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COMBINING ABILITY ANALYSIS IN LINSEED (*Linum usitasissimum* L.)

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ABSTRACT

Evaluation of combining ability was done by using 34 lines and 3 testers in a line × tester mating design to developed 102 crosses in linseed during *rabi* 2018-19. In *rabi* 2019-20, a total of 139 entries (37 parents + 102 F_1) were evaluated in Randomized Block Design at farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. The observations were recorded on 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 yield plant^{-1} (g), budfly infestation (%) and alternaria blight infestation (%). The analysis of variance to test the significant differences in the mean values of 2019-20 revealed that highly significant differences existed among genotypes for all nine quantitative characters. Mean squares due to line were significant for all the characters except days to maturity, number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight. The mean squares due to testers were significant for all the characters except days to maturity, number of branches plant^{-1}, number of capsules plant^{-1}, alternaria blight infestation (%) and seed yield plant^{-1}. Mean squares due to line x tester interactions were significant for all the characters except number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight. Five parents *viz.,* NL 451, NL 442, NL 441, NL 371 and NL 435 possessed positive significant GCA effects for seed yield plant^{-1}. But none of these parents possessed high mean performance for seed yield plant^{-1}. Hence, these parents can be used in hybridization. The parents NL 351 and NL 450 possessed higher mean performance for seed yield plant^{-1} hence can be utilized in varietal development programme. Significant negative SCA effect for seed yield plant^{-1} was displayed by the crosses NL 448 × T 397, NL 436 × PKV NL 260, NL 351 × LSL 93, NL 439 × PKV NL 260, NL 452 × T 397, NL 351 × T397 and NL 457 × T 397. The presence negative SCA effects for seed yield plant^{-1} in the crosses indicated the predominant role of additive gene action for yield components.

(Key words: Linseed, combining ability, GCA, SCA)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) belongs to genus *Linum* of the family Linaceae. It is commonly known as 'alsi' or *'Tisi'*. The somatic chromosome number of the cultivated species is 2n = 30. Combining ability studies provide useful information for selection of good combiners, which are expected to give high performance in their crosses and progenies.Nature and magnitude of combining ability effects help in identifying superior parents and their utilization in further breeding programme. Keeping this background in view, the present study was undertaken.

MATERIALS AND METHODS

The experimental material comprised of 34 lines and 3 testers crossed in line x tester fashion to obtain 102 crosses during *rabi* 2018-19. These 102 crosses along with 37 parents were grown in Randomized Block Design in two replications with the spacing of 30 cm x 5 cm during *rabi* 2019-20 at farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. Five plants were taken randomly from each plot for recording the observations. Observations were recorded for nine quantitative characters viz.,Days to 50% flowering (on plot basis), days to maturity (on plot basis), plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight (g), seed yield plant^{-1} (g), budfly infestation (%), alternaria blight infestation (%). The combining ability analysis was carried out as per standard method given by Kempthrone (1957) and ANOVA as per Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Data regarding analysis of variance for combining ability has been presented in Table 1. Mean squares due to

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Table 1.Analysis of variance for combining ability in linseed

Source of variation	d.f.	Mean sum of squares								
		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	Bud fly infestation (%)	Alternaria blight infestation (%)	1000 seed weight (g)	Seed yield plant^{-1} (g)
Lines	33	28.588*	15.788	104.038*	0.425	469.853**	4.897	3.407*	1.526	14.844**
Testers	2	15.235	173.77**	156.103**	0.005	23.461	10.549**	1.878	3.981*	0.784
Lines x Testers	66	39.872**	37.209*	185.971**	0.659	1,257.64**	5.324	2.494*	0.990	19.772**
Error	101	4.433	5.67	18.16	0.281	17.575	1.513	0.584	0.636	0.489
GCA vs. SCA(Baker,1978)		0.644	0.846	0.661	0.564	0.433	0.792	0.777	0.876	0.606

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

Table 2. Mean performance (m) and general combining ability effects (gca) of the parents for different characters

