combinations showed all the three possible combinations between the parents with high and low GCA effects *viz.*, High × High, High × Low, Low × Low. On the basis of these fact thirteen cross combinations were identified as potential crosses for seed yield plant^{-1} (g), 1000 seed weight (g), number of capsules plant^{-1}. Selected promising crosses and their performance are presented in Table 3.

Table 1: Analysis of variance for combining ability

Source of Variation	d.f.	Mean squares								
		Days to 50 % flowering (Days)	Days to maturity (Days)	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant $^{-1}$ (g)	Bud fly infestation (%)	Alternaria blight infestation (%)
Due to GCA	14	53.58**	84.14**	1,288.51**	9.17**	2,953.89**	14.58**	8.20**	456.79**	21.15**
Due to SCA	105	29.37**	55.83**	359.53**	7.13**	2,163.62**	9.91**	3.77**	363.50**	15.87**
Error	238	6.57	22.92	13.98	0.06	44.25	0.17	0.11	12.03	0.38

Note: * Significant at 5 % level, ** Significant at 1 % level

Table 2a: General combining ability effects of the parents for different characters

Sr. No.	Genotypes	Days to 50 % flowering (Days)	Days to Maturity (Days)	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)	Bud fly infestation (%)	Alternaria blight infestation (%)
	Lines									
1.	PKV NL-260	-0.965**	-0.342	5.907**	-0.684**	-8.592**	0.340**	0.446**	-5.128**	-1.584**
2.	Neela	-1.573**	-0.342	-2.413**	-0.430**	16.649**	0.395**	0.755**	-2.073**	0.516**
3.	Indira Alsi-32	-0.808*	0.030	-0.407**	0.018	8.521**	0.119*	0.234**	-2.586**	-0.280**
4.	JLS 9	-1.416**	0.795	0.080	-0.354**	-2.625**	-1.039**	-0.631**	1.315**	0.116*
5.	JRF 2 (Tiara)	0.133	-0.950	-0.967**	0.558**	-8.735**	0.238**	-0.462**	1.591**	-0.320**
6.	Mutant 2	1.310**	3.148**	14.139**	-0.351**	-1.228	0.201**	0.201**	0.430	-0.306**
7.	Mutant 4	0.231	-0.146	-3.798**	0.294**	5.74**	-0.879**	-0.071	7.036**	-0.444**
8.	JLS 95	-0.475	1.893**	-4.740**	0.331**	-12.31**	0.646**	-0.471**	-3.798**	0.013*
9.	JLS 79	0.349	0.422	-4.694**	-0.200**	-2.453**	-0.570**	-0.547**	2.007**	0.941**
10.	Mau Azad Alsi- 2	1.996**	0.422	-5.612**	-0.403**	-5.164**	-0.624**	-0.115**	-2.449	1.224**
11.	Kota Barani-4	-0.180	-0.068	1.786**	0.672**	-0.629	-0.222**	0.015	1.376**	-0.183*
12.	Kota Barani- 3	0.604	-1.068	3.295**	0.493**	8.085**	0.514**	0.453**	0.714	0.059*
13.	Pratap Alsi -1	1.388**	-0.284	-0.592**	-0.233**	-1.203	0.381**	0.173**	1.611**	-0.178*
14.	Arpita	-0.180	-1.558*	0.618	0.385**	-0.316	0.409**	-0.002	1.511**	0.246**
15.	TL 99	-0.416	-1.950**	-2.603**	-0.095**	4.257**	0.092	0.023	-1.557**	0.180*
	S.E.	0.347	0.648	0.506	0.034	0.900	0.056	0.056	0.469	0.084

