Int.J.Curr.Microbiol.App.Sci (2018) *7*(2): 1602-1611

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 02 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.702.193

Estimate Heterosis for Yield and Yield Components in Linseed (*Linum usitatissimum* L.) Germplasm

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Keywords

Linseed (*Linum usitatissimum* L.), Heterosis, Harvest index

Article Info

Accepted:
15 January 2018
Available Online:
10 February 2018

A B S T R A C T

The present investigation entitled “To the estimate heterosis for yield and yield components in linseed (*Linum usitatissimum* L.) germplasm” was undertaken to collect information on genetic parameters for yield and its components from a ten parents diallel mating design in linseed at Crop Research Centre (Chirodi), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) during *rabi* 2013-14 and 2014-15. The experimental material was comprised of 10 diverse parents and their 45 F_1s excluding reciprocals of a diallel cross. All genotypes were evaluated in a Complete Randomized Block Design with three replications. The data were recorded on twelve characters; days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, 1000 seed weight, biological yield per plant, harvest index, oil content and seed yield per plant. Thirteen cross combinations which showed the highest value of heterosis for seed yield, namely; Sweta × Garima, Sweta × Shekhar, Sweta × Kiran, Sweta × Surbhi, Sweta × Mukta, Garima × Shekhar, Garima × Shubhra, Garima × Kiran, Garima x T-397, Garima × Neelam, Garima × Mukta, Garima × Hira and Shubhra × Neelam over better parent may be exploited for developing hybrids with better yield in linseed.

Introduction

Linseed (*Linum usitatissimum* L.) belongs to the genus Linum of the family Linaceae. The somatic chromosome number of the cultivated species is 2n = 30 is cultivated for the main products, fiber (flax fiber) and seed oil (linseed) or both (dual purpose linseed), but recently it has gained a new interest in the emerging market of functional food due to its high content of fatty acids, alpha linolenic acid (ALA), an essential Omega-3 fatty acid and lignin oligomers which constitute about 57 % of total fatty acids in linseed. Traditionally, the oil pressed from the seed (linseed oil) has been used for a variety of industrial purposes and the oil free meal could be fed to livestock. Omega-3 fatty acids lower levels of triglycerides in the blood, thereby reducing heart disease, 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. Linseed oil contains three times as much Omega-3 fatty acid fatty than Omega-6 fatty acid.

The commercial exploitation of heterosis led to the remarkable yield advances in several cross pollinated crops. In self-pollinated crops, it is now well recognized that heterosis is very useful increasing productivity. The magnitude of heterosis provides a basis for genetic diversity and guideline to the choice of desirable parents for developing superior F1 hybrids so as to exploit hybrid vigour and for building gene pool to be exploitation in population improvement. In the present studies heterosis (mid-parent and better-parent) was estimated for seed yield and some important agronomic traits in F1 generation of linseed genotypes using diallelmodel suggested by Kempthorne (1961).

Materials and Methods

The experimental material included in present study comprised of 45 F1's and 10 parents were grown in a randomized block design with three replications. The experimental at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. The basic experimental material for this investigation comprised ten genotypes of linseed (*Linum usitatissimum* L.) namely Sweta, Garima, Shekhar, Shubhra, Kiran, Surbhi, T 397, Neelam, Mukta and Hira selected on the basis of morphological diversity for different agronomical traits. All possible single cross was made under 10×10 diallel mating system set excluding reciprocals. The data was subjected to analysis of variance according to Panse and Sukhatme (1961) the percent increase (+) or decrease (-) of F1 cross over mid parent as well as better parent was calculated to observe heterotic effects of all the parameters. To estimation of heterosis over the mid-parent and better-parent was calculated using the procedure of Shull, 1908 and (Fonseca and Patterson, 1968) respectively. The difference of F1 mean from the respective mid-parent and better-parent values was evaluated by using t-test according to Wynne *et al.,* (1970).