Sr. No.	Genotypes	Days to 50% Flowering		Days to Maturity		Plant height (cm)		Number of branches plant^{-1}		Number of capsuls plant^{-1}		1000 seed weight (g)		Seed yield plant^{-1} (g)		Bud fly infection (%)		Alternaria blight infestation (%)	
	Lines	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
1	NL 350	65	-0.245	121	-1	61.2	-4.088*	4.2	0.306	37.4	-11.875**	8.800	-0.043	2	-0.713	4.2	-1.301**	1.5	0.227
2	NL 351	61	-0.245	116	-0.667	77.9	-0.465	3.9	-0.172	34	-3.856**	9.200	-0.576**	1.45	-1.839**	3.8	-0.035	3.6	0.244
3	NL 356	68	3.422	131	2	98.8	-4.546*	2.6	-0.294	29	14.941**	10.600	-0.143	1.6	0.274	2	-2.051**	0.8	-1.262**
4	NL 371	63	0.088	126	2.333*	83	0.054	3.1	-0.011	32.9	9.4**	10.400	0.190	1.9	1.404**	3.3	0.849**	0.6	0.713
5	NL 430	61	6.755**	131	4.667**	76.6	-4.438**	4	-0.077	45.9	-5.809**	10.600	-0.843	1.3	-0.803**	6.5	-0.51**	3	0.622**
6	NL 431	68	-1.912	119	-1	83	0.757	4.3	0.439	38.6	-1.167	9.200	-0.143	0.9	1.437**	3.5	-0.154	1.7	1.055*
7	NL 432	61	-0.245	129	3	77.9	8.521**	4.6	-0.027	48.4	6.875	8.600	0.357	2.5	0.874	4.6	-0.251	2.2	-0.478
8	NL 433	66	-2.245	115	0	78.5	-5.513**	5.3	-0.111	42.4	-3.725	10.600	0.324	1.8	-1.106**	4.4	0.599**	2.2	0.538
9	NL 434	58	0.422	129	-0.333	73.3	-6.457*	5.6	-0.027	42.1	-10.409**	10.000	-0.310	2.2	-1.609**	5.5	1.382**	3	0.222
10	NL 435	65	-0.912	113	-0.667	76.4	-4.043**	4	0.056	34.5	-0.962	9.200	-0.976**	2.2	2.937**	1.3	0.035	0.4	0.083
11	NL 436	66	-1.578	117	0.167	81.8	-4.946	3.8	0.006	40	-14.625**	11.600	0.190	1.7	-0.159	4.3	1.324**	0.1	1.005**
12	NL 438	67	-2.578	130	0	76.8	-5.418**	4.3	0.178	48	-9.692**	7.000	0.357	3.2	0.197	4	0.849	0.7	1.372**
13	NL 439	67	-2.578	126	0	78.5	6.787**	4.7	-0.136	31.7	2.325	8.000	0.124	2.4	0.287	2.3	-0.36	0.8	0.097
14	NL 440	68	1.088	130	1.667	75.8	4.287	4.2	-0.327	46.4	14.475**	9.800	0.957**	1.2	0.567	3.8	0.149	0.5	0.805**
15	NL 441	65	-2.912	125	-1.333	56.6	-2.813**	3.9	-0.561**	32.3	-1.142	12.400	0.457	2	2.811**	0.8	-0.218	0.3	0.688**
16	NL 442	67	-2.912	129	-0.667	82	0.187	5.1	-0.077	47.7	2.625	12.200	0.124	1.4	0.954*	4.2	-0.335	1.3	0.438
17	NL 443	56	-1.578	114	-0.333	62.1	-1.068	6.2	0.328	40.7	-1.487	12.000	0.057	2.9	1.047	4	-1.812	1.6	-0.612
18	NL 444	69	-1.245	129	-1.333	97.6	5.048**	4.3	0.259	41.7	-3.917	9.200	-0.460	1	-1.206**	1.9	-1.482**	0.5	-0.395**
19	NL 445	70	2.422	127	2	62.5	5.412	3	-0.194	29	-10.317**	8.800	0.440	2.6	-1.203*	7.5	1.015*	1.5	0.072
20	NL 446	68	3.088	121	-1	77.2	2.937	3.9	-0.172	39.9	-5.917	9.200	-1.010**	1.7	-2.373**	5.8	0.29	2.7	0.063
21	NL 447	69	-1.245	130	-0.333	89.2	-0.577	3.6	-0.066	36.8	-2.942	9.400	0.524	1.3	-0.549	2.4	0.593	0.6	-0.406
22	NL 448	70	-1.245	131	-0.333	78.1	-8.69**	4.7	0.123	39.7	3.219	10.600	0.407	1.6	-1.463**	4.7	0.226	0.8	-0.806*
23	NL 449	68	1.755	126	-0.667	80.1	-1.213	3.8	-0.027	42.9	1.241	9.600	0.857**	1.6	0.111	3.8	1.215**	1.4	0.738