Note: *Significant at 5% level, ** Significant at 1% level

Table 2b: Specific combining ability effects of crosses for different characters

Sr. No.	Genotypes	Days to 50 % flowering (days)	Days to maturity (days)	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)	Bud fly infestation (%)	Alternaria blight infestation (%)
	Lines									
1.	PKV NL 260 × Neela	-2.36	-5.80*	-4.75*	-0.08	-22.40**	-2.35**	-1.40**	7.40**	0.43
2.	PKV NL 260 × Indira Alsi-32	-2.79*	-3.51	1.78	-2.19**	-21.70**	-0.31	-0.59**	-3.76	0.44
3.	PKV NL 260 × JLS 9	-1.85	2.73	-14.20**	1.71**	-7.21*	1.11**	0.46*	-1.49	-0.67*
4.	PKV NL 260 × JRF 2 (Tiara)	17.60**	1.47	54.76**	-0.20	29.65**	-1.24**	2.03**	8.15**	-0.07
5.	PKV NL 260 × Mutant 2	-3.58*	-4.96	-6.93**	2.84**	20.89**	0.30	1.07**	-4.02*	-0.25
6.	PKV NL 260 × Mutant 4	-3.83**	4	-2.16	1.90**	30.09**	0.61**	0.77**	-5.46**	0.39
7.	PKV NL 260 × JLS 95	-3.46*	-4.04	1.53	-0.17	4.14	0.55*	0.22	5.46**	0.65
8.	PKV NL 260 × JLS 79	-4.28**	-3.90	1.82	-0.31*	10.70**	1.82**	0.82**	-0.60	-1.33**
9.	PKV NL 260 × Mau Azad Alsi-2	4.07**	5.77*	0.07	0.86**	-0.92	0.46*	0.02	-4.39*	-1.78**
10.	PKV NL 260 × Kota Barani 4	6.25**	9.26**	-3.99	-1.28**	-6.71	0.14	-0.50**	-7.80**	0.29
11.	PKV NL 260 × Kota Barani 3	4.46**	7.92**	13.50**	-2.13**	-30.60**	2.71**	-0.33	-5.06**	-0.84*
12.	PKV NL 260 × Pratap Alsi-1	-3.33*	-4.863	-3.37	-0.74**	-19.30**	1.10**	-0.64	-0.04	0.73*
13.	PKV NL 260 × Arpita	-2.42	-3.26	5.59**	-0.36**	9.07*	-2.06**	0.35	-0.27	-0.30
14.	PKV NL 260 × TL 99	0.81	-2.53	-1.60	0.39**	2.41	0.35	-0.31	-2.53	-0.74**
15.	Neela × Indira Alsi-32	-2.19	0.157	8.60**	1.59**	94.12**	0.05	5.42**	11.32**	-0.78*
16.	Neela × JLS 9	-0.25	-1.94	0.43	0.11	-3.50	1.81**	-0.28	-0.21	1.06**
17.	Neela × JRF 2 (Tiara)	-0.79	-1.96	-7.84**	-1.79**	-18.30**	1.68**	-0.78**	-2.65	-0.84
18.	Neela × Mutant 2	4.03**	0.71	-19.23**	1.11**	4.69	-0.46*	-0.11	6.32**	-0.57
19.	Neela × Mutant 4	-2.89*	2.00	-12.34**	-0.69**	-43.56**	-2.31**	-1.54**	-19.27**	2.12**
20.	Neela × JLS 95	0.15	-1.37	4.34*	-1.19**	11.45**	-1.19**	0.34	-1.20	1.71**
21.	Neela × JLS 79	8.32**	5.43*	-5.78**	-0.70**	-11.21**	1.33**	0.03	-2.07	-1.85
22.	Neela × Mau Azad Alsi-2	-4.32**	8.77**	1.73	-0.29*	-15.64**	2.35**	0.04	0.35	-3.10**
23.	Neela × Kota Barani 4	-0.15	-0.75	7.50**	-0.57**	35.39**	1.71	-0.25	-6.77**	5.11**
24.	Neela × Kota Barani 3	1.74	-1.75	0.07	-1.67**	1.87	-3.80**	-0.81**	16.53**	-1.63
25.	Neela × Pratap Alsi-1	1.28	-3.20	3.90	-0.82**	-0.90	0.77**	0.03	21.35**	2.55**
26.	Neela × Arpita	0.52	-1.59	-6.92**	1.22**	28.05**	0.37	0.20	-5.49**	-3.02**
27.	Neela × TL 99	-2.25	-1.53	4.80*	1.70**	-6.42	1.76**	-1.17**	-5.26**	-2.25**
28.	Indira Alsi-32 × JLS 9	1.32	3.35	4.61*	-0.49	62.51**	2.78**	2.84**	-5.45**	-0.98**
29.	Indira Alsi-32 × JRF 2 (Tiara)	-0.23	0.10	15.84**	0.67**	4.82	-0.54*	0.61**	-2.67	-0.44
30.	Indira Alsi-32 × Mutant 2	2.27	-6.00*	-14.87**	-1.49**	5.95	1.04**	-0.19	27.24**	0.39
31.	Indira Alsi-32 × Mutant 4	-0.66	3.96	-0.01	1.03**	31.73**	1.36**	-0.17	-4.42*	1.75**
32.	Indira Alsi-32 × JLS 95	-0.62	-4.75	-0.07	1.08**	11.11**	0.26	0.99**	-3.17	-1.21**
33.	Indira Alsi-32 × JLS 79	4.89**	-1.94	-1.45	0.52**	-37.41**	-2.19**	-1.14**	1.94	0.03
34.	Indira Alsi-32 × Mau Azad Alsi-2	0.91	-4.28	0.09	1.08**	10.5**	3.12**	0.66**	-0.69	0.16
35.	Indira Alsi-32 × Kota Barani 4	-0.91	-2.12	-3.43	-1.68**	-44.40**	-2.77**	-1.87**	14.41**	-0.35
36.	Indira Alsi-32 × Kota Barani 3	1.30	-2.79	-1.94	-1.34**	5.55	-2.57**	-0.79**	-2.26	3.91**