Heterosis expressed as percentage increase or decrease of F_1s over better parent and economic parent was calculated by using following formula:

Heterosis (%) over better parent = $\frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

Heterosis (%) over mid parent = $\frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$

Where,

$\overline{F}$ = mean value of F1

$\overline{BP}$ = mean value of better parent

$\overline{MP}$ = mean value of mid parent

Results and Discussion

The mean value for fourteen characters of F_1 hybrids were compared with the mid parent and better parent. Estimates of heterosis over better parent (heterobeltiosis) expressed as percentage increase or decrease are presented in Table-1 and described character wise as under:

Days to 50% flowering

Heterobeltiosis for days to 50% flowering ranged from -11.228 (Sweta × Hira) to 24.159 (Garima × Kiran). Ten crosses showed negative significant heterosis over better-parent heterosis. Similarly early flowering in linseed can provide adequate time for grain formation process and can certainly cause early maturity higher yields; therefore, negative heterosis is desirable for flowering. The data presented in Table 1 for 50% flowering showed that out of 45 crosses, Sweta × T-397 (-9.002) exhibited significant earliness for this character followed by Sweta × Mukta showed significant heterosis over mid-parent. Nine crosses showed significant negative heterosis over mid-parent heterosis.

Days to maturity

Heterobeltiosis ranged from -7.534 (Sweta × Shekhar) to 12.074 (Sweta × Shubhra). Out of 45 crosses 9 showed positive better-parent heterosis. Maximum heterosis over better-parent was observed in Sweta × Shubhra. Early maturity is useful in most of the plant species, especially linseed where delayed maturity causes losses to yield and quality of oil due to rise in temperature; therefore, negative heterosis is desirable for early maturity. Heterotic data presented in Table 1 showed that out of 45 crosses, 8 crosses showed significant negative heterosis over mid-parent.

Plant height

Heterobeltiosis for plant height values ranged from -10.048 (Sweta × Kiran) to 58.019 (Kiran × Mukta). Three crosses revealed negative significant heterosis over better parent for dwarf stature.Crosses Shubhra × Hira and Sweta × Neelam showed significant decrease in plant height over mid-parent. Three crosses showed significant negative heterosis and 13 crosses showed significant positive heterosis for plant height. Heterosis estimates over mid-parent (Table 1) showed that out of 45 crosses, 16 crosses had positive effects where values ranged from -32.928 (Shekhar × Shubhra) to 68.441 (Garima × Surbhi). Sixteen crosses showed positive significant heterosis over mid-parent. Better-parent heterosis ranged from -37.107 to 70.970 percent in crosses Shekhar × Kiran and Garima × Surbhi. The positive and significant heterosis over better parent, suggested that good performance for number of primary branches per plant.

Number of secondary branches per plant

Heterobeltiosis over the better parental ranged from -29.727 (Garima × T-397) to 48.688 (Kiran × Surbhi). Fifteen crosses were observed positive and significant heterosisover better parent (Table-I) for a number of secondary branches per plant. Heterosis estimates over mid-parent (Table I) showed that out of 45 crosses, 15 crosses had positive effects where values ranged from -29.227 (Surbhi × T-397) to 40.109 (Shubhra × Neelam).

Number of capsules perplant

Highest positive significant heterosis for more number of capsules per plant over better-parent was observed in crosses Garima × Kiran (46.993) followed by Garima × Shubhra (40.788) and Shekhar × T-397 (40.650). The maximum heterosis for number of capsules per plant over mid-parent (Table 1) was showed by Garima × Kiran (45.205) and Garima × Shubhra (43.700).

Number of seeds per capsules

Heterobeltiosis for number of seeds per capsules over better parental values ranged from -21.254 (Garima × Hira) to 31.265 (Shubhra × Kiran). Out of forty five crosses, only twelve best hybrids observed significant and positive heterosis over better parent (Table 1) which indicated that good performance for more number of seeds per capsule.

Table.1 Estimation Heterosis of crosses for yield components in linseed (*Linum usitatissimum* L.)