24	NL 450	58	0.088	110	1.333	83.9	4.054	3.9	0.056	37.5	-0.037	8.400	0.274	1.6	-0.059	2.9	-0.296**	0.6	-0.82**
25	NL 451	66	1.088	122	0	73.4	3.118	2.8	0.084	40.8	1.277	10.000	-0.210	1.4	1.777**	3.9	-0.376	0.5	0.008
26	NL 452	66	-1.245	130	0.333	69.3	-2.09	4.5	0.523**	43.8	-10.903**	9.200	0.157	2.3	0.344	2.2	-0.196	0.2	-1.423**
27	NL 453	61	2.088*	123	-0.333	75.2	1.771	4.5	0.473	47.3	10.125	10.200	-0.876**	2	-1.939**	3.4	-0.418	1.4	-1.062
28	NL 454	68	1.588	128	1.667	78	-0.454	4	-0.486*	43	-10.684**	7.400	-0.143	1.3	-2.306**	1.5	1.374**	0.5	1.097**
29	NL 455	68	3.255**	130	-0.5	74.7	3.076**	3.9	-0.144	45.3	-6.048*	8.600	-0.643**	1.9	-0.753**	1.5	0.938**	0.6	-0.395
30	NL 456	70	0.755	117	-0.667	72.7	4.571**	6.2	0.414**	44.9	8.583**	11.000	-0.476**	1.4	1.007**	3.2	1.124	0.9	0.497
31	NL 457	68	1.422	121	0.333	68.6	1.504*	2.8	0.273	42.8	23.058**	9.000	0.557**	3	1.934**	2.6	0.099	1	-0.595
32	NL 458	58	-0.578	113	-2.333	69.4	2.621	3.7	-0.361	52.6	8.341**	8.600	0.090	1.1	3.677**	1.7	-1.118	0.7	-0.078
33	NL 459	68	-1.912	125	-4	68.2	3.254	3.6	-0.111	33.5	11.975**	11.400	0.424**	2.8	-1.116**	2.8	-0.418	1.4	-1.178**
34	NL 460	57	-1.912*	131	-2	75.4	-1.14**	3.4	-0.138	37.6	-2.942	12.000	-0.010	2.2	-2.446**	1.1	-0.729	0.6	-1.078**
	SE (g_i)		**0.208**		**0.236**		**0.422**		**0.053**		**0.415**		**0.079**		**0.069**		**0.122**		**0.076**
	Testers																		
35	LSL 93	51	0.529	131	-0.113	62.2	0.93	5.5	-0.007	37.5	0.669	6.800	-0.153	1.6	-0.082	2.4	0.287	1	-0.147
36	PKV NL 260	67	-0.147	129	-1.539	73.1	-1.749	3.6	-0.003	33	-0.24	9.600	0.279**	3.5	0.122	1.4	-0.449	0.7	-0.033
37	T 397	66	-0.382	128	1.652	76.8	0.819	4.4	0.01	39.8	-0.429	11.800	-0.125	1.7	-0.04	3.3	0.162	1.7	0.18
	SE(g_j)		**0.847**		**0.958**		**1.714**		**0.213**		**1.686**		**0.321**		**0.281**		**0.495**		**0.307**

