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Heterosis studies for yield and its attributes in Lentil (*Lens culinaris* Medik. L)

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Abstract
The breeding material for the study comprises of fifteen crosses involving eight divergent parents including three lines (female parent) *viz*, L 4076, JL 3, IPL 81 and five testers (male parents) *viz*, RL 7, EC 267554, LL 4710, L 4717, EC 267583, and L 4717 grown in a Randomized Complete Block Design with three replications. The eight diverse genotypes were crossed in line x tester mating design following the method given by Kempthorne (1957). Data collected were subjected to analysis for heterosis. Heterosis was found significant positive for all traits except for days to maturity noted with significant and negative under study. Significant positive heterosis better parent found in nine crosses *viz,* JL 3×RL 7, IPL 81×EC 267554, JL 3×EC 267554, IPL 81×RL 7, L 4076×EC 267554, L 4076×L 4717, JL 3×L 4717, L 4076×EC 267583 and L 4076×RL 7 for seed yield plant^{-1} revealing its significance in future crop improvement programme.

Keywords: lentil, line x tester, heterosis etc.

Introduction
Pulses play an equally important role in rainfed and irrigated agriculture by improving physical and biological properties of soil and are considered as excellent crops for natural resource management and environmental security. By virtue of their management and environmental security.

Lentil is also commonly known as "Poor man's meet", as it is one of affordable protein rich legume. During the past few years, world production of lentil has increased from 2.76 to 3.60 metric tons. In India, lentil was cultivated on 1.47 million hectares area in 2014-15 with a production of 1.04 metric ton (Anonymous, 2016) [1].

In lentil breeding programme, breeding techniques of self-pollinated crops are widely used for development of high yielding varieties which includes techniques such as pure line, mass selection, hybridization and recurrent selection. Recently, more imphasis is being placed on heterosis breeding and tissue culture techniques. Heterosis express the superiority of F_1 hybreeds over its better parental values in terms of yield and other related characters. Exploitation of hybrid vigour has been recognized as an important tool for genetic improvement of yield, which may serve as a major fruitful techniques to break existing barriers.

Heterosis is essential to bring genetic improvement of the genotypes for high seed yield. The magnitude of heterosis is helpful in obtaining transgressive segregants in further generation to be handled through pedigree method of breeding.

Materials and Methods
The experimental material for the present investigation consisted of eight divergent parents *viz,* L 4076, JL 3, IPL 81, RL 7, EC 267554, LL 4710, L 4717, EC 267583 and their 15 hybrids. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each genotype was grown in a row of 2 meter length. The row to row distance was 30 cm and 5-7 cm between plants. All the recommended package of practices was followed to facilitate crop growth and development. Better parent heterosis for each trait was worked out by utilizing the overall mean of each hybrid over replications for each trait. Five competitive plants were randomly selected from each genotype in each replication. Averages of the data from the sampled plants in respect of following quantitative characters were used for heterosis analysis.

Result and Discussion

The present investigation was undertaken with the eight parents and their 15 F_1s for studying the genetic variability, heterosis for different characters. The estimates of heterosis expressed in percentage better parent for different characters have been presented in Table 3. Importance of heterosis is twofold in crop improvement. The first objective was to assess the extent of heterosis present in F_1 hybrids and to know the possibility of exploiting heterosis in hybrid breeding programme subjected to the biological feasibility. The secondary aim was to know the relationship between the heterosis in F_1 hybrids and superior segregates in F_2. This will help a breeder to eliminate certain crosses at F_2 stage and to concentrate on few promising crosses for advanced generation studies aimed at the development of high yielding lines of lentil.

Analysis of variance revealed the considerable amount of variability for all the characters (Table 1). Considerable amount of heterosis was observed for the characters under study. However, the magnitude varied with characters. The extent of heterosis for seed yield ranged from 10.08 to 292.56% (Table 2). Out of 15, nine crosses exhibited positive heterobeltiosis for seed yield. Cross IPL 81×EC 267554 recorded heterosis for seed yield (292.56%), primary branches plant^{-1}, secondary branches plant^{-1}, number of pods plant^{-1}, number of pod clusters plant^{-1} and number of seeds plant^{-1} (Table 3). Whereas, JL 3×RL 7 registered heterosis for seed yield (276.65%), number of seeds plant^{-1}, primary branches, secondary branches^{-1}, number of pods plant^{-1}, number of pod clusters plant^{-1}, tallness and high biomass production.