Characters	Days to 50% flowering		Days to maturity		Plant height (cm)	
Crosses	MP	BP	MP	BP	MP	BP
Sweta × Garima	-5.625	-5.779**	-1.610	-6.066**	10.302**	11.403
Sweta × Shekhar	4.143**	4.633**	-4.934**	-7.534**	2.566	2.414
Sweta × Shubhra	19.367**	22.428**	11.915**	-12.074**	1.719	1.786
Sweta × Kiran	20.228**	21.311**	4.831	2.086	10.929**	-10.048**
Sweta × Surbhi	9.267**	10.290**	0.010	1.041	1.934	2.087
Sweta × T-397	-9.002**	-11.155**	-3.076**	-4.547**	6.539**	7.720
Sweta × Neelam	-3.360**	-4.698**	3.256**	-3.674**	-7.6.4*	-9.099**
Sweta × Mukta	-8.673**	-10.616**	4.311**	7.944**	-4.061	9.579
Sweta × Hira	-7.589**	-11.228**	-5.639**	-6.101**	8.399	10.869
Garima × Shekhar	3.023**	3.066**	0.700	-1.211	-0.856	-1.820
Garima × Shubhra	12.343**	12.630**	2.790	7.033	13.075**	13.731**
Garima × Kiran	21.857**	24.159**	3.669	1.579	0.742	0.734
Garima × Surbhi	0.581	0.301	0.955	-2.632*	1.443	5.710
Garima × T-397	-7.523**	-9.326**	-0.419	-6.303**	1.173	-1.359
Garima × Neelam	1.145	1.408	3.268	1.000	5.577	6.676
Garima × Mukta	0.436	0.761**	6.666**	5.821**	4.521**	5.715**
Garima × Hira	14.505**	14.745**	-1.075	-5.995	18.850**	35.990**
Shekhar × Shubhra	-7.997**	-8.840**	1.124	-1.468	-1.175**	-2.266**
Shekhar × Kiran	0.194	0.077	1.302	1.178	6.635**	7.389**
Shekhar × Surbhi	-2.099**	-3.383**	4.663	4.862	2.782	4.158
Shekhar × T-397	-2.568	-2.614	-1.392	-5.503**	-1.321	-1.458
Shekhar × Neelam	0.009	0.719	-2.634	-4.895	-1.060	-2.148
Shekhar × Mukta	1.803	1.756	9.747**	8.514**	0.291	0.755
Shekhar × Hira	9.267**	14.855**	2.728	3.556	6.018	6.610
Shubhra × Kiran	5.588	5.255	-1.211	-3.628	-3.006	16.230**
Shubhra × Surbhi	-2.703	-7.411	-1.106	-1.970	0.262	0.446
Shubhra × T-397	-5.257	-10.925	4.641**	6.255**	-0.839	9.704**
Shubhra × Neelam	-4.02	-6.408	-4.838**	-5.080**	8.304**	-0.233
Shubhra × Mukta	-3.313**	-4.999**	3.828	0.059	7.033**	14.406**
Shubhra × Hira	12.901**	13.035**	1.351	0.674	-15.794**	26.726**
Kiran × Surbhi	6.268**	6.019**	1.561	-0.065	1.537	2.535
Kiran × T-397	0.258	0.782	0.195	3.869	0.656	0.384
Kiran × Neelam	2.012	3.747	-0.533	-2.726	8.535	1.123
Kiran × Mukta	3.053	3.478	3.964	2.672	49.509**	58.019**
Kiran × Hira	8.964**	13.687**	3.568	3.376	0.905	0.697
Surbhi × T-397	0.019	1.247	2.925**	-5.386**	9.652	2.399
Surbhi × Neelam	-1.054	-3.509	1.950	1.315	5.539	7.592
Surbhi × Mukta	-4.390**	-7.457**	5.609	2.647	-2.929	-2.180
Surbhi × Hira	9.058**	13.584**	-3.770**	-5.242**	15.182**	35.218**
T-397 × Neelam	-3.310	-6.873	-2.955**	-4.834**	10.535**	11.658**
T-397 × Mukta	-0.413	-4.787	1.117	-4.140	-2.492	-3.662
T-397 × Hira	10.368	15.851**	7.504**	8.464**	22.566**	37.743
Neelam × Mukta	-4.101	-4.833	5.097	1.530	1.389	1.331
Neelam × Hira	13.994**	16.253**	3.087	2.141	20.861**	35.753
Mukta × Hira	14.492	16.109**	2.067	-2.270	19.432**	23.086**