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

Table 3. Mean performance (m) and specific combining ability effects (sca) of crosses for different characters

Sr. No.	Crosses	Days to 50% flowering		Days to maturity		Plant height (cm)		Number of capsules plant^{-1}		Seed yield plant^{-1} (g)		Alternaria bliht infestation (%)	
		Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
1	NL 350 X LSL 93	58	-0.196	110	0.779	55.4	-0.75	41.4	-19.853**	2	-4.125**	1.9	-0.908
2	NL 350 X PKV NL 260	58	-0.196	110	0.446	68.2	8.423**	61.3	-7.972**	3.6	-1.398*	2.1	-0.725
3	NL 350 X T 397	69	7.137**	118	5.779**	52	-3.696	35.5	-52.569**	5.49	-1.622**	2	0.681
4	NL 351 X LSL 93	56	-2.529*	108	-4.554*	56.2	-4.096	81.475	-1.053	8.06	-0.182**	1.875	-1.419**
5	NL 351 X PKV NL 260	70	4.804**	110	-4.887	48	-7.805	48.5	-18.819**	6.12	0.085	1.5	-1.703**
6	NL 351 X T 397	56	-0.529	108	-1.221	53.833	-7.166	65.5	-6.461**	7.17	-1.105**	1.917	-1.719
7	NL 356 X LSL 93	61	2.804	113	-0.221	73.5	4.737**	69.5	-10.503**	5.22	-2.492**	1	-1.103**
8	NL 356 X PKV NL 260	60	3.804	112	1.779	49.6	-5.13**	71.5	2.097	3.2	-2.532**	3.9	0.781**
9	NL 356 X T 397	60	1.137	114	4.113	49.5	-4.285**	46	-16.719**	2.2	-3.028**	3.5	0.697
10	NL 371 X LSL 93	55	-2.529**	107	-2.554*	43.333	-12.866**	93.75	21.583**	12.1	2.325**	0.917	-1.747**
11	NL 371 X PKV NL 260	57	0.137	113.5	3.113*	53.5	-1.796	23.5	-35.003**	2.15	-4.528**	3.75	0.164
12	NL 371 X T 397	56	0.137	110	-0.221	49.5	-5.324*	71	7.564	6.12	-0.915**	4.5	0.547
13	NL 430 X LSL 93	55	-0.863	108	-2.221	62.5	-4.529	75.4	-0.053	9.33	2.205**	2.5	-0.178
14	NL 430 X PKV NL 260	61	1.471	111	-0.887	69	4.47	102.9	15.297**	4.42	-2.985**	3.6	0.214
15	NL 430 X T 397	60	4.471*	113	4.113*	67.8	10.371**	45.6	-26.386**	4.86	-4.788**	2.8	-0.469*
16	NL 431 X LSL 93	56	0.471	109	-0.554	70	9.57	81.25	5.497	4.48	-3.312**	4.5	1.481**
17	NL 431 X PKV NL 260	64	7.137**	116	6.113**	69.833	10.659**	63.667	-7.975**	3.97	-3.915**	2	0.031

