Heterosis over Superior Parents under Diallel Cross in Linseed/Flax (*Linum usitatissimum* L.)

SC Pant[1] and VK Mishra[2]

[1] *Department of Horticulture, Chauras Campus, HNB Garhwal University, Srinagar, Uttarakhand, India*

[2] *Department of Genetics and Plant Breeding, CS Azad University of Agriculture and Technology, Kanpur, UP, India*

A heterozygous individual resulting from the cross of two unlike parents is a hybrid which is usually vigorous. This increased vigour is often referred as hybrid vigour or heterosis. In general, considerable amount of heterosis over superior parent was observed for almost all the characters. Forty crosses showed positive and significant heterosis for seed yield per plant and 13 crosses for fibre yield per plot while nine crosses showed heterosis in both seed yield per plant and fibre yield per plot.

Key Words: Heterosis, Seed yield, Fibre yield

Introduction

Linseed/Flax (*Linum usitatissimum* L.) is an oilseed crop grown in winter (*rabi*) season in India mainly for industrial oil purpose. Besides oil, linseed is an excellent fibre producing crop with immense medicinal properties. India is one of the major linseed growing countries but its utilization is confined to only industrial oil purpose. The importance of this crop needs great attention to popularize the diverse use of linseed for better reaps of harvest. It is a highly self-pollinated crop. The scope for exploitation of hybrid vigour in genetically diverse population depends on direction and magnitude of heterosis and type of gene action. Techniques of hand emasculation and crossing have been standardized in this crop and the studies on the extent of heterosis for yield and its components were carried out through diallel mating design.

Materials and Methods

Experimental materials comprised of ten varieties, namely, Shubhra, Garima, Shekhar, Janki, J-23, T-397, Gaurav, Belinca, Rasmi and Nagarkot. The above varieties crossed in diallel mating design (without reciprocal) thus 45 F_1 were produced which were advanced to get the sufficient seeds for F_2 generation, the 10 parents along with 45 F_1s and 45 F_2s were grown in a Randomized Block Design with three replications at Oilseeds farm, CSA University of Agriculture and Technology, Kalyanpur, Kanpur, during *Rabi* 2002-2003. In 5 x 2 sq m plot size, row-to-row and plant-to-plant distance were maintained at 45 cm and 30 cm, respectively. The crop protections and other cultural operation were carried out as required to raise a good crop. The data were recorded on 5 randomly selected plants on thirteen characters, namely, days to 50% flowering, plant height (cm), technical plant height (cm) days to maturity, stem diameter (mm), number of capsules/plant, number of tillers/plant, seed yield/plant (g), oil content (%), fibre length (cm), fibre strength (Tax), fibre fineness (g/Tax) and fibre yield/plot (kg). Magnitude of heterosis was calculated as per cent of F_1 performance in favorable direction over superior parent as suggested by Hays *et al.* (1955).

Results and Discussion

For all the characters under study, F_1 crosses varied in magnitude and direction of heterosis (Table 1). This can be ascribed to the presence of genetic diversity among parents for all characters. The main cause of heterosis is dominant effect. The negative heterosis, which is desirable for days to 50% flowering, plant height, technical plant height and days to maturity was common in most of the crosses. The high negative heterosis over superior parent was observed in T-397 x Nagarkot, J-23 x Nagarkot, T-397 x Guarav, Janki x Belinca, and T-397 x Rasmi for days to 50% flowering, T-397 x Gaurav, Shekhar x Janki, Garima x Belinca, Shekhar x Belinca, and Janki x Belinca for plant height, for techmichal plant height Garima x Rasmi, T-397 x Rasmi, J-23 x Nagarkot and Garima x Balinca. Likewise for days to maturity, T-397 x Nagarkot, Garima x Nagarkot and Shekher x Nagarkot were found to have negative heterosis over superior plants. These results are in conformity with the findings of Singh *et al.* (1981), Singh and Srivastava (1987), Thakur and Bacteria (1991) for plant height and days to maturity.