* Significant at 5% probability level ** Significant at 1% probability level

Contd…

Characters	Number Primary branches per plant		Number secondary branches per plant		Number of capsules per plant	
Crosses	MP	BP	MP	BP	MP	BP
Sweta × Garima	1.720	2.842	8.732**	9.048**	0.598	0.543
Sweta × Shekhar	0.570**	1.142	6.880	7.837	17.962**	29.078**
Sweta × Shubhra	1.554	2.791	0.180	0.244	21.379**	22.270**
Sweta × Kiran	49.087**	50.337**	1.145	2.947	17.236**	19.457**
Sweta × Surbhi	36.247**	41.097**	1.088	12.294	2.570	1.409
Sweta × T-397	-3.728	-4.197	-6.155**	-7.085**	1.807	1.612
Sweta × Neelam	-6.658**	-6.943**	26.658**	32.887**	-27.732**	36.887**
Sweta × Mukta	24.761**	25.645**	2.703	5.949	2.636	8.356**
Sweta × Hira	-1.609	-1.707	7.668	8.782	1.583	2.805
Garima × Shekhar	58.286**	64.683**	9.800**	8.415**	-3.629**	-4.419**
Garima × Shubhra	0.412	8.721	6.475	-7.744*	43.700**	40.788**
Garima × Kiran	-4.885**	-5.162**	-1.287	-1.179	45.205**	46.993**
Garima × Surbhi	68.441**	70.970**	6.694	7.289	-0.903	0.118
Garima × T-397	1.920	2.207	-18.499**	-29.727**	37.845**	26.582**
Garima × Neelam	40.687**	50.805**	7.894	8.060	2.754	-11.133**
Garima × Mukta	5.701	-6.375	1.579	3.477	-0.174	0.957
Garima × Hira	7.277	9.560	-8.518**	-10.806**	-8.389**	-17.203**
Shekhar × Shubhra	-32.928**	38.558**	-14.190**	-17.870**	13.544	24.672**
Shekhar × Kiran	-30.276**	-37.107	-8.595**	-10.589**	18.377**	31.355**
Shekhar × Surbhi	2.402	4.983	-12.221**	22.886**	26.368**	39.978**
Shekhar × T-397	31.315**	35.566**	32.759**	41.391**	25.629**	40.650**
Shekhar × Neelam	-0.891**	-1.103**	0.805	1.021	-10.624**	-11.680**
Shekhar × Mukta	26.365**	38.558**	14.729**	2.446	4.107	7.337
Shekhar × Hira	5.017	4.045	-3.497	-8.242	-8.429**	-13.820**
Shubhra × Kiran	37.315**	38.372**	-2.880**	-3.315	3.790	7.713
Shubhra × Surbhi	34.059**	41.860**	17.474**	28.717**	-2.757	-1.107
Shubhra × T-397	-2.472**	-3.566**	2.402	3.143	-4.116	-4.297
Shubhra × Neelam	34.788**	41.609**	40.901**	42.448**	0.710	1.784
Shubhra × Mukta	1.238	2.791	8.342	12.963	0.541	1.073
Shubhra × Hira	-3.140	-5.581	2.880	8.593	-0.634	-1.807
Kiran × Surbhi	-28.739**	36.221**	42.718**	48.688**	0.358	3.445
Kiran × T-397	0.931	1.055	36.216**	43.323**	-20.882**	-25.869**
Kiran × Neelam	29.111**	37.471**	1.916	-2.762	15.299**	-2.082
Kiran × Mukta	7.021	-7.341	11.450**	-2.394	-0.886	0.315
Kiran × Hira	1.644	1.930	-14.500**	-16.943**	4.349	6.493
Surbhi × T-397	-9.586**	-9.631**	-29.227**	-29.870**	-3.018	-5.654
Surbhi × Neelam	20.298**	36.092**	22.336**	31.633**	2.017	2.862
Surbhi × Mukta	-7.140	-9.269	29.386**	35.714**	-1.715	-1.365
Surbhi × Hira	-2.504	-6.984	-26.069**	41.399**	-1.284	-2.033
T-397 × Neelam	-17.953**	-21.153**	0.120	-22.427**	25.83**	40.276**
T-397 × Mukta	6.939	7.544	-7.662	-26.864**	-19.098**	33.697**
T-397 × Hira	-7.374	-8.566	21.832**	38.457**	-20.711**	33.572**
Neelam × Mukta	-13.514**	-3.471**	35.336**	31.340**	2.300	2.942
Neelam × Hira	26.404**	-47.586**	-6.047	-8.095	-0.020	-4.839
Mukta × Hira	33.122**	29.897**	-1.927	-2.720	0.555	-2.163