18	NL 431 X T 397	62	4.804*	114	5.113	76.583	11.293**	61.25	-7.961	6.66	1.028**	3.125	0.939**
19	NL 432 X LSL 93	55	-5.863	108	-4.221	52.475	-13.18**	84.875	22.064**	5.33	-0.305	3.475	0.822**
20	NL 432 X PKV NL 260	65	3.471	109	-0.221	61.25	-1.93	92.75	25.539**	8.85	4.385**	4.5	1.856**
21	NL 432 X T 397	56	-1.196	110	0.113	71	11.334**	88.3	18.114**	12	5.712**	1.8	-0.375
22	NL 433 X LSL 93	53	-4.196	106	-3.887	60.7	9.148**	90.7	14.353	7.88	2.505**	2.1	0.325
23	NL 433 X PKV NL 260	55	-5.196	108	-1.554	57.1	-1.929**	75.4	1.031	6.82	-0.128	5.1	1.781
24	NL 433 X T 397	55	-3.529	110	-1.554	70.3	6.004**	52.6	-20.492**	7.31	0.532	1.5	-0.261
25	NL 434 X LSL 93	56	-3.529	112	1.779	50.333	-13.027**	68.75	-5.655*	14.6	5.985**	3.5	0.911
26	NL 434 X PKV NL 260	58	0.804	114	3.446	57.917	-0.235	75.167	12.942**	7.54	0.358	1.167	0.008
27	NL 434 X T 397	63	2.471	113	3.113	66	3.987**	126.5	43.247**	5.7	0.802**	1	-0.519
28	NL 435 X LSL 93	55	-5.029*	106	-5.887**	46.075	-13.713**	67.325	4.881	7.02	2.488**	4.475	0.797**
29	NL 435 X PKV NL 260	56	-5.696	105	-4.721	71	7.682**	68.4	1.32	5.7	-0.385	2.2	0.014
30	NL 435 X T 397	61	1.804	111	1.446	64.4	-0.413	99.5	17.789**	7.72	-0.125	2.75	-0.328
31	NL 436 X LSL 93	57	-2.863**	107	-3.554**	57	-4.746	87	-9.186	13.4	4.628**	1	-0.986
32	NL 436 X PKV NL 260	56	-1.863	107	-0.887	73.5	10.637**	90.1	8.631**	8.67	-1.845**	2.2	-0.303
33	NL 436 X T 397	58	1.471	106	-0.221	76.3	12.804**	105.7	20.597**	9.55	3.828**	2.4	0.997**
34	NL 438 X LSL 93	54	-2.529*	111	2.779**	44.6	-14.502**	74.3	4.114*	7.24	2.848**	1.2	-0.303
35	NL 438 X PKV NL 260	58	0.48	110	2.206	52.9	-0.576	90.1	29.757**	8.95	2.622**	4.2	1.277**
36	NL 438 X T 397	61	3.48**	111	2.873	55.042	-2.057	41.708	-26.655**	6.11	0.908	3.917	0.977**
37	NL 439 X LSL 93	54	-7.186**	106	-4.794**	46	-7.018**	159.5	72.34**	8.15	0.835	1	-0.434
38	NL 439 X PKV NL 260	62	4.147**	112	0.873	62.5	4.882**	69.5	-12.118**	7.8	-0.645**	3.75	0.341
39	NL 439 X T 397	68	3.48**	118	4.539	66	12.874**	43	-23.41**	6.23	-0.008	4.75	1.433**