The range of heterosis over superior parents is given in Table 3. The results indicated that seed yield/plant, fibre yield, stem diameter, technical plant height and fibre

Table 1. Percent heterosis over superior parent for 13 characters of a 10 x 10 diallel crosses of Linseed/Flax

Cross	Days to 50% flowering	Plant height	Technical plant height	Days to maturity	Stem dia	Number of capsules/ plant	Number of tillers plant	Seed yield/ plant	Oil content	Fibre length	Fibre strength	Fibre fineness	Fibre yield/plot
Shubhra x Garima	6.36**	5.72**	28.94**	4.49**	–2.02**	–4.84	0.25	–11.95**	3.14**	14.55**	26.32**	7.01**	18.34**
Shubhra x Shekhar	–0.89	10.44**	25.17**	0.72	4.67**	6.57*	14.17**	–15.15**	5.73**	–9.12**	24.15**	10.85**	–2.70**
Shubhra x Janki	–11.20**	1.77	–0.83	–5.79**	23.96**	72.20**	15.73**	26.11**	3.07**	–14.26**	4.73**	14.12**	26.76**
Shubhra x J–23	7.83**	23.61**	22.55**	5.27**	8.11**	20.87**	16.99**	16.13**	0.98*	1.50	3.44**	15.30**	74.45**
Shubhra x T-397	3.69**	21.16**	29.41**	2.60*	50.56**	20.48**	50.00**	34.67**	6.64**	–3.90**	6.23**	3.55**	8.28**
Shubhra x Gaurav	2.71*	–8.87**	–22.60**	–1.66	35.35**	12.02**	29.71**	13.04**	6.26**	–11.32**	–5.90**	–19.19**	–15.22**
Shubhra x Belinca	–5.06**	–6.58**	–10.97**	–7.30**	4.81**	38.07**	–13.04**	34.05**	1.02**	–16.70**	–4.40**	–3.87**	–29.71**
Shubhra x Rasmi	–5.95**	–2.76	–15.75**	–3.53**	21.87**	–17.42**	21.66**	16.66**	8.75**	–26.81**	–6.03**	7.10**	–22.43**
Shubhra x Nagarkot	–15.22**	–13.36**	–16.73**	–9.53**	18.02**	37.79**	10.23**	77.49**	0.59	–24.18**	0.77	–2.41**	–29.87**
Garima x Shekhar	–3.35*	–3.67*	1.35	–2.31*	8.41**	–12.65**	–9.63**	–4.74**	5.50**	–23.24**	–2.58*	14.12**	–1.09**
Garima x Janki	–2.73	–6.28**	–9.00**	–4.40**	3.12**	17.84**	–3.93**	35.14**	2.77**	–25.84**	0.29	15.83**	24.66**
Garima x J-23	1.55	5.87**	9.47**	2.98**	–15.32**	–4.62	10.46**	17.63**	4.40**	–17.48**	8.26**	4.15**	22.36**
Garima x T-397	5.17**	2.37	–3.30	4.56**	6.74**	–18.53**	1.35**	13.71**	3.67**	–4.52**	3.34**	16.68**	–.032
Garima x Gaurav	–3.18*	–10.62**	–26.32**	–3.17**	–17.17**	8.59**	4.35**	1.07**	0.78*	–4.64**	1.81	–29.89**	–19.14**
Garima x Belinca	–13.14**	–21.49**	–38.05**	–8.44**	2.88**	34.86**	–7.61**	56.75**	–2.10**	–22.09**	7.45**	–17.44**	–39.81**
Garima x Rasmi	4.29**	–7.92**	–53.99**	–6.17**	–20.83**	2.97	16.98**	30.03**	3.62**	–42.12**	–11.61**	–11.93**	–49.07**
Garima x Nagarkot	–12.26**	–13.35**	–31.17**	–10.99**	–37.84**	74.92**	15.91**	103.96**	–2.79**	–28.87**	5.74**	–0.47**	–36.29**
Shekhar x Janki	–9.78**	–25.46**	–32.57**	–5.55**	–22.92**	22.97**	12.36**	40.14**	13.61**	–15.77**	34.10**	2.16**	–13.01**
Shekhar x J-23	2.91*	5.77**	–6.94**	6.39**	–24.32**	3.62	34.64**	30.70**	5.21**	7.33**	6.61**	0.55**	67.57**
Shekhar x T-397	1.29	–8.31**	–27.67**	1.11	–11.24**	–19.31**	8.78**	45.15**	–0.43	3.90**	18.84**	5.53**	1.94**
Shekhar x Gaurav	2.43	–14.44**	–8.75**	–0.46	–24.24**	–1.77	23.19**	16.83**	4.89**	21.05**	14.94**	–5.93**	27.58**
