HETEROSIS AND GENETIC VARIABILITY FOR 6-PARENT HALF DIALLEL CROSS IN LATHYRUS

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Abstract: Fifteen F_1 hybrids of grasspea and their parents were evaluated in randomized complete block design to estimate heterosis and variability of seed yield and neurotoxin content. The magnitude of heterosis varied significantly between hybrids. Heterosis over mid parent in seed yield per plant and neurotoxin content ranged from 6.95% to 161.33% and 1.47% to 41.10% respectively. Heterotic effect for 100 seed weight, protein content, and biological yield per plant respectively varied from 0.86% to 24.05%, 10.36% to 93.14% and 3.33% to 87.85%. Pusa-24 x Ratan exhibited maximum heterosis and heterobeltiosis for seed yield per plant, whereas, Mahateora x RLS-3004 expressed maximum heterobeltiosis and heterosis for ODAP content. Analysis of variance indicated significant differences due to genotypes for all the characters except plant height (cm), pod length (cm), no. of seeds pod^{-1}, biological yield plant^{-1} and harvest index (%). High heritability coupled with high genetic advance was observed for only protein content.

Keywords: Heterosis, *Lathyrus*, genetic variability, grasspea

INTRODUCTION

Grasspea (*Lathyrus sativus* L.) locally called '*Khesari*', '*Teora*', '*Lakh*'/'*Lakhdi*' is an important rabi pulse crop of the Chhattisgarh region. In India it occupies an area of about 1.6 million ha. *Lathyrus* belongs to family Leguminosae, and sub family Poaceae a grain legume with high nutritional profile having diploid chromosome 2n=14. Manifestations, suitable for comprehensive genetic studies and breeding for high yield and low neurotoxin content coupled with resistance for biotic stresses will be land mark on this poormans' crop. *Lathyrus* proved to be a most economical pulse for human food and animal feed in rice fields during the cool winter period. Because of its drought tolerance, it is only potential crop in chhattisgarh under rice based relay (*Utera*) cropping system. *Lathyrus* contain very high protein, but has *a* neurotoxic principle *i.e.,* β-N-oxalyl-L-α, β- diamino propionic acid (ODAP), present in seed and plant of grasspea. If consumed in excess quantity may cause the irreversible crippling disease known as lathyrism. Advancements in the development of crop varieties greatly depend upon genetic variability. The study of genetic variability with the estimates of phenotypic and genotypic variance along with heritability and genetic advance using methods of analysis of variance and computation of heritability are necessary to start crop development programme. These simple statistical derivations give knowledge of mean, variance, standard deviation present in the population. The ultimate aim of a farmer or breeder is to get high quality yield. Yield is a complex character and is the multiplicative end product of many yield components and hence knowledge of the existing genetic variations between various yields traits and their heritability assumes importance. Heritability (h^2) is an approximate measure of the expression of a character.

Heterotic response of progenies further helps the breeders to isolate desirable segregates in subsequent generations. Association and contribution of component characters on yield and quality parameters like ODAP content in present reference also helpful in evolving high yielding genotype with better nutritional qualities.

MATERIAL AND METHOD

Fifteen F_1 hybrids and their parents constituted the experimental material of this study. The hybridization between pure lines was performed under field conditions following emasculation and pollination simultaneously in morning. The list of F_1 hybrid and their parents is given bellow:

Parents: Pusa-24, Prateek, Ratan, Mahateora, RLS-3004 and Siraha Local.

F_1 hybrids: Pusa-24 x Prateek, Pusa-24 x Ratan, Pusa-24 x Mahateora, Pusa-24 x RLS-3004, Pusa-24 x Siraha Local, Prateek x Ratan, Prateek x Mahateora, Prateek x RLS-3004, Prateek x Siraha Local, Ratan x Mahateora, Ratan x RLS-3004, Ratan x Siraha Local, Mahateora x RLS-3004, Mahateora x Siraha Local and RLS-3004 x Siraha Local.

