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Short Communication

Heterosis and combining ability for yield related traits and protein content in lentil (*Lens culinaris* Medik.)

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Sufficient heterosis has been reported in the F_1s of various grain legumes including lentil (*Lens culinaris* Medik.) [1]. In self-pollinated crops like lentil, the development of pure lines from segregating population is very important. For the success of any breeding programme, the basic requirement is the selection of appropriate parents. The study of heterosis indicates the percentage increase of the F_1 over better parent or the standard parent but it fails to identify the possible causes for the superiority of hybrids. Combining ability analysis provided information on the overall gene action controlling the quantitative characters and helps the breeder in the choice of appropriate parents. The present investigation was undertaken to study the nature and magnitude of heterosis as well as analysis of combining ability in lentil using line x tester mating design.

Twenty genetically diverse lines *viz.*, K 75, L 4076, KLS 86-13, KLB 148, KLS 221, KLB 86-11, KLB 2001, NDL 2-3, IPL 304, KLB 97-5, HUL 57, KLS 133, IPL 306, KLB 97-3, KLS 219, DPL 58, PL 406, DPL 15, PL 639 and FLIP 56-61 were used as female parents and pollinated by each of three testers *viz.*, DPL 62, KLS 218 and Precoz. The resulting 60 hybrids and their parents were evaluated in a randomized block design with three replications during 2005-06. Each entry was sown in single row of two metres long spaced at 30 cm apart keeping 5 cm distance between plant to plant.

The observations were recorded on ten competitive plants from each plot on plant height (cm), branches per plant, pods per plant, seeds per pod, 1000-seed weight (g), grain yield per plant (g) and protein content (%), whereas data on days to 50% flowering were recorded on plot basis. The mean value of the observations was subjected for statistical and biometrical analysis. Based on the average values of 10 plants in each replication, heterobeltiosis and standard heterosis (against DPL 62) for these characters were estimated. Combining ability analysis was carried out following Kempthorne [2] and fixed effects model was used to test the significance of combining ability effects.

Analysis of variance (Table 1) revealed that all the genotypes expressed highly significant differences for all the characters under study. It also revealed that parents differed significantly among themselves for all the characters indicating sufficient variability in the basic material. Variance due to parents was further partitioned into the lines, testers and line vs. tester. Both lines and testers showed significant differences among themselves for all the characters, whereas, line vs tester showed significant differences only for days to 50 % flowering, branches per plant, pods per plant and 1000-seed weight. The differences among the crosses were significant for all the characters indicating the manifestation of parental genetic variability in their crosses. The mean squares for hybrids were partitioned in to three components *viz.*, due to lines, due to testers and due to line × tester interactions. The differences among hybrids due to the lines were significant for branches per plant, seeds per pod, 1000-seed weight and grain yield per plant. The differences among hybrids due to testers were significant for all the characters except days to 50 % flowering, plant height and protein content. However, differences among hybrids due to the line x tester interaction were significant for all the characters except seeds per pod.

Estimates of *gca* variance (Table 1) due to lines were found to be lower than due to testers for seeds per pod, 1000-seed weight and grain yield per plant. The estimates of variance due to *gca* (pooled) and *sca* indicated that the greater importance of former for seeds per pod, 1000-seed weight and grain yield per plant indicating the pre dominance of additive gene action for these traits These results are in agreement with those published earlier for seeds per pod [3] and

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Table 1. Analysis of variance and estimates of combining ability variances for different characters in lentil

Source of variation	df	Mean squares							
		Days to 50% flowering	Plant height (cm)	Branches per plant	Pods per plant	Seeds per pod	1000-seed weight (g)	Grain yield per plant (g)	Protein content (%)
Replications	2	6.70	3.86	7.26	233.32	56.11	21.99	9.34	0.61
Treatments	82	49.46**	45.89**	38.73**	4646.02**	182.57**	100.87**	43.45**	4.28**
Parents	22	71.24**	15.88**	24.85**	2838.27**	190.55**	160.35**	38.95**	3.21**
Among lines	19	60.87**	15.59**	22.19**	2143.99**	199.03**	135.10**	40.50**	3.23**
Among testers	2	85.78**	22.32**	51.96**	8571.57**	162.11*	389.94**	43.72**	4.12*
Among line vs. tester	1	239.14**	8.39	21.13*	4562.94**	85.51	180.85**	0.05	0.90
Crosses	59	41.13**	56.01**	39.44**	3964.11**	91.60**	70.83**	27.48**	3.98**
Due to lines	19	27.46	53.34	55.19*	4815.73	104.40*	61.05*	27.78*	3.48
Due to testers	2	64.62	83.04	97.57*	22087.62**	874.34**	977.28**	295.79**	5.48
Due to line × tester	38	46.73**	55.92**	28.50**	2584.43**	44.00	28.02**	13.21**	4.15**
Parents vs. crosses	1	61.45*	109.13**	302.54**	84648.83**	5374.19**	564.23**	1084.72**	46.07**
Error	164	11.62	4.10	4.89	472.59	46.82	9.91	4.95	1.08
σ^2*gca* (line)		1.83	5.42	5.56	478.80	8.09	5.56	2.46	0.25
σ^2*gca* (tester)		0.89	1.31	1.54	359.68	14.05	16.11	4.84	0.07
σ^2*gca* (pooled)		1.02	1.84	2.07	375.22	13.27	14.73	4.53	0.10
σ^2 *sca* (line × tester)		11.91	17.17	7.79	692.64	4.13	5.68	2.52	1.00
$\sigma^2 gca/\sigma^2 sca$		0.09	0.11	0.27	0.54	3.21	2.59	1.80	0.10
$\sigma^2 gca/\sigma^2 sca$		3.42	3.05	1.94	1.36	0.56	0.62	0.75	3.21