40	NL 440 X LSL 93	51	-4.853**	102	-5.794**	57	-1.321	89	17.948**	12.9	4.422**	5	1.25
41	NL 440 X PKV NL 260	58	0.48	111	-0.794	68.25	2.165**	72.75	-6.343**	8.18	0.265	2	-0.217
42	NL 440 X T 397	53	-2.52	104	-4.794**	63.5	11.449**	79.5	11.007**	5.75	-0.185	2.5	-0.734
43	NL 441 X LSL 93	55	-3.186	106	-2.461	48.167	-2.94	63.75	1.94	6.3	0.868	3.25	0.333
44	NL 441 X PKV NL 260	63	6.147**	114	5.873**	56.6	3.079	63.7	-7.557**	9.97	-0.008	5.1	2.322**
45	NL 441 X T 397	58	1.814	111	2.039*	57	4.382**	52.5	-5.093	8.74	1.858**	3.75	0.05
46	NL 442 X LSL 93	54	-1.186	105	-3.794	57.083	4.938**	55.5	-7.027	7.07	-0.168	4.2	0.133
47	NL 442 X PKV NL 260	56	0.814	108	-0.794	65.2	0.849	37.5	-37.043**	5.3	-2.028**	3.9	1.108*
48	NL 442 X T 397	61	2.147	112	1.539	67.3	5.449**	74.2	-12.493**	4.84	-2.768**	3	-0.5*
49	NL 443 X LSL 93	51	-3.853	102	-5.461	39.2	-15.551**	80.1	9.023**	15.4	5.548**	3.2	-0.184
50	NL 443 X PKV NL 260	51	-3.853**	102	-6.127**	60	2.249	56	-18.843**	9.14	1.145**	3	-0.134
51	NL 443 X T 397	51	-5.186**	103	-5.461**	53.9	-2.596**	64	-6.732**	10.9	2.812**	3.1	1.016**
52	NL 444 X LSL 93	54	-2.52	106	-1.461	70	7.388**	83.375	15.073**	7.18	1.345*	0.875	-1.425**
53	NL 444 X PKV NL 260	59	-1.186	111	0.206	60	-2.976	47.5	-14.402**	3.35	-2.488**	2.75	-0.017
54	NL 444 X T 397	63	2.147	113	5.206**	71	10.499**	26	-40.302**	1.4	-3.268**	1.5	-1.259*
55	NL 445 X LSL 93	58	1.48	113	4.539*	50.25	-6.737	78	8.723	3.48	-3.012**	2	-0.289
56	NL 445 X PKV NL 260	54	-2.52	106	-2.461	37	-11.874**	61.5	-13.938**	4.1	-1.478**	0.5	-1.389**
57	NL 445 X T 397	69	9.48	111	2.873**	59.5	3.149**	60.1	-13.36**	5.03	-2.122**	1.9	-1.534**
58	NL 446 X LSL 93	54	-3.853	108	-2.127*	51.3	-10.318**	83	10.818*	8.37	1.388**	2.225	0.35
59	NL 446 X PKV NL 260	63	4.147	110	1.206	64	3.318	87.5	14.004**	5.25	-3.568**	2	-0.703
60	NL 446 X T 397	58	1.48	110	0.873	50.5	-4.974	55	-6.316*	5.62	-1.765**	1	-0.273
61	NL 447 X LSL 93	56	-3.853**	106	-2.461	46	-13.335**	79	-3.343	7.76	2.658**	1.5	-0.134
62	NL 447 X PKV NL 260	60	0.647	111	0.539	64.5	7.39**	87.5	25.965**	5.17	0.435	2.5	-1.292*