37.	Indira Alsi-32 × Pratap Alsi-1	-1.48	10.43**	1.53	1.39**	-15.41**	1.59**	-0.94**	-7.44**	-0.60
38.	Indira Alsi-32 × Arpita	0.42	-0.29	-1.65	0.77**	-21.49**	1.76**	-0.45*	-4.01*	0.45
39.	Indira Alsi-32 × TL 99	0.32	-0.57	0.74	-0.05	-0.79	-1.17**	-0.25	-2.46	0.38
40.	JLS 9 × JRF 2	4.72**	9.33**	26.783**	-0.25	62.96**	-2.07**	1.27**	-2.32	0.51
41.	JLS 9 × Mutant 2	0.21	-1.77	2.57	-1.12**	-22.30	-2.61**	-0.99**	11.62	-1.62**
42.	JLS 9 × Mutant 4	-1.382	-2.471	3.09	0.99**	19.96**	-0.20	0.88**	-12.57**	-1.48**
43.	JLS 9 × JLS 95	-0.343	7.157**	8.66**	0.20	8.49*	0.591**	0.20	-9.22**	-2.35**
44.	JLS 9 × JLS 79	0.17	-3.04	-10.10**	3.73**	35.99**	1.75**	0.26	-10.46**	-2.95**
45.	JLS 9 × Mau Azad Alsi-2	-1.15	-2.71	-8.02**	-2.07**	-26.55**	-1.28**	-0.89**	-1.67	2.69**
46.	JLS 9 × Kota Barani 4	0.03	-2.22	7.92**	-0.14	11.41**	2.34**	0.01	-4.33*	-1.49
47.	JLS 9 × Kota Barani 3	0.58	-1.55	-0.42	0.04	-25.41**	2.80**	-0.51**	8.22**	-1.12**
48.	JLS 9 × Pratap Alsi-1	1.13	-5.00*	-2.29	-0.24	-2.10	-2.18**	-0.54**	-15.06**	-2.25**
49.	JLS 9 × Arpita	1.36	-0.06	-8.25**	0.14	-32.67**	-2.52**	-1.12**	37.54**	6.16**
50.	JLS -9 × TL 99	-1.07	0.33	-11.36**	-0.38**	-29.80**	-1.53**	-1.08**	27.61**	7.56**
51.	JRF 2 × Mutant 2	-2.68	-3.02	-28.47**	0.55**	-1.05	-0.416	-0.39	2.43	-0.35
52.	JRF 2 × Mutant 4	0.07	-0.73	-12.45**	-0.01	-31.18**	-1.94**	-1.15**	22.07**	-0.38
53.	JRF 2 × JLS 95	2.11	-6.43*	5.425**	2.95**	10.04**	0.817**	0.34	-1.51	0.67*
54.	JRF 2 × JLS 79	-1.72	-0.29	-14.78**	-1.02**	-16.99**	-1.837**	-0.31	22.10**	-0.43
55.	JRF 2 × Mau Azad Alsi-2	-5.03**	-1.29	-1.47	2.02**	33.47**	0.92**	0.67**	-8.61**	-2.13**
56.	JRF 2 × Kota Barani 4	-1.52	2.86	-7.70**	-2.05**	-2.65	2.97**	0.51**	-6.60**	-1.22**
57.	JRF 2 × Kota Barani 3	-2.30	0.53	-19.71**	-1.54**	-35.03**	-2.49**	-1.61**	-10.11**	0.95**
58.	JRF 2 × Pratap Alsi-1	-3.42*	-0.59	-0.26	-1.02**	-19.01**	2.46**	-0.76**	12.08**	2.92**