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Characters	Number of seeds per capsule		1000 seed weight (g)		Biological yield per plant (g)	
Crosses	MP	BP	MP	BP	MP	BP
Sweta × Garima	2.088	4.815	13.446**	16.806**	29.590**	34.342**
Sweta × Shekhar	-19.175**	-21.111**	0.671	0.986**	29.112**	30.559**
Sweta × Shubhra	0.122	0.889	13.474**	18.944**	5.667	6.138
Sweta × Kiran	15.364**	17.778**	5.647	6.503	16.114**	18.540**
Sweta × Surbhi	24.884**	27.778**	-19.555**	19.915**	39.174**	39.906**
Sweta × T-397	-8.645**	-10.370**	6.064	2.912	5.133	6.861
Sweta × Neelum	-14.996**	-16.296**	1.738	2.913	-34.474**	-36.503**
Sweta × Mukta	14.912	18.148	31.498**	35.675**	0.312	0.692
Sweta × Hira	-7.361	-10.105	32.144**	37.323**	0.696	1.364
Garima × Shekhar	1.065	3.502	2.544	9.443	25.049**	31.193**
Garima × Shubhra	14.106**	14.106**	20.671**	24.424**	27.606**	38.374**
Garima × Kiran	10.841	10.841	30.630**	32.057**	6.298	7.237
Garima × Surbhi	0.321	0.321	1.006	5.484	1.861	1.202**
Garima × T-397	1.319	1.319	5.890	6.090	19.710**	32.992**
Garima × Neelam	-5.556	-5.556	16.258**	16.031**	26.904**	29.347**
Garima × Mukta	22.934**	22.934**	8.430	9.898	37.576**	41.725**
Garima × Hira	-21.254**	-21.254**	10.630	11.623	23.033**	38.822**
Shekhar × Shubhra	-24.514**	24.514**	10.009	11.311	-9.295	-10.797
Shekhar × Kiran	2.724	2.724	75.303**	73.618**	1.530	2.998
Shekhar × Surbhi	8.949	8.949	-4.179	-5.788	4.163	5.823
Shekhar × T-397	-14.165**	-14.165**	-6.243	-8.411	-1.139	-1.873
Shekhar × Neelam	25.292**	25.292	0.069	1.719	-27.658**	37.500**
Shekhar × Mukta	8.560	8.560	6.243	12.648	27.816**	35.635**
Shekhar × Hira	31.010**	31.010**	2.053	3.587	7.722	9.571
Shubhra × Kiran	31.265**	31.265**	38.684**	48.513**	-0.095	-1.945
Shubhra × Surbhi	3.291	3.291	31.381**	33.882**	-9.634	-10.573
Shubhra × T-397	5.617	5.617	31.579**	33.305**	5.982*	6.467
Shubhra × Neelam	-2.965	-2.965	-2.705	-4.315	-22.295**	-31.898**
Shubhra × Mukta	11.411	11.411	20.943**	20.360**	2.896	6.869
Shubhra × Hira	6.132	6.132	10.380	11.469	-14.121**	-14.661**
Kiran × Surbhi	-12.804**	-12.804**	-15.855**	-16.373**	10.077	11.400
Kiran × T-397	25.327**	25.327**	-6.705	-7.991	-11.807**	-18.383**
Kiran × Neelam	5.378	5.378	15.789	10.095	28.937**	34.525**
Kiran × Mukta	2.019	2.019	-9.786	-10.186	-29.756**	-33.023**
Kiran × Hira	-16.028**	-16.028**	-14.949**	-14.538**	-1.807**	1.949
Surbhi × T-397	25.327**	25.327**	0.704	2.523	3.810	4.312
Surbhi × Neelam	1.926	1.926	-5.122	-9.675	30.348**	41.822**
Surbhi × Mukta	9.149	9.149	-6.366	-9.832	-17.668**	-20.519**
Surbhi × Hira	-18.815**	-18.815**	8.178	-9.129	-6.866	-7.427
T-397 × Neelam	22.633	22.633**	22.077**	27.634**	-18.277**	-29.837**
T-397 × Mukta	29.176**	29.176**	14.165	8.756	11.591	21.682**
T-397 × Hira	8.892	8.892	0.700	1.878	-2.572	4.293
Neelam × Mukta	4.630	4.630	56.250**	54.399**	39.859**	41.988**
Neelam × Hira	-18.118**	-18.118**	9.257	-14.461**	2.346	3.788
Mukta × Hira	1.725	1.725	38.403**	31.952**	4.003	5.403