Shekhar x Belinca	–4.70**	–21.05**	–26.05**	–6.90**	–25.96**	11.48**	–20.65**	45.78**	–6.07**	10.99**	15.01**	–14.56**	–7.87**
Shekhar x Rasmi	–4.71**	–8.83**	–21.74**	–3.45**	–17.71**	0.08	23.66**	23.48**	4.07**	8.23**	–9.26**	–10.38**	–10.28**
Shekhar x Nagarkot	–11.19**	–16.91**	–33.42**	–10.45**	–28.83**	49.57**	–4.55**	56.91**	5.12**	–2.72*	10.59**	–7.48**	–23.90**
Janki x J-23	5.29**	–3.44*	–20.35**	4.95**	–15.32**	4.46	29.41**	17.91**	6.67**	–4.32**	10.19**	2.30**	62.16**
Janki x T-397	6.43**	–9.44**	–31.97**	3.02**	–13.48**	–13.77**	26.35**	27.55**	4.84**	–7.19*	25.23**	9.38**	1.29**
Janki x Gaurav	–3.87**	–11.88**	–1.93	–2.98**	–32.32**	5.94	29.71**	16.26**	1.10**	9.72**	23.86**	–21.54**	–6.15**
Janki x Belinca	–16.36**	–20.86**	–30.88**	–8.98**	–30.77**	42.30**	0.00	41.84**	1.56**	8.73**	9.82**	0.00	–25.62**
Janki x Rasmi	–6.99**	–7.89**	–33.14**	–2.31*	–30.21**	11.64**	9.63**	13.03**	–2.25**	–3.58**	13.62**	–8.83**	–21.50**
Janki x Nagarkot	–10.52**	–8.70**	–14.28**	–8.08**	–30.63**	60.90**	11.36**	45.51**	–8.88**	2.18	23.60**	11.84**	–24.20**
J-23 x T-397	0.83	–1.49	–23.65**	2.73**	2.25**	–10.19**	27.03**	12.46**	3.00**	11.70**	24.47**	–2.50**	–15.05**
J-23 x Gaurav	–5.57**	–19.48**	1.26	–1.87	–22.22**	55.89**	55.07**	36.89**	10.44**	37.59**	18.55**	–15.75**	–5.12**
J-23 x Belinca	–3.80*	–12.66**	–32.50**	–6.05**	–35.58**	50.51**	–1.09*	42.96**	–0.40	10.24**	16.59**	–12.81**	–13.35**
J-23 x Rasmi	–7.71**	–14.25	–32.52**	–2.24*	–19.79**	19.52**	45.72**	28.36**	–2.16**	10.02**	5.36**	–6.65**	–13.46**
J-23 x Nagarkot	–19.16**	–12.21**	–38.53**	–10.11**	–22.52**	56.42**	–1.70**	48.79**	7.82**	–12.31**	31.25**	–15.81**	–32.48**
T 397 x Gaurav	–17.72**	–34.31**	–28.33**	–4.49**	2.02**	50.34**	50.72**	34.24**	–6.16**	12.92**	11.69**	3.74**	–31.31**
T 397 x Belinca	–12.59**	–15.67**	–28.13**	–4.82**	–21.15**	30.94**	–11.41**	34.43**	4.56**	1.08	22.01**	–18.27**	–24.53**
T 397 x Rasmi	–16.24**	–17.43**	–44.28**	–3.57**	1.04**	–2.89	14.30**	7.87**	3.16**	–6.80**	0.83	–4.10**	–8.60**
T 397 x Nagarkot	–20.34**	–18.57**	–21.78**	–11.65**	–0.90**	80.84**	10.23**	66.57**	6.93**	–16.99**	23.72**	–14.41**	–42.70**
Gaurav x Belinca	–5.51**	–15.67**	–21.63**	0.83	21.15**	38.79**	–8.70**	38.27**	6.16**	8.80**	21.44**	–21.30**	–12.65**
Gaurav x Rasmi	4.79**	–16.78**	–21.28**	0.39	5.21**	–6.88**	12.97**	–2.30**	5.08**	29.59**	7.92**	–8.83**	7.10**
Gaurav x Nagarkot	–8.89**	–18.47**	–25.76**	0.46	–15.32**	75.05**	6.82**	51.30**	–0.81*	6.10**	36.22**	5.30**	–7.49**
Belinca x Rasmi	8.38**	5.81**	–8.38**	6.37**	25.00**	–18.86**	3.61**	–14.70**	6.74**	16.59**	19.31**	29.96**	33.51**
Belinca x Nagarkot	–1.97	5.67**	–5.14**	3.31**	21.62**	28.04**	3.41**	26.28**	2.93**	0.98	36.86**	–1.40**	11.46**
Rasmi x Nagarkot	–12.68**	–4.45**	–6.26**	–2.18*	–15.32**	61.22**	0.00	59.71**	2.36**	6.54**	23.85**	–9.35**	–27.93**