59.	JRF 2 × Arpita	0.82	0.69	-7.03**	-1.77**	-20.29**	-3.22**	-1.06**	-18.07**	-1.57**
60.	JRF 2 × TL 99	0.05	2.75	2.02	-2.87**	-21.36**	0.71**	-0.78**	-17.34**	-0.67*
61.	Mutant 2 × Mutant 4	-0.44	7.51**	3.53	-0.77**	-0.94	2.58**	-0.02**	-15.10**	1.28**
62.	Mutant 2 × JLS 95	0.93	1.47	-8.05**	1.20**	14.48**	1.04**	1.04**	11.07**	3.19**
63.	Mutant 2 × JLS 79	-1.23	-3.73	1.76	-0.27	-28.00	-2.03**	0.16	-11.57**	-2.69**
64.	Mutant 2 × Mau Azad Alsi-2	-0.54	-4.06	2.10	0.60**	14.57**	1.24**	1.52**	3.03	-2.79**
65.	Mutant 2 × Kota Barani 4	2.30	2.10	25.08**	-1.15**	38.33**	1.07**	2.58**	-4.11**	-0.74*
66.	Mutant 2 × Kota Barani 3	-0.15	7.10**	-14.98**	-0.97**	-23.35**	0.67**	-1.32**	-11.00	-0.12
67.	Mutant 2 × Pratap Alsi-1	1.07	2.98	5.79**	-0.87**	-8.20*	-1.15**	-0.74**	8.17**	0.29
68.	Mutant 2 × Arpita	-1.03	-3.75	17.04**	1.14**	1.84	0.22	-0.42*	-0.65	5.14**
69.	Mutant 2 × TL 99	3.87**	-1.69	-12.67**	0.95**	-9.79*	-0.74**	-0.51**	-10.09**	1.07**
70.	Mutant 4 × JLS 95	-1.32	-6.90**	-2.18	-2.45**	-25.27	-2.19**	-1.13**	9.29**	0.957**
71.	Mutant 4 × JLS 79	-1.15	-0.43	-1.78	-0.92**	8.62*	-0.71	0.72**	-6.57	-0.22
72.	Mutant 4 × Mau Azad Alsi-2	-1.13	-3.10	1.03	1.48**	-3.59	2.52**	0.17	0.21	-3.07**
73.	Mutant 4 × Kota Barani 4	0.05	0.73	7.80**	-2.46**	-33.29	-1.12**	-1.03**	19.29**	-0.85**
74.	Mutant 4 × Kota Barani 3	-1.07	-1.28	20.84**	0.55**	99.66**	1.20**	3.29**	9.78**	-1.26**
75.	Mutant 4 × Pratap Alsi-1	1.81	-5.73*	-10.10**	0.70**	-18.66**	0.04	-0.70**	-14.2**	2.15**
76.	Mutant 4 × Arpita	-1.62	-0.12	-4.81*	3.50**	6.40	1.62**	0.15	6.37**	0.50
77.	Mutant 4 × TL 99	4.95**	4.94	2.52	-2.02**	38.49**	-2.39**	0.70**	26.55**	-0.88**
78.	JLS 95 × JLS 79	-0.44	7.86**	19.64**	-0.96**	-13.16**	2.40**	-0.03	-10.74**	-2.01**
79.	JLS 95 × Mau Azad Alsi-2	-1.42	8.20**	-7.36**	0.25	-10.70**	-1.87**	-0.97**	-2.89	-2.71**