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Characters	Harvest index (%)		Oil content (%)		Seed yield per plant (g)	
Crosses	MP	BP	MP	BP	MP	BP
Sweta × Garima	1.895	1.819	-3.658	-4.183	32.848**	33.213**
Sweta × Shekhar	6.738	7.082	0.802	1.533	40.208**	45.153**
Sweta × Shubhra	0.770	0.597	3.784	4.637	-1.434	-1.124
Sweta × Kiran	1.837	3.697	-5.114**	-7.936**	31.681**	39.287**
Sweta × Surbhi	1.104	2.879	-7.729**	8.289**	47.354**	35.455**
Sweta × T-397	5.599	11.280**	-0.659	-2.824	1.006	-0.070
Sweta × Neelum	3.935	4.617	-3.558	-4.114	-0.896	-0.649
Sweta × Mukta	3.092	15.254**	1.348	1.972	34.105**	41.176**
Sweta × Hira	-24.179**	-26.296**	0.682	2.778	-1.321	25.246**
Garima × Shekhar	-3.3.99	-4.801	0.072	-2.723	20.653**	32.575**
Garima × Shubhra	-5.888	-11.391**	13.310**	16.566**	32.510**	45.422**
Garima × Kiran	8.937	14.862**	-2.526	-4.919	23.915**	36.043**
Garima × Surbhi	-4.033	-5.532	14.130**	14.184**	0.659	26.999**
Garima × T-397	0.089	13.560**	3.266	4.865	25.348**	34.462**
Garima × Neelam	0.809	0.879	5.014	5.043	20.806**	30.771**
Garima × Mukta	32.796**	39.101**	-5.953**	-6.037**	20.050**	37.764**
Garima × Hira	-14.710**	17.030**	3.603	5.129**	34.006**	42.814**
Shekhar × Shubhra	0.894	0.203	0.408	0.444	-3.034	-0.727
Shekhar × Kiran	2.062	5.671	0.209	0.147	8.842**	0.418
Shekhar × Surbhi	0.749	1.818	-1.198	-3.900	17.718**	0.967
Shekhar × T-397	-0.146	-4.776	7.706**	8.795**	-0.972	-1.662
Shekhar × Neelam	15.688**	21.976**	-2.751	-3.494	-1.913	-1.722
Shekhar × Mukta	5.214	8.043	-1.250	-3.925	-0.813	24.395**
Shekhar × Hira	-26.524**	27.485**	8.423**	9.567**	18.652**	-20.515**
Shubhra × Kiran	7.216	8.401	-2.643	-3.974	-0.256	-0.929
Shubhra × Surbhi	33.013**	34.620**	0.864	0.940	0.953	12.989**
Shubhra × T-397	26.858**	34.980**	1.772	1.441	21.964**	29.112**
Shubhra × Neelam	-2.861	-7.233	1.855	1.941	23.771**	30.441**
Shubhra × Mukta	0.666	0.817	3.803	4.446	22.495**	16.494**
Shubhra × Hira	15.227**	17.634**	-1.541	-3.750	22.581**	28.690**
Kiran × Surbhi	-10.051**	10.325	8.608**	10.799**	0.041	-0.255
Kiran × T-397	-8.911**	19.554**	8.427**	9.188**	-18.440**	-22.467**
Kiran × Neelam	26.964**	22.124**	10.619**	12.787**	-1.239	-13.311**
Kiran × Mukta	28.695**	11.922	8.439**	10.610**	-18.472*	-16.823**
Kiran × Hira	11.241	1.370	8.082	8.910**	-1.099	-0.564
Surbhi × T-397	10.310	2.837	0.376	0.835	19.373**	2.019
Surbhi × Neelam	22.584**	28.259**	-5.421**	-5.450**	13.459**	25.732**
Surbhi × Mukta	34.575**	37.342**	4.705	4.731	28.104**	25.710**
Surbhi × Hira	1.450	2.260	-6.564**	-7.986**	-10.931**	-22.899**
T-397 × Neelam	2.502	3.637	6.653**	8.168**	-1.696	-0.159
T-397 × Mukta	0.157	1.066	-3.092	-4.609	-1.670	14.611**
T-397 × Hira	-0.873	-0.961	-0.505	-0.577	-0.131	-0.589
Neelam × Mukta	35.454**	39.936**	-3.041	-3.098	-0.974	17.130**
Neelam × Hira	6.297	17.549**	-1.073	-2.609	-2.341	-0.337
Mukta × Hira	11.316**	13.495**	-3.026	-4.477	11.895**	-1.552

* Significant at 5% probability level ** Significant at 1% probability level

Over mid-parent heterosis varied from -19.165 (Sweta × Shekhar) to 27.206 (Shekhar × Hira). Whereas, nine hybrids had significant and negative heterosis over mid parent, indicated that poor performance for number of seeds per capsule.