The experiment was laid out in a Randomized Complete Block Design (RBD) with three replications. Each genotype was grown in a row of 2 meter length. The row to row distance was 30 cm and 20 cm between plants. All the recommended package of practices was followed to facilitate good crop growth and development. Five competitive plants were randomly selected from each genotype of each replication to record data on seventeen characters *viz.* days to flower initiation, days to 50 % flowering, days to pod initiation, days to 50 % pod formation, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}, biological yield plant^{-1}, harvest index (%), 100 seed weight (g), protein content (%) and ODAP content (%). The data were statically analyzed to determine the significance of difference between genotypes for parameters under consideration. Heterosis was calculated by following formulae:

$$\text{Heterosis} = \frac{\text{F1} - \text{mid parent value}}{\text{mid parent value}} \times 100$$

$$\text{Heterobeltiosis} = \frac{\text{F1} - \text{better parent value}}{\text{better parent value}} \times 100$$

RESULT AND DISCUSSION

Heterosis: The hybrid with high heterotic effects may offer better chances of identification of desirable pure lines in the following advance generations as compared to hybrid with low heterosis. The results of present study revealed significant differences among various hybrids. The heterosis and heterobeltiosis estimates indicated both negative and positive heterosis for all the traits in different cross combination. The heterotic effects in 15 F_1 hybrids their mid parental value and their negative heterosis ranged from 4.23% (Pusa-24 x Ratan) to 6.04% (Pusa-24 x Siraha Local) in days to flower initiation, 3.75% (Pusa-24 x Ratan) to 7.19% (Pusa-24 x Siraha Local) in 50% flowering, 3.68% (Pusa-24 x Ratan) to 5.29% (Pusa-24 x Siraha Local) in pod initiation, 2.76% (Pusa-24 x Prateek) to 6.63% (Pusa-24 x Siraha Local) in 50% pod formation, 2.93% (Pusa-24 x RLS-3004) in days to maturity, 0.87% (Prateek x RLS-3004) to 40.58% (Pusa-24 x Ratan) in ODAP content, whereas, the positive heterosis ranged from 61.91% (Prateek x Mahateora) to 185.47% (Pusa-24 x Ratan) in number of pods per plant, 48.16% (Prateek x Mahateora) to 157.24% (Pusa-24 x Ratan) in seeds per plant, 17.64% (Prateek x Ratan) to 138.08% (Pusa-24 x Ratan) in seeds yield per plant, 55.48% (Pusa-24 x Ratan) to 101.41% (Ratan x RLS-3004) in biological yield per plant, 6.57% (Prateek x Mahateora) to 8.38% (RLS-3004 x Siraha Local) in 100 seed weight and 10.78% (Mahateora x RLS-3004) to 37.89% (Pusa-24 x Ratan) in protein content. As for as heterobeltiosis was exhibited negative value ranging from 0.71% (Pusa-24 x Siraha Local) to 3.55% (Pusa-24 x Ratan) in days to flower initiation, 2.52% (Pusa-24 x Siraha Local) to 3.14% (Pusa-24 x Ratan) in 50% flowering, 0.62% (Pusa-24 x Siraha Local) to 3.09% (Pusa-24 x Ratan) in pod initiation, 2.76% (Pusa-24 x Prateek) to 3.31% (Pusa-24 x Ratan) in 50% pod formation, 0.90% (Prateek x Ratan) to 3.07% (Ratan x Mahateora) in days to maturity and 2.13% (RLS-3004 x Siraha Local) to 41.89% (Mahateora x RLS-3004). The positive values ranging from 74.03% (Prateek x Siraha Local) to 193.64% (Ratan x RLS-3004) in number of pods per plant, 49.36% (Prateek x Siraha Local) to 150.63% (Ratan x RLS-3004) in seeds per plant, 71.94% (Ratan x RLS-3004) to 161.33% (Pusa-24 x Ratan) in seeds yield per plant, 87.85% (Ratan x RLS-3004)) in biological yield per plant, 1.60% (Prateek x Ratan) to 22.64% (Prateek x RLS-3004) and 9.88% (Prateek x Siraha Local) to 93.14% (Pusa-24 x Prateek). The similar result was also reported by Dahiya and Jeswani (1974), Dahiya (1986), Mourya (1998), Kumari and Prasad (2003).

Table 1. Heterosis over superior parent for seed yield, its components and Neurotoxin (ODAP) content in grasspea