80.	JLS 95 × Kota Barani 4	2.09	-2.65	-10.43**	1.17**	-19.91**	-0.83**	-0.98**	-5.88**	2.86**
81.	JLS 95 × Kota Barani 3	1.64	-1.65	-10.10**	0.02	-25.95**	-3.00**	-1.47**	9.28**	3.29**
82.	JLS 95 × Pratap Alsi-1	-0.48	-4.43	3.45	0.66**	5.42	1.38**	0.39*	0.97	-1.98**
83.	JLS 95× Arpita	1.42	-2.16	-0.59	-0.71**	7.53*	0.10	0.35	-0.85	0.52
84.	JLS 95 ×TL 99	-1.01	-3.77	-0.46	0.61**	4.13	1.90**	-0.26	-0.78	0.25
85.	JLS 79 × Mau Azad Alsi-2	4.42**	-4.33	0.09	0.78**	7.55*	-1.49**	0.71**	0.47	-0.31
86.	JLS 79 × Kota Barani 4	2.27	-3.18	-5.04*	3.70**	23.91**	-0.76**	-0.18	2.31	-0.57
87.	JLS 79 × Kota Barani 3	-3.52*	-4.18	3.10	-0.12	31.36**	2.99**	-0.05	4.23*	1.36**
88.	JLS 79 × Pratap Alsi-1	-2.64	-2.63	5.24*	-2.39**	-11.02**	-2.09**	-0.12	-9.17**	5.51**
89.	JLS 79 × Arpita	-1.069	-1.02	-1.47	-0.68**	36.09**	1.55**	-0.47**	-10.49**	-1.91**
90.	JLS 79 × TL 99	-0.83	-0.63	6.41**	-0.53**	14.77**	1.10**	0.52**	8.14**	7.24**
91.	Mau Azad Alsi-2 × Kota Barani 4	-2.72	1.82	2.17	-2.09**	-21.05**	-2.14**	-1.22**	12.77**	0.82
92.	Mau Azad Alsi-2 ×Kota Barani 3	-0.17	-0.51	0.64	-1.25**	17.84**	0.48*	0.47**	-3.82*	0.91**
93.	Mau Azad Alsi-2 × Pratap Alsi-1	3.05*	8.37**	5.66**	2.81**	44.86**	-1.60**	0.75**	2.09	-1.85**
94.	Mau Azad Alsi-2 × Arpita	0.62	-3.02	0.45	-0.81**	-8.03*	1.07**	-0.18	0.41	4.61**
95.	Mau Azad Alsi-2 × TL 99	5.19**	-2.29	-6.50**	-1.33**	-5.60	-0.56*	-0.05	6.70**	-0.10
96.	Kota Barani 4 × Kota Barani 3	-1.32	-1.69	-3.13	2.51**	-5.55	-0.41	0.58**	1.39	2.32**
97.	Kota Barani 4 × Pratap Alsi-1	-1.44	-1.14	-5.85**	1.74**	21.07**	-2.85**	0.84**	0.04	0.44
98.	Kota Barani 4 × Arpita	-0.54	0.14	-8.29**	-0.30*	-16.65**	-0.69**	-0.02**	-5.61**	-1.21**
99.	Kota Barani 4 × TL 99	-3.30*	-1.80	1.65	-1.07**	19.41**	0.29	0.98**	-4.99**	-1.54**
100.	Kota Barani 3 × Pratap Alsi-1	1.78	1.20	-6.92**	1.08**	10.94**	-3.54**	1.26**	14.04**	-1.69**