*Significant at 5% per cent level; **Significant at 1 per cent level

Table 2. Crosses showing maximum heterosis for 13 characters in Linseed/Flax

S.No.	Character	Cross	Heterosis (%)
1.	Days to 50% flowering	T-397 x Nagarkot	-20.34
		J-23 x Nagarkot	-19.16
		T-397 x Gaurav	-17.72
		Janki x Belinca	16.36
		T-397 x Rasmi	-16.24
2.	Plant height	T-397 x *Gaurav*	-34.31
		Shekhar x Janki	-25.46
		Garima x Belinca	-21.49
		Shekhar x Belinca	-21.05
		Janki x Belinca	-20.86
3.	Technical plant height	Garima x Rasmi	-53.99
		T-397 x Rasmi	-44.28
		J-23 x Nagarkot	-38.53
		Garima x Belinca	38.05
4.	Days to maturity	T-397 x Nagarkot	-11.65
		Garima x Nagarkot	-10.99
		Shekhar x Nagarkot	-10.45
5.	Stem diameter	Shubhra x T-397	50.56
		Shubhra x Gaurav	35.35
		Belinca x Rasmi	25.00
6.	Number of capsules/plant	T-397 x Nagarkot	80.84
		Gaurav x Nagarkot	75.05
		Garima x Nagarkot	74.92
7.	Number of tillers/plant	J-23 x Gaurav	55.07
		T-397 x Gaurav	50.72
		Shubhra x T-397	50.00
8.	Seed yield/plant	Garima x Nagarkot	103.96
		Shubhra x Nagarkot	77.49
		T-397 x Nagarkot	66.59
9.	Oil content	Shekhar x Janki	13.61
		J-23 x Gaurav	10.44
		Shubhra x Rasmi	8.75
10.	Fibre length	J-23 x Gaurav	37.59
		Gaurav x Rasmi	29.59
		Shekhar x Gaurav	21.05
11.	Fibre strength	Belinca x Nagarkot	36.46
		Gaurav x Nagarkot	36.22
		Shekhar x Janki	34.10
		J-23 x Nagarkot	31.25
12.	Fibre fineness	Belinca x Rasmi	29.96
		Gamma x Janki	15.83
		Garima x T-397	15.68
13.	Fibre yield/plot	Shubhra x J-23	74.45
		Shekhar x J-23	67.57
		Janki x J-23	62.16

Table 3. Range of heterosis for 13 characters in Linseed/Flax

S.No.	Character	Range in heterosis (%)
1.	Days to 50% flowering	-20.34 – 8.33
2.	Plant height	-34.31 – 23.61
3.	Technical plant height	-53.99 – 29.41
4.	Days to maturity	-11.65 – 6.39
5.	Stem diameter	-37.84 – 50.56
6.	Number of capsule/plant	-19.31 – 80.84
7.	Number of tillers/plant	-20.65 – 55.07
8.	Seed yield/plant	-15.15 –103.96
9.	Oil content	-8.88 – 13.61
10.	Fibre length	-42.12 – 37.59
11.	Fibre strength	-11.61 – 36.46
12.	Fibre fineness	-29.89 – 29.96
13.	Fibre yield/plot	-49.07 – 74.45

length, heterosis was maximum for seed yield/plant up to 103.96% as observed over superior parents.

Positive heterosis, which is desirable for stem diameter, number of capsules/plant, number of tillers/ plant, seed yield/plant, oil content, fibre length, fibre strength, fibre fineness and fibre yield. High positive heterosis over superior parents was observed and T-397 x Nagarkot for seed yield/plant, T-397 x Nagarkot, Gaurav x Nagarkot and Garima x Nagarkot for no. of capsules/ plant, Shubhra x J-23, Shekhar x J-23 and Janki x J-23 for fibre yield, Shubhra x T-397, Shubhra x Gaurav, T-397 x Gaurav and Shubhra x T-397 for no. of tillers/ plant. For oil content the crosses, Shekhar x Janki, J-23 x Gaurav and Shubhra x Rasmi showed low heterosis percentage over superior parents. The results were in agreement with those of Kansal and Gupta (1981) Singh *et al.* (1983), Dakhore *et al.* (1987) and Rao *et al.* (1987) for seed yield and number of capsules/plant.