*,**Significant at 5 and 1 per cent probability level, respectively

Table 2. Two best crosses for heterobeltiosis and standard heterosis alongwith *sca* effects and status of *gca* effects of the parents for different characters in lentil

Character	Best heterotic crosses over BP	Hetero-beltiosis (%)	*sca* effects	*gca* effects	Best heterotic crosses over SP	Standard heterosis (%)	*sca* effects	*gca* effects
Days to 50 % flowering	DPL 58 × Precoz	–18.72**	–4.13*	A × H	PL 406 × Precoz	–12.56**	–5.91**	H × H
	KLB 148 × Precoz	–11.52**	–1.80	H × H	PL 639 × Precoz	–11.59**	–8.36**	A × H
Plant height (cm)	KLB 148 × KLS 218	18.98**	8.49**	A × L	K 75 × DPL 62	31.27**	6.30**	H × A
	IPL 304 × Precoz	18.61**	–1.05	H × H	PL 406 × DPL 62	22.65**	7.37**	A × A
Branches per plant	KLS 221 × Precoz	29.60**	0.48	A × A	K 75 × DPL 62	30.55**	1.47	H x H
	KLB 86-11 × DPL 62	28.96**	0.34	H × H	KLB 86-11 × DPL 62	29.93**	0.34	H x H
Pods per plant	K 75 × DPL 62	50.69**	44.79**	H × H	K 75 × DPL 62	60.90**	44.79**	H × H
	L 4076 × DPL 62	41.49**	54.99**	A × H	KLS 221 × DPL 62	34.06**	25.66	H × H
Seeds per pod	HUL 57 × DPL 62	7.93**	6.22	A × L	KLB 97-3 × KLS 218	14.09**	3.37	A × H
	KLS 86-13 × DPL 62	6.81*	1.44	A × L	NDL 2-3 × KLS 218	14.09**	1.82	H × H
1000-seed weight (g)	KLS 219 × KLS 218	49.34**	–0.05	H × A	KLB 97-3 × Precoz	28.19**	5.86**	H × A
	IPL 304 × KLS 218	28.13*	–0.07	H × A	DPL 58 × DPL 62	13.85	2.50	H × A
Grain yield per plant (g)	KLS 86-13 × KLS 218	75.51**	0.39	A × L	K 75 × DPL 62	44.01**	2.38	H × H
	KLS 219 × KLS 218	63.92**	0.43	A × L	IPL 306 × DPL 62	42.34**	2.09	H × H
Protein content (%)	KLB 2001 × Precoz	17.15**	1.09	A × L	KLS 133 × DPL 62	9.72**	1.14	H × A
	KLS 219 × Precoz	13.12**	1.79**	A × L	PL 639 × KLS 218	8.37*	1.79**	H × A

*Significant at 5 and 1 per cent probability level, respectively; BP = Better parent, SP = Standard parent, H = Good general combiner, A = Average general combiner, L = Poor general combiner

seed weight [4]. However, the characters like, days to 50% flowering, plant height, branches per plant, pods per plant and protein content noted with higher *sca* variance than *gca* variance indicating the preponderance of non additive gene action for these traits. It was also reported that variation due to *sca* was significant for all the traits studied except plant height, branches per plant and 1000-seed weight [5].

The magnitude of heterosis differed widely for traits and crosses as well. Heterosis for grain yield was not proportional to the heterosis observed for yield components. Since plant height, branches per plant, pods per plant etc. are important yield components, the prevalence of overdominance for these traits could be the probable reason for heterosis to grain yield.

For days to 50% flower, DPL 58 × Precoz and PL 406 × Precoz exhibited maximum desirable heterobeltiosis and standard heterosis, respectively as well as significant negative *sca* effects (Table 2) indicating the operation of non-additive gene action. However, high *gca* of the respective parents involved in the crosses KLB 148 × Precoz and PL 406 × Precoz suggested the role of additive and additive × additive types of interaction for early flowering. For major yield components, namely, plant height, branches per plant, pods per plant, seeds per pod and seed weight, the heterosis observed was either due to good general combining ability of the parents or due to high sea effect of the respective crosses. It was noted that crosses with high × high *gca* effects could produce desirable transgressive segregants if additive genetic system present in the good combiners. The best specific combinations resulted from crosses between parents with high and low or both with low *gca* effects [6].

The presence of additive, additive × additive gene action for grain yield in K 75 × DPL 62 and IPL 306 × DPL 62 suggested that part of heterosis can be fixed in subsequent generations. The present study also identified the parents K 75 among the lines and DPL 62 among the testers had potentiality for generating high heterotic cross combinations for most of the traits and can be utilized in transgressive breeding.

Refe-ences

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