63	NL 447 X T 397	61	-0.02	111	2.706**	61.167	0.526	95.833	29.662**	10.7	4.412**	1.5	-0.8
64	NL 448 X LSL 93	57	-1.52	107	-1.127	54.25	-7.885**	66.125	-14.677**	7.51	-0.538	1.625	-1.567**
65	NL 448 X PKV NL 260	60	0.814	112	2.873**	61.2	2.132**	98.3	3.023	7.06	-1.915*	3.9	1.8**
66	NL 448 X T 397	63	5.814**	114	7.539**	59.8	-0.385	94.3	13.74**	8.72	-1.998**	3	0.383
67	NL 449 X LSL 93	54	-1.853	107	2.206	55.4	-5.418**	90.1	5.907**	3.36	-2.565**	1.75	0.233
68	NL 449 X PKV NL 260	56	0.147	106	-0.794	65.667	9.243**	70	0.723*	3.6	-0.995**	1.5	-0.117
69	NL 449 X T 397	57	-0.284	108	-2.985**	57.375	1.331	50.25	-9.904**	7.67	1.503**	2.767	-0.369
70	NL 450 X LSL 93	54	-3.284**	108	-3.319**	53.3	-6.366**	102.8	34.627**	5.53	0.49	2.9	-0.252
71	NL 450 X PKV NL 260	61	0.049	113	-0.985	66.3	10.714**	67.2	-19.771**	7.94	0.787*	1.4	-0.247
72	NL 450 X T 397	56	-1.618	118	3.681	59.4	-0.786	94.6	13.171**	9.11	0.827	4.7	1.078**
73	NL 451 X LSL 93	56	-8.284**	117	0.348	50.625	-5.069**	108.45	42.229**	6	-0.077	3.8	0.27
74	NL 451 X PKV NL 260	61	5.382**	118	7.015**	69.375	8.486	59.375	-11.487*	5	-3.317**	4.433	0.47*
75	NL 451 X T 397	54	-3.284	116	1.015	61.75	-6.903	95.75	16.846**	9.98	2.227**	3.75	1.32**
76	NL 452 X LSL 93	54	-1.284	115	3.015	48.3	-6.319**	55.2	-13.104*	8.49	2.717**	3.4	-0.047
77	NL 452 X PKV NL 260	60	2.049	110	-1.652	60.9	7.225**	76.4	14.779**	7.43	2.16**	2.1	-1.03
78	NL 452 X T 397	53	-3.618	108	-3.319	65.875	9.786*	57.042	-14.026**	7.5	-2.317**	2.417	-0.575**
79	NL 453 X LSL 93	54	-1.951	107	-5.152	52.6	-2.586**	97.5	40.096**	9.39	2.67**	3.7	-0.213
80	NL 453 X PKV NL 260	56	1.049	116	4.015**	55.1	0.386	61.8	-0.537	8.16	1.083	3.6	-0.68
81	NL 453 X T 397	55	0.049	115	3.015	70.6	3.681	111.45	37.096**	6.99	-0.177	2.075	-0.93**
82	NL 454 X LSL 93	55	-3.618	113	-0.652	54.5	-9.919**	83.7	-2.804	13.2	5.753**	4	0.287
83	NL 454 X PKV NL 260	54	-0.618	112	1.348	62.5	5.181	88.25	17.363**	8.93	-0.76	4.25	0.653**
84	NL 454 X T 397	58	3.382	118	6.681**	48.5	-11.819**	88	13.346**	10	2.167**	2	-1.347
85	NL 455 X LSL 93	54	-1.951*	111	-0.652	51	-8.064*	85.25	14.707**	9.03	1.103	1.25	-1.047
86	NL 455 X PKV NL 260	54	-2.284*	107	-3.652	46.5	-18.68*	61	-7.112**	3.3	-2.373**	3	0.487
87	NL 455 X T 397	67	7.049	118	4.015**	81.7	16.156**	54.05	-7.662**	8.47	2.793**	2.175	-0.805
88	NL 456 X LSL 93	55	-5.618**	106	-4.985*	54.5	-8.569**	80.875	14.763**	3.39	-1.117**	2.375	-0.597
89	NL 456 X PKV NL 260	56	-0.284	107	-4.652*	54.958	-4.597	42.25	-26.837**	3.63	-2.7**	3.167	0.664**
90	NL 456 X T 397	63	6.716**	118	6.348	54.167	2.725	74.833	-0.415	4.39	-1.027*	3.167	1.064
91	NL 457 X LSL 93	55	-4.284**	110	-1.319	57.7	-1.219	85.6	12.329**	9.24	2.25**	3.4	-0.247
92	NL 457 X PKV NL 260	65	7.382**	117	3.681**	68.5	4.314**	81.667	9.674**	4.9	-1.92**	2	-0.088
93	NL 457 X T 397	58	-0.618	109	-2.985**	72.958	9.709**	64.958	-8.348	6.24	-2.417**	2.708	-0.208**
94	NL 458 X LSL 93	54	-2.284*	108	-4.319*	63.25	5.209**	54.5	-6.626**	8.63	1.407**	1.75	0.264
95	NL 458 X PKV NL 260	61	1.382	111	-0.652	71.25	9.347**	42.25	-39.904**	1.48	-3.46**	2.5	0.653
96	NL 458 X T 397	63.5	4.382*	119	5.348**	66	6.322**	30.5	-30.846**	1.65	-2.923**	4.5	0.495
97	NL 459 X LSL 93	66.5	5.716*	113.5	2.015	55	-8.208**	35	-30.982**	2.1	-4.027**	3.3	0.787**
98	NL 459 X PKV NL 260	58	-0.284	111	-0.319	73	8.297**	77.5	-3.112**	8.55	0.663	5.3	1.895**
99	NL 459 X T 397	61	2.049	113	0.681	64.25	2.614	101.25	6.163**	6.1	-2.713**	1.5	-0.813
100	NL 460 X LSL 93	53	-3.951*	103	-6.652	52.5	-10.253**	58	-22.371**	14.4	3.843**	2.75	-0.08
101	NL 460 X PKV NL 260	56	0.382	106	-1.985	56	-7.386**	57.5	-26.504**	4.5	-1.263*	0.5	-1.23*
102	NL 460 X T 397	58	2.382*	108	-1.985	64.25	5.259**	64.25	-4.837	2.58	-1.853**	2.25	0.42
	SE(s_{ij})		**1.198**		**1.354**		**2.424**		**2.385**		**0.398**		**0.435**