Other heterobeltiotic crosses were also found good for seed yield plant^{-1} and other yield component. Cross L 4076×EC 267554 was recorded as best heterobeltiotic for seed yield (209.30%), days to 50% flowering, number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds plant^{-1} and number of seeds plant^{-1}. Cross IPL 81×RL 7 was recorded as desirable heterobeltiotic for seed yield (208.12%), days to 50% flowering, 100-seed weight (g), number of seed plant^{-1}, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1} and number of pod clusters plant^{-1}. Cross JL 3×EC 267554 was recorded as desirable heterobeltiotic for seed yield (197.57%), number of pod clusters plant^{-1}, 100 seed weight (g), number of pods plant^{-1} and number of seeds plant^{-1}. Cross L 4076×L 4717 was recorded as desirable heterobeltiotic for seed yield (158.87%), days to maturity, 100-seed weight, number of pods plant^{-1}, number of pod clusters plant^{-1} and number of seeds plant^{-1}. Crosses JL 3×L 4717 was recorded as desirable heterobeltiotic for seed yield (109.46%), 100-seed weight, number of seeds plant^{-1}, number of pod clusters, number of pods and secondary branches plant^{-1}. Other crosses also registered significant positive heterosis were L 4076×RL 7 for seed yield (100.51%), 100-seed weight, number of seeds plant^{-1}, primary branches plant^{-1}, number of pods plant^{-1}, number of pod clusters plant^{-1} and earliness. Cross L 4076×EC 257583 was recorded as desirable heterobeltiotic for seed yield (83.21%), days to maturity, 100-seed weight, number of pods plant^{-1}, number of pod clusters plant^{-1} and number of seeds plant^{-1}. A very high degree of positive heterobeltiosis was also reported earlier by Kumar *et al.* (1995) [4] and Shukla and Singh (1999) [5] for seed yield and 100-seed weight. Chahota *et al.* (1997) [2] for number of seeds plant^{-1}. Among the nine heterobeltiotic crosses, combinations JL 3×RL 7, IPL 81×EC 267554, IPL 81×RL 7 and L 4076×EC 267583 showed high *per se* performance (Table 4). Hence, these heterobeltiotic crosses should be utilized in obtaining transgressive segregants in further generation to be handled through pedigree method.

Table 1: Analysis of variance for yield and its attributes in lentil

Source of variation	DF	Days to 50% flowering	Days to maturity	Plant height (cm)	No of primary branches plant^{-1}	No of secondary branches plant^{-1}	No of pods plant^{-1}	No. of pod clusters plant^{-1}
Replications	2	2.26	0.13	0.31	0.10	21.46	1.28	23.98
Treatments	22	15.83**	52.90**	6.84**	0.67**	114.23**	20720.26**	5324.36**
Error	44	1.47	0.33	0.38	0.06	8.27	7.25	10.32

*, ** differed significantly at 5 and 1 per cent, respectively.

Table 1: Contd...

Source of variation	DF	No of seeds plant^{-1}	Length of first pod bearing node (cm)	100 seed weight (g)	Protein content (%)	seed yield plant^{-1} (g)	Harvest index (%)
Replications	2	27.24	0.03	0.01	0.49	0.09	10.24
Treatments	22	25562.97**	2.13**	0.18**	10.47**	17.35**	143.34**
Error	44	17.66	0.37	0.01	0.65	0.10	4.83

*, ** differed significantly at 5 and 1 per cent, respectively.

Table 2: Estimates of genetic parameters of variability for yield and its attributes in lentil

Characters	General mean	Range		PCV GCV (%) (%)		Heritability (%)	GA as % of mean
		Min	Max				
Days to 50% flowering	68.65	64.00	72.67	3.19	3.64	69.47	5.74
Days to maturity	99.60	93.00	107.00	4.20	4.24	94.17	8.58
Plant height (cm)	37.66	34.50	40.65	17.31	19.88	68.87	31.07
No. of primary branches plant^{-1}	2.59	1.53	3.13	8.96	9.95	81.04	16.61
No. of secondary branches plant^{-1}	66.33	55.93	78.60	3.90	4.22	85.09	7.41
No. of pods plant^{-1}	160.28	15.40	317.73	51.84	51.87	96.90	91.74
No. of pod clusters plant^{-1}	87.84	21.00	154.33	47.91	48.05	93.42	89.41
No. of seeds plant^{-1}	179.92	18.66	363.73	51.29	51.34	91.79	87.54
Length of first pod bearing node (cm)	11.78	10.73	14.46	6.50	8.29	61.36	10.48
100 seed weight (g)	2.39	2.02	2.83	9.83	10.19	93.03	19.52
Protein content (%)	19.00	15.90	22.58	9.52	10.41	83.61	17.94
Seed yield plant^{-1} (g)	5.20	1.55	9.89	46.09	46.50	94.27	89.12
Harvest index (%)	26.36	9.61	42.07	25.77	27.08	90.55	50.52