Conclusion

The studies on diallel (10 x 10 parents) without reciprocal analysis were carried out in linseed during *rabi* (winter) season 2002-03 to work out in the extent of heterosis for yield and its contributing traits. Garima, T-397, Nagarkot, Shekhar and Shubhra were observed to be best performing

Table 4. Estimates of SCA effects for 13 different characters in a 10 x 10 diallel cross of Linseed/Flax

Cross	Days to 50% flowering F_1	Plant height F_1	Technical plant height F_1	Days to maturity F_1	Stem dia F_1	Number of capsules/ plant F_1	Number of tillers/ plant F_1	Seed yield/ plant F_1	Oil content F_1	Fibre length F_1	Fibre strength F_1	Fibre fineness F_1	Fibre yield/plot F_1
Shubhra x Garima	1.08	–3.06**	5.80**	3.72**	–0.64**	8.47**	0.43	–0.68**	0.96**	4.93**	0.03	0.19*	6.20**
Shubhra x Shekhar	–0.47	3.14**	2.77**	3.11**	–0.02	12.26**	0.73*	–0.65**	1.01**	–0.57	–0.03	–0.11	4.65**
Shubhra x Janki	–4.69**	2.79**	–0.07	–3.09**	0.36*	22.28**	0.35	0.30	–1.52**	0.41	–0.05	0.09	–1.83*
Shubhra x J-23	1.63	1.84	1.63	1.04	0.18	0.78	–0.53	–0.20	–1.78**	–0.13	0.25**	0.08	–1.15
Shubhra x T-397	1.27	2.76**	3.12*	–0.66	0.56**	20.19**	1.16**	0.86**	1.57**	–0.59	–0.13*	0.02	–1.84*
Shubhra x Gaurav	4.88**	3.55**	–8.77**	–0.87	0.53**	–14.10**	–0.15	–0.15	0.48	–2.38**	–0.16**	–0.16*	–2.70**
Shubhra x Belinca	2.73**	6.98**	6.82**	–3.41**	–0.44**	–5.71**	–0.74*	–0.09	–0.71**	–0.41	0.31**	–0.22**	–2.18**
Shubhra x Rasmi	–0.56	3.54**	2.88*	–1.88**	0.06	–25.09**	–0.05	0.11	1.47**	–2.88**	0.39**	–0.12	–0.16
Shubhra x Nagarkot	–3.32**	–3.73**	–0.03	–3.94**	0.31	–17.23**	–0.02	0.81**	–1.11**	–0.75	0.18**	–0.09	–1.97*
Garima x Shekhar	–1.30	–0.91	2.21	1.27	0.98**	–1.58	–0.34	–0.20	1.65**	–2.06**	0.17**	0.07	–1.61
Garima x Janki	4.37**	2.24	4.16**	1.05	0.51**	–8.73**	–0.41	0.50*	–0.89**	–1.47	0.11	0.23**	–2.55**
Garima x J-23	–2.00*	–2.99**	4.92**	0.41	0.13	–14.59**	–0.46	–0.36	0.35	–2.25**	0.02	–0.11	0.32
Garima x T-397	3.74**	–2.39*	0.88	4.04	0.08	–13.98**	–0.83**	–0.44*	1.06**	0.55	0.40**	0.10	–2.11**
Garima x Gaurav	0.56	7.43**	–3.05*	–0.74	–0.89*	–11.47**	–0.91**	–0.94**	–0.98**	0.40	–0.54**	–0.06	–0.26
Garima x Belinca	–4.25**	–3.82**	–5.53**	–2.88**	0.31	–1.72	0.01	0.48*	–1.27**	–0.83	–0.18**	–0.30**	1.62
Garima x Rasmi	2.34**	4.82**	–14.16**	–3.55**	–0.49**	–3.32**	0.13	0.52**	0.16	–5.91**	–0.20**	–0.43**	–1.52
Garima x Nagarkot	1.09	1.84	–1.79	–3.91**	0.94**	7.33**	0.73*	1.49**	–1.76**	–0.94	0.37**	–0.07	–0.36
Shekhar x Janki	–3.57**	–10.51**	–6.72**	–2.34**	–0.20	0.96	0.45	0.57**	2.90**	–3.67**	–0.26**	–0.36**	3.66**
Shekhar x J-23	–2.42*	–1.26	–1.53	2.86**	–0.08	–3.46**	0.67*	0.09	0.23	–2.05**	–0.06	–0.02	–1.73*
Shekhar x T-397	–0.81	–6.68**	–7.45**	–2.11**	–0.33	–10.48**	–0.57	0.99**	–1.12**	–2.28**	0.07	–0.09	–0.42