Note:- sca effect of crosses for number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight (g) was not estimated as mean square due to Line x Tester was non significant.

line were significant for all the characters except days to maturity, number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight indicating substantial genetic variability for general combining ability among lines. The mean squares due to testers were significant for all the characters except days to 50% flowering, number of branches plant^{-1}, number of capsules plant^{-1}, alternaria blight infestation (%) and seed yield plant^{-1} indicating the considerable genetic variability for general combining ability among testers. The line x tester interactions were significant for all the characters except number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight indicating genetic variability for specific combining ability among crosses. The significant mean squares for line, tester and lines x testers were also observed by Prasad *et al.* (2014), Jadhav *et al.*(2011)and Upadhyay *et al*.(2019). Significance of mean squares indicates significant variation among crosses for combining ability hence allows the estimates of gca and sca effects.

The data regarding SCA effects of lines and testers were estimated for nine characters presented in Table 2. SCA effects of crosses for all characters except number of branches plant^{-1}, 1000 seed weight (gm) and budfly infestation (%) calculated and data are presented in Table 4. The SCA effect of crosses for number of branches plant^{-1}, budfly infestation (%) and 1000 seed weight (g) was not estimated as its respective mean square due to Line x Tester was non- significant.

The choice of parents for hybridization programme influences the success in any crop improvement programme. Out of the 37 parents selected in the present study five of the parents namely, NL 451, NL 442, NL 441, NL 371 and NL 435 possessed positive significant GCA effects for seed yield plant^{-1}. But none of these parents possessed high mean performance for seed yield plant^{-1}. Hence, these parents can be used in hybridization programme to get better transgressive segregants. The parents NL 351 and NL 450 possessed higher mean performance for seed yield plant^{-1}. Hence can be utilized in varietal development programme.

Among the 102 crosses studied, the cross NL 448 × T 397 showed negative significant SCA effect for seed yield plant^{-1} and positive significant SCA effect for days to maturity along with high mean performance for seed yield plant^{-1}, number of capsules plant^{-1} with early maturity. Other cross NL 436 × PKV NL 260 possessed negative significant SCA effect for seed yield plant^{-1}, positive non- significant SCA effect for number of capsules plant^{-1} and negative non-significant SCA effect for days to maturity with high mean for all the two characters with early maturity. The cross NL 351 × LSL 93 also exhibited negative significant SCA effect for seed yield plant^{-1} and days to maturity and negative non- significant SCA effect for number of capsules plant^{-1} along with high mean performance for all the two characters with early maturity. NL 439 × PKV NL 260, NL 452 × T 397 and NL 351 × T397 also exhibited negative significant SCA effect for seed yield plant^{-1}, number of capsules plant^{-1} and negative non- significant SCA effect for days to maturity along with high mean performance for all the two characters with early maturity. NL 457 ×T 397 exhibited negative significant SCA effect for seed yield plant^{-1} and days to maturity but negative non- significant SCA effect for number of capsules plant^{-1} along with high mean performance for all the two characters with early maturity. The presence SCA effects for seed yield plant^{-1}, number of capsules plant^{-1} in the above crosses indicated the predominant role of additive gene action for yield components which is a general situation observed in self pollinated crops. Due to the presence of additive gene action in these crosses the genotypes of inherent superiority can be produced from this population by blending and fixing maximum favorable genes.

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