101.	Kota Barani 3 × Arpita	1.34	3.80	11.62**	1.55**	7.14*	2.60**	1.61**	-10.20**	-2.28**
102.	Kota Barani 3 × TL 99	-2.09	0.20	8.54**	4.23**	3.70	-0.13*	1.51**	-1.39	-1.28**
103.	Pratap Alsi-1 × Arpita	2.89**	12.02**	7.23**	-1.64**	-19.16	1.57**	-0.27	16.49**	-1.21**
104.	Pratap Alsi-1 × TL 99	4.46**	-2.26	7.40**	0.50**	19.44**	2.13**	1.56**	5.06**	-1.89**
105.	Arpita × TL 99	-1.64	1.35	-7.48**	-0.87**	1.13	-0.52*	0.64**	-9.67**	-2.32**
	S.E. (sij)	1.40	2.61	2.04	0.14	3.62	0.23	0.18	1.89	0.34

Table 3: Potential identified crosses

Sr. No.	Name of crosses	Seed yield plant^{-1} (g)				Number of capsules plant^{-1}				1000 seed weight (g)			
		Mean	SCA effects	GCA effects of parents		Mean	SCA effects	GCA effects of parents		Mean	SCA	GCA effects of parents	
1	PKV NL 260 × Indira Alsi-32	8.73**	-0.59**	0.446**	0.234**	161.80**	-21.70**	-8.592	8.521	8.58	0.31	0.34**	0.119*
2	Kota Barani 4 × Arpita	4.38**	-0.02**	0.015	-0.002	57.42**	-16.65**	-0.629	-0.316	11.54**	-0.69**	-0.222	0.409**
3	PKV NL 260 × Neela	3.96**	-1.40**	0.446**	0.775**	48.97	-22.40**	-8.592	16.649	7.96	-2.35**	0.34**	0.395**
4	Mau Azad Alsi-2 × TL 99	3.33**	-0.05**	-0.115	0.023	65.55**	-5.60	-5.164	4.257**	8.18	-0.56*	-0.624	0.092
5	JLS 79 × Pratap Alsi 1	3.12	-0.12	-0.547	0.173**	81.00**	-11.02**	-2.453**	-1.203	6.17	-2.09**	0.570**	0.381**
6	Mutant-2 × TL 99	2.97**	-0.51**	0.201**	0.023	91.00**	-9.79*	-1.228	4.257**	4.84	-0.74**	0.201**	0.092
7	Neela × JRF 2	2.70	-0.78**	0.755**	-0.453**	47.12	-18.30**	16.649**	-8.735**	7.83	-1.68**	0.395**	0.238**
8	JLS 9 × Mau Azad Alsi-2	2.42	-0.89**	-0.631**	-0.115**	62.08**	-26.55**	-2.625**	-5.164**	8.55	-1.28**	-1.039	-0.624**
9	JLS 95 × Mau Azad Alsi-2	2.37	-0.97**	-0.471**	-0.115**	42.44	-10.70**	-12.31**	-5.164**	5.33	1.87**	0.646**	-0.624**
10	Neela × Mutant-4	2.32	-1.54**	0.755**	-0.071	88.50**	-43.56**	16.649**	5.74**	8.62	-2.31**	0.395	-0.879
11	JLS 95 × Kota Barani 3	2.18	-1.47**	0.471**	0.453**	79.50**	-25.95**	-12.31**	8.085**	10.96**	-3.00**	0.646**	0.514**
12	JRF 2 × Kota Barani 3	1.66	-1.61**	0.462**	0.453**	26.02	-35.03**	-8.735**	8.085**	9.40**	-2.19**	0.238**	0.514**
13	JLS 95 × Kota Barani 4	1.61	-19.91**	-0.471**	0.015	63.33**	-19.91**	-12.31**	-0.629	6.47	-0.83**	0.646**	-0.222**

Conclusion

The crosses PKV NL 260 × Indira Alsi-32, Kota Barani 4 × Arpita, PKV NL 260 × Neela, Mutant-2 × TL 99, Mau Azad Alsi-2 × TL 99, JLS 79 × Pratap Alsi 1, Neela × Mutant-4, JLS 95 × Mau Azad Alsi-2, JLS 9 × Mau Azad Alsi-2, JLS 95 × Kota Barani 3, JRF 2 × Kota Barani 3, JLS 95 × Kota Barani 4, Neela × JRF 2 were identified as most promising crosses for yield and yield components. The presence of negative SCA effects for yield components in the above crosses indicates the presence of predominant role of additive gene action for yield components, which is general situation observed in the autogamous crops. These crosses therefore found be the best crosses which can be forwarded to the next generation for their use in varietal breeding programme in linseed.

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