Shekhar x Gaurav	4.24**	5.59**	5.19**	1.21	0.50**	–14.21**	–0.14	–0.37	0.02	2.10**	0.58**	0.48**	1.72*
Shekhar x Belinca	2.91**	–1.55	2.39	–2.39**	–0.56**	–10.32**	–0.90**	–0.07	–3.38**	5.21**	–0.03	0.26**	2.21**
Shekhar x Rasmi	0.46	5.27**	5.74**	–1.37*	–0.27	–1.29	0.36	0.04	–0.11	3.96**	–0.11	0.04	–2.47**
Shekhar x Nagarkot	0.73	0.17	–4.20**	–5.36**	–0.48**	–1.20	–0.58*	–0.30	1.02**	2.86**	0.10	–0.01	–0.75
Janki x J-23	–0.37	–9.03**	–7.37**	1.23	0.40*	–0.51	0.27	–0.08	2.24**	–3.39**	–0.09	0.08	–1.20
Janki x T-397	3.43**	–9.71**	–10.11**	0.46	–0.26	–2.57*	0.16	0.54**	2.51**	3.36**	0.11	0.01	0.64
Janki x Gaurav	–1.38	5.64**	7.40**	–2.12**	–0.62**	–6.73**	0.02	0.04	0.11	0.22	–0.22**	0.07	3.85**
Janki x Belinca	–8.98**	–3.73**	–2.53*	–5.32**	–0.59**	8.93**	0.24	0.23	1.21**	5.22**	0.53**	0.04	0.33
Janki x Rasmi	–1.56	3.76**	–2.99*	–0.41	–0.52**	10.02**	–0.47	–0.02	–1.23**	1.38	–0.14*	–0.02	4.02**
Janki x Nagarkot	1.61	5.75**	6.94**	–1.61*	–0.40*	6.78**	0.22	–0.26	–3.29**	5.08**	0.84**	0.12	2.31**
J-23 x T-397	2.12*	–1.36	–5.13**	–1.46*	0.00	–4.13**	0.22	–0.12	0.54*	–0.97	–0.15*	–0.08	0.48
J-23 x Gaurav	0.18	2.23*	11.52**	0.78	–0.49**	21.98**	1.21**	1.11	2.66**	5.94**	0.17**	0.15*	–2.39**
J-23 x Belinca	7.14**	9.09**	–1.28**	0.41	–0.96**	8.24**	0.19	0.88	0.81**	5.01**	0.09	0.32**	2.34**
J-23 x Rasmi	0.86	1.71	–0.13	1.87**	–0.40*	11.29**	1.35**	0.82**	–2.40**	4.50**	0.06	0.18*	1.56
J-23 x Nagarkot	–4.34**	6.17**	–6.44**	2.86**	–0.31	–0.72	–1.52**	–0.03	2.34**	–0.04	–0.22**	–0.01	4.32**
T 397 x Gaurav	–8.82**	7.62**	–0.64	–1.76**	0.22	14.49**	1.27*8	0.68**	–4.36**	2.21**	0.88**	–0.26**	1.53
T 397 x Belinca	0.25	10.07**	5.27**	3.34**	–0.55**	–6.29**	–0.18	–0.23	0.92**	4.11**	–0.33**	0.06	4.98**
T 397 x Rasmi	–5.17**	3.07**	–4.42**	1.10	0.18	–10.33**	0.04	–0.46*	–0.61*	1.74*	–0.02	0.28**	1.10
T 397 x Nagarkot	–3.36**	4.29**	7.80**	–4.10**	0.40*	7.93**	0.44	0.27	1.63**	0.47	–0.34**	–0.22**	3.40**
Gaurav x Belinca	–1.63	–6.94**	–3.08*	4.16**	0.89**	10.19**	0.11	0.45*	2.71**	0.21	–0.86**	–0.08	1.22
Gaurav x Rasmi	5.92**	–13.35**	–2.70*	–0.98	0.28	–1.32	0.10	–0.40*	1.28**	5.85**	–0.59**	0.12	–0.22
Gaurav x Nagarkot	0.54	–12.63**	–7.94**	6.59**	–0.16	17.13**	0.36	0.29	–0.41	0.98	0.11	0.13	3.07**
Belinca x Rasmi	3.82**	–4.72**	–4.13**	2.88**	0.78**	–1.60	–0.32	–0.44*	1.44**	–1.71*	0.75**	0.22**	1.50
Belinca x Nagarkot	1.12	–1.43	–4.24**	6.59**	1.07**	2.46*	0.21	–0.01	0.62*	–4.01**	–0.26**	0.14	1.56
Rasmi x Nagarkot	–5.93**	–2.04	2.47*	3.18**	–0.07	11.25**	–0.04	0.52**	1.09**	0.54	–0.21**	–0.31	0.35
SE (S_{ij})+	0.968	1.066	1.246	0.648	0.171	1.172	0.295	0.197	0.268	0.764	0.0595	0.074	0.828
SE (S_{ii}-S_{ik})+	1.088	1.126	1.143	0.909	0.241	1.318	0.413	0.276	0.376	1.056	0.0834	0.104	1.065