	Characters								
Hybrids	**Days to flower initiation**			**Days to 50% flowering**			**Days to pod initiation**		
	MP	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**
Pusa-24 x Prateek	-2.14	-2.84*	0.75	-1.90	-2.52	0.66	-1.86	-2.47**	0.65
Pusa-24 x Ratan	-4.23**	-3.55**	0.00	-3.75**	-3.14**	0.00	-3.68**	-3.09**	0.00
Pusa-24 x Mahateora	0.36	-1.42	2.21	1.60	0.00	3.25*	0.31	-1.23	1.91
Pusa-24 x RLS-3004	10.18**	11.35**	15.44**	7.69**	10.06**	13.64**	8.54**	9.88**	13.38**
Pusa-24 x Siraha Local	-6.04**	-0.71**	2.96**	-7.19**	-2.52**	0.66	-5.29**	-0.62**	2.56*
Prateek x Ratan	11.35**	12.95**	15.44**	10.06*	11.46**	13.64**	9.88**	11.25**	13.38**
Prateek x Mahateora	1.82	0.72	2.96*	2.89**	1.91	3.90**	1.58	0.62	2.56*
Prateek x RLS-3004	10.95**	12.95**	15.44**	8.36**	11.46**	13.64**	9.20**	11.25**	13.38**
Prateek x Siraha Local	4.73**	11.51	13.99**	2.41*	8.28*	10.40**	4.14**	10.00	12.12**
Ratan x Mahateora	13.26**	10.49**	16.19**	11.11**	8.70**	13.64**	11.53**	9.15**	14.03**
Ratan x RLS-3004	-0.35	0.00	5.16**	-1.53	0.00*	4.56**	-0.61	0.00	4.47**
Ratan x Siraha Local	4.67**	9.79	15.44**	2.98**	7.45	12.35**	4.09**	8.54	13.38**
Mahateora x RLS-3004	1.43	4.41	4.41**	0.00	3.90**	3.90**	0.93	3.82	3.82**

Mahateora x Siraha Local	7.85**	16.18	16.19**	6.99**	14.29	14.30**	6.87**	14.01	14.03**
RLS-3004 x Siraha Local	18.94**	24.31**	31.63**	15.54**	18.67**	27.94**	16.28**	20.48**	27.40**

Hybrids	**Characters**								
	Days to 50% pod formation			**Days to maturity**			**Plant height (cm)**		
	MP	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**
Pusa-24 x Prateek	-2.76**	-2.76**	-1.11	0.62	3.16**	10.13**	7.85	6.75	4.03
Pusa-24 x Ratan	-4.37**	-3.31**	-1.69	-1.25	0.32	7.09**	10.67	11.00	8.17
Pusa-24 x Mahateora	0.36**	2.21**	3.94**	-0.65	-3.80**	2.70**	2.42	3.76	1.11
Pusa-24 x RLS-3004	6.52**	8.29**	10.11**	-2.93**	-5.70	0.67	-20.09	-20.70	-22.72
Pusa-24 x Siraha Local	-6.63**	-2.76	-1.11	1.95**	-0.95**	5.74**	-22.40	-21.68	-23.68
Prateek x Ratan	7.10**	8.29**	10.11**	0.00	-0.90**	11.15**	-14.86	-13.72	-17.63
Prateek x Mahateora	2.51**	1.66**	3.37**	5.73**	0.00**	12.16**	-10.13	-8.01	-12.17
Prateek x RLS-3004	7.61**	9.39**	11.24**	5.40**	0.00**	12.16**	9.46	9.74	4.78
Prateek x Siraha Local	1.86	6.08**	7.87**	5.40**	0.00**	12.16**	2.32	4.35	-0.37
Ratan x Mahateora	9.64**	7.57**	11.80**	1.61*	-3.07**	6.75**	6.46	7.53	5.41
Ratan x RLS-3004	-0.54	0.00**	3.94**	4.49**	0.00**	10.13**	5.50	4.39	2.34
Ratan x Siraha Local	2.89**	5.95**	10.11**	5.45**	0.92**	11.15**	-17.78	-17.27	-18.90
Mahateora x RLS-3004	-0.82	1.69	1.69	11.11**	11.49**	11.48**	-21.99	-23.57	-23.57
Mahateora x Siraha Local	5.88**	11.24**	11.24**	6.06**	6.42**	6.42**	-5.91	-6.26	-6.26
RLS-3004 x Siraha Local	13.84**	16.58**	22.48**	9.40**	9.40**	10.13**	-19.41	-18.03	-21.34