1000 seed weight

Heterobeltiosis for hybrids over their better parental values ranged from -16.373 (Kiran × Surbhi) to 73.618 (Shekhar × Kiran). For 1000 Seed weight fifteen crosses exhibited significant positive heterosis for 1000 Seed weight over mid-parent. Maximum positive heterosis over mid-parent was shown by Shekhar × Kiran (75.303) followed by Neelam × Mukta 25 (56.250) and Shubhra × Kiran (38.684). Seventeen crosses showed positive heterosis over better-parent (Table-1). Maximum positive heterosis for 1000 Seed weight over better-parent was recorded by cross Shekhar × Kiran (73.618) followed by Neelam × Mukta (54.399) and Shubhra × Kiran 5 (48.513). While three hybrids showed negative and significant heterosis over better parent for this character.

Biological yield per plant

Heterobeltiosis for biological yield per plant values ranged from -36.503 (Sweta × Neelam) to 41.988 (Neelam × Mukta). Eighteen hybrids exhibited positive significant heterosis over better parental). For biological yield per plant sixteen crosses exhibited significant positive heterosis for biological yield per plant over mid-parent. Heterotic data presentedinTable1.

Harvest index

Heterobeltiosis ranged from -11.391 (Garima × Shubhra) to 39.936 (Neelam × Mukta). The hybrids viz., Nineteen crosses were observed positive significant heterosis over better parent for harvest index. Whereas, only one hybrid exhibited negative significant heterosis over better parent for this character. Over mid-parent heterosis ranged from -24.179 (Sweta × Hira) to 35.454 (Neelam × Mukta). The 11 hybrids revealed positive significant heterosis over mid parent for this trait, whereas five hybrids showed negative significant heterosis over mid parent for harvest index in Table-1.

Oil content

Over better parent for oil content values ranged from -7.936 (Sweta ×Kiran) to 16.566 (Garima ×Shubhra). Out of forty five hybrids, only twelve hybrids were found positive significant heterosis over better parent for high oil content, while four hybrids showed significant negative heterosis over better parent for low oil content. Heterosis over mid parent varied from -7.729 (Sweta × Surbhi) to 14.130 (Garima × Surbhi). Ten crosses were exhibited significant positive heterosis over mid parent, whereas four hybrids observed significant negative heterosis over mid parent for oil content in Table1.

Seed Yield per plant

In the present study mid-parent heterosis for seed yield per plant ranged from -20.050 to 47.354 percent in crosses (Table 1) Garima × Mukta and Sweta × Surbhi respectively. Twenty one crosses exhibited positive significant mid-parent heterosis and twenty four crosses showed positive and significant heterosis over better parent for high seed yield per plant. Better-parent ranged from -22.899 (Surbhi × Hira) to 45.422 (Garima × Shubhra).

The Similar results on the importance of these traits have been reported by Galkin (1973), Patil and Chopde (1983), Dakhore and Narkhede (1987), Wang *et al.*, (1990), Mishra and Rai (1993),), Saraswat and Kumar (1993),Verma and Sinha (1993), Yadav and Gupta (1999), Sharma *et al.*, (2005), Vishnu *et al.*, (2005), Singh *et al.*, (2005), Mohammadi *et al.*, (2010), Deepak *et al.*, (2011), Yadav *et al.*, (2013), Pali and Mehta (2014) and Kumar *et al.*, (2014).Considering the predominance of non-additive gene action for yield and yield contributing traits manifesting high magnitude of hybrid vigor, heterosis breeding may be useful for improving yield in this crop.

Out of forty five crosses, only thirteen crosses exhibited superiority over better parent (heterobeltiosis) more than 10% for seed yield. The hybrids namely Sweta x Garima, Sweta x Shekhar, Sweta x Kiran, Sweta x Surbhi, Sweta x Mukta, Garima x Shekhar, Garima x Shubhra, Garima x Kiran, Garima x T-397, Garima x Neelam, Garima x Mukta, Garima x Hira and Shubhra x Neelam showed more than 30% heterobeltiosis over better parents. These individual crosses can be exploited in heterosis breeding programme for improvement in seed yield and also suggesting that it is possible to produce higher seed yield varieties.