*, ** differed significantly at 5 and 1 per cent, respectively

Table 3: Estimates of Heterobeltiosis for yield and its attributes in lentil

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	No of pods plant^{-1}	No of pod clusters plant^{-1}
L 4076 × RL 7	-5.24**	-0.67	-4.26*	23.53*	-7.07	161.78**	218.33**
L 4076 × EC 267554	-3.33*	-0.34	3.19*	23.53*	5.96	109.00**	182.15**
L 4076 × LL 4710	-1.90	3.37**	2.13	0.00	13.04**	28.63	93.37*
L 4076 × EC 267583	3.81*	6.73**	-6.61*	0.00	22.30**	27.45	21.10
L 4076 × L 4717	0.00	4.38**	0.00	-7.14	4.21	181.32**	166.08*
JL 3 × RL 7	6.03**	11.85**	3.69*	46.87**	14.35**	304.06**	318.21**
JL 3 × EC 267554	7.04**	10.45**	-0.26	25.00*	5.20	199.44**	327.99**
JL 3 × LL 4710	2.87	6.27**	-1.04	14.63	8.94*	130.94**	178.92*
JL 3 × EC 267583	1.46	3.47**	3.89*	4.76	-5.50	64.65*	42.53
JL 3 × L 4717	1.44	8.28**	-10.62**	-4.76	13.62**	160.46**	367.36**
IPL 81 × RL 7	-3.47*	-4.73	-7.58**	54.17**	13.56**	268.57**	323.48**
IPL 81 × EC 267554	3.96*	4.05**	-2.53	75.00**	17.43**	259.20**	294.02**
IPL 81 × LL 4710	0.00	4.73**	-0.51	7.32	8.87*	62.67	77.71
IPL 81 × EC 267583	2.93	2.03**	-9.60**	4.76	0.61	3.38	2.27
IPL 81 × L 4717	-7.69**	-5.74	-9.34**	4.76	5.20	143.57**	308.01**

*, ** differed significantly at 5 and 1 per cent, respectively.

Table 3: Contd…

Crosses	No of seeds plant^{-1}	Length of first pod bearing node (cm)	100 Seed weight (g)	Protein content (%)	Seed yield plant^{-1} (g)	Harvest index (%)
L 4076×RL 7	145.07**	-9.39*	9.89*	-24.46**	100.51*	-13.69*
L 4076×EC 267554	99.80*	-13.36**	-12.14**	-16.24**	209.30**	-26.01**
L 4076×LL 4710	39.29	-7.73	4.49	-16.40**	24.30	-34.30**
L 4076×EC 267583	33.62	-6.08	-2.90	-2.77	83.21*	-15.83**
L 4076×L 4717	207.89**	-0.55	12.14**	-19.17**	158.87**	-7.70
JL 3×RL 7	578.61**	-6.21	5.85	-13.23**	276.65**	72.75**
JL 3×EC 267554	166.51**	-18.43**	7.98*	-16.22**	197.57**	-10.19
JL 3×LL 4710	135.03*	10.73*	4.12	-4.28	80.00	-31.14**
JL 3×EC 267583	65.18	-7.34	8.63*	-14.41**	49.92	5.63
JL 3×L 4717	211.44**	-5.59	25.96**	2.88	109.46**	6.60
IPL 81×RL 7	244.70**	7.95	7.63*	1.75	208.12**	-2.45
IPL 81×EC 267554	230.53**	-25.81**	-11.58**	-9.56*	292.56**	-4.14
IPL 81×LL 4710	69.73	2.84	-2.63	-15.93**	41.49	-45.50**
IPL 81×EC 267583	0.50	-1.14	-8.95*	-18.20**	10.08	-44.70**
IPL 81×L 4717	137.68*	2.23	-11.45**	-22.62**	32.98	-35.74**

*, ** differed significantly at 5 and 1 per cent, respectively

Table 4: Per se performance of heterobeltiotic crosses.

S. No.	Heterotic cross	Per se performance (g)	Heterobeltiosis (%)
1	JL 3×RL 7	9.89	276.65**
2	IPL 81×EC 267554	9.15	292.56**
3	IPL 81×RL 7	8.09	208.12**
4	L 4076×EC 267583	8.00	83.21*

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