*Significant at 5% per cent level; **Significant at 1 per cent level

parents for seed yield and earliness. Shubhra, Shekhar, Janki and J-23 were observed good parents for fibre yield but not for other fibre quality characters like fibre strength and fibre fineness. Appreciable heterosis were found over superior parents for all the characters of desirable directions. Parents Subhra, Janki, J-23 are observed to be

Table 5. Estimates of GCA effect of the parents for 13 different characters in F_1s of linseed/Flax

Crosses	Days to 50% flowering F_1	Plant height F_1	Technical plant height F_1	Days to maturity F_1	Stem diameter F_1	Number of capsules/ plant F_1	Number of tillers/ plant F_1	Seed yield/ plant F_1	Oil content F_1	Fibre length F_1	Fibre strength F_1	Fibre fineness F_1	Fibre yield/ plot F_1
Shubhra	–1.53*	0.43	1.34**	–1.72**	0.74**	11.48**	0.35**	0.15	0.82	–4.32	–2.27	–0.11	–0.11
Garima	–2.82**	–5.12**	–6.33**	–3.96**	–0.08	5.72**	–0.06	0.39	0.08	–5.56	–2.57	0.21	–0.28
Shekhar	–1.34*	–6.91**	–5.39**	–2.14**	–0.20*	1.42	0.05	0.55	0.53	–1.36	–0.92	–0.24	–0.06
Janki	–1.52*	–4.53**	–4.02**	–2.31**	–0.34**	–0.83	0.18*	0.11	–0.88	–2.08	–0.58	–0.16	–0.20
J–23	–4.64**	–8.35**	–6.48**	–3.68**	–0.14	4.40**	0.16*	0.00	0.32	–1.40	–0.59	–0.28	–0.26
T 397	–6.85**	–12.65**	–90.79**	–4.77**	–0.05	8.12**	–0.10	0.31	0.67	–3.34	–1.63	–0.10	–0.27
Gaurav	2.36**	4.38**	3.35**	2.84**	–0.02	–4.02**	–0.22**	–0.23	–0.46	8.31	1.96	0.29	0.17
Belinca	7.93**	16.59**	13.12**	7.35**	0.11	–13.14**	–0.27**	–0.79	0.04	6.64	8.64	0.38	0.57
Rasmi	3.75**	7.29**	5.68*	2.25**	–09.12	5.13**	–0.23**	–0.18	–0.66	3.79	1.45	–0.02	0.14
Nagarkot	4.65**	8.84**	8.52**	6.15**	0.10	–8.02**	0.14	–0.32	–0.47	4.42	1.53	0.45	0.30
$SE_{gi} \pm$	0.29	0.35	0.37	0.19	0.05	0.58	0.08	0.06	0.08	0.22	0.25	0.01	0.02
SE (gi-gj) $\pm$	0.49	0.52	0.55	0.28	0.08	0.86	0.13	0.09	0.11	0.33	0.37	0.03	0.03

*Significant at 5 per cent level; **Significant at 1 per cent level

good parents for fibre yield and oil content and Shubhra is good parent for seed yield, fibre yield and oil content, while Belinca, Rasmi, Gaurav, and Nagarkot good parents for fibre quality character.

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