Acknowledgments

All authors acknowledge the Head, Genetics and Plant Breeding, SVP University of Agriculture and Technology, Meerut provided the facilities and JK acknowledge the ICMR for the fellowship grant during this research.

References

Dakhore, S.R. and Narkhede, M.N. 1987. Heterosis in relation to combining ability effects in linseed (*Linum usitatissimum* L.) Maharashtra Agric. Uni. J. 12(3): 308-310.

Deepak, G.; Rao, S. S. and Pandagare, J. M. 2011. Genetic analysis of yield and yield attributing characters in linseed (*Linum usitatissimum* L.). Asian Journal of Bio Science 6(1):16-22.

Fonseca, S. and Patterson. F. 1968. Hybrid vigour in a seven parent diallel cross in common winter wheat. (*Linum usitatissimum* L.). Crop Sci.8: 85-88.

Galkin, F.M. 1973. Heterosis in inter-varietal hybrids of linseed. Byal Maunchtackhan Malichr Kulhrame, 2: 7-10.

Kempthorne, O., and Curnow, R.N. 1961. The partial diallel cross. Biometrics, 17(2): 229-250.

Kumar, S.; Kumar, R.; Kumar, S.; Singh, H.; Kumar, S. and Singh, M. P. (2014). Estimation of heterosis in linseed (*Linum usitatissimum* L.). J Agric Sci. 10(1):356-359.

Mishra, V.K. and Rai M. 1993. Estimates of heterosis for seed yield and oil linseed *(Linum usitatissimum* L.). Indian J. Genetics. 53 (2): 161-164.

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

Pali, V. and Mehta, N. 2014. Combining ability and heterosis for seed yield and it's attributes in linseed *(Linum usitatissimum* L.).The Bioscan 9(2):701-706.

Panse, V.G. and Sukhatme, P.V. 1961. Statistical methods for agricultural workers. *ICAR, New Delhi 4th edition* 235-257.

Patil, V.D. and Chopde, P.R. 1983. Heterosis in relation to GCA and SCA effects in linseed. Indian J. Genet. 43 (2): 226-228.

Saraswat, A.V. and Kumar, Satyendra 1993. Heterosis and inbreeding depression in some early hybrids of linseed. In heterosis breeding in crop plant theory and application symposium Ludhiana pp 23-24.

Sharma, R.; Tiwari, S.K.; Singh, P. and Ramakant 2005. Heterobeltiosis and inbreeding depression in linseed. Agricultural Science Digest. 25(1): 35-37.

Shull, G.H. 1908. The composition of field of maize, Rept. Am. Breeders Assoc. 4: 246-301

Singh, P.; Singh, D. and Singh, S.K. 2005. Heterosis in relation to other genetic parametersin linseed. Farm Science Journal, 14(2):1-3.

Verma, A.K. and Sinha, P.K. 1993. Heterosis in linseed. Theory and application: short communication: symposium Ludhiana 23-24.

Vishnu, A.; Shah, M.A. and Lakshyadeep. 2005. Studies on heterosis and combining ability for fatty acids in linseed (Linum usitatissimum L.). Indain J. Genetics. 63 (5):29-35.

Wang, YuFu; Yan Zhongfeng; Fan Jian Qiaogu angjun; Lu yun; Wu Guangwen; Wang Diankui; Yang Lijun and Wang Yan hua.1990. Study on heterosis and affinity of flax. Chinas Fibre Crops. No. 2: 10-13

Wynne, J.C., D.A. Emery and P.M. Rice, 1970. Combining ability analysis over environments in spring wheat. Wheat In for. Serv. Japan. 67:21-24.

Yadav, P.; Verma, P. N.; Yadav, R. K. and Singh, S. 2013. Combining ability and heterosis analysis for seed yield and its related traits in linseed (*Linum usitatissimum* L.). Progressive Research 8:593-596.

Yadav, R.K. and Gupta, R.R. 1999. Genetic studies for some metric and quality characters in linseed under different environments. Crop Res. J. 18 (1): 57-59.

How to cite this article:

Ajeet Kumar, Jitendra Kumar, Kushal Pal Singh Tomar and Pradeep Kumar Sharma. 2018. To the Estimate Heterosis for Yield and Yield Components in Linseed (*Linum usitatissimum* L.) Germplasm. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 1602-1611.
doi: https://doi.org/10.20546/ijcmas.2018.702.193