Hybrids	**Number of seeds pod^{-1}**			**Number of seeds plant^{-1}**			**Seed yield plant^{-1} (g)**			**Biological yield plant^{-1}**		
	MP	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**
Pusa-24 x Prateek	-2.17	-6.25	-13.54	4.61	14.13	32.90	5.09	12.39	6.39	-31.19	-33.90	-2.64
Pusa-24 x Ratan	-4.00	0.00	-7.78	157.24**	122.93**	159.61**	138.08**	161.33**	147.25**	55.48*	27.83	88.33*
Pusa-24 x Mahateora	-20.00	-16.67*	-14.41*	59.28**	48.03*	72.39**	91.72*	97.12*	86.50	43.23	20.24	77.14*
Pusa-24 x RLS-3004	-19.15	-20.83	-27.09*	12.60	22.40	42.55	34.49	50.81	42.63*	3.29	-19.56	18.49
Pusa-24 x Siraha Local	-6.93	-2.08	-9.80	29.81	34.63	56.78**	-2.33	-8.26	-13.14	-9.54	-26.48	8.34
Prateek x Ratan	-14.58	-6.82*	-21.33*	28.71	4.28	43.54	17.64**	20.55	29.84	43.04	21.54	64.98
Prateek x Mahateora	-2.08	6.82	-9.80	48.16**	27.90	76.06**	68.76*	62.64	75.31*	59.76*	38.74	88.33*
Prateek x RLS-3004	0.00	2.27	-13.54	18.68	18.29	62.83**	28.32	34.18	44.58	74.78*	40.27	90.41*
Prateek x Siraha Local	15.46	27.27	7.49	56.49**	49.36**	105.59**	137.47**	110.33**	126.64**	73.53*	45.67	97.71*
Ratan x Mahateora	1.92	1.92	1.73	79.20**	94.53**	66.11**	28.85	21.36	37.30	27.38	30.80	24.18
Ratan x RLS-3004	-8.16	-13.46	-13.54	92.70**	150.63**	114.01**	68.58**	71.94*	94.49*	101.41**	87.85*	78.32**
Ratan x Siraha Local	-18.10	-17.31	-17.29	60.74**	98.12	69.17**	82.02**	57.91	78.51*	59.14	56.81	48.85
Mahateora x RLS-3004	-2.04	-7.69	-7.78	-5.62	11.71	11.71	39.79	52.13	52.04	-2.80	-11.49	-11.47
Mahateora x Siraha Local	-10.48	-9.62	-9.80	12.78	26.93	26.94	31.82	20.73	20.60	7.57	3.33	3.34
RLS-3004 x Siraha Local	1.01	8.70	-4.03	-6.37	-10.35	22.58	9.03	-6.95	9.41	27.38	35.14	10.98

Hybrids	**Number of primary branches plant^{-1}**			**Number of pods plant^{-1}**			**Pod length (cm)**		
	MP	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**
Pusa-24 x Prateek	-6.63**	-11.00	-38.01**	18.68	38.82	46.74	0.21	5.03	6.67
Pusa-24 x Ratan	1.55**	1.55	-35.89**	185.47**	155.97**	170.53**	-2.83	-2.41	-1.00
Pusa-24 x Mahateora	-16.00**	-31.48**	-31.48**	147.32**	140.67**	154.38**	-0.77	-1.53	0.00
Pusa-24 x RLS-3004	-12.59**	-14.74	-43.39**	32.67	34.79	42.47	-2.92	1.97	3.67
Pusa-24 x Siraha Local	-12.83**	-13.95	-45.68**	40.86	35.29	43.01	-4.94	-3.06	-1.67
Prateek x Ratan	-6.63**	-11.00	-38.01**	47.83	17.69	66.61	-4.99	-8.78	1.67
Prateek x Mahateora	-35.96**	-45.67**	-45.68**	61.91*	38.14	95.58*	-6.41	-11.18*	-1.00
Prateek x RLS-3004	-10.55**	-12.64	-39.15**	67.54*	48.31	109.97**	-3.98	-3.79	7.00
Prateek x Siraha Local	-9.70**	-14.98	-40.78**	106.25**	74.03**	146.39**	-0.20	-2.79	8.33
Ratan x Mahateora	-32.60**	-45.02**	-45.02**	67.54	83.69	54.01	7.14	5.86	8.33

Ratan x RLS-3004	-9.32**	-11.54	-41.27**	155.25**	193.64**	146.20**	1.24	5.86	8.33
Ratan x Siraha Local	4.71	3.35	-34.75**	140.20**	159.53**	117.61**	0.64	2.17	4.67
Mahateora x RLS-3004	-23.53**	-36.37**	-36.38**	14.02	19.18	19.18	0.73	6.67	6.67
Mahateora x Siraha Local	-24.65**	-39.15**	-39.15**	41.13	39.25	39.28	0.54	3.33	3.33
RLS-3004 x Siraha Local	-9.95**	-13.26	-42.41**	43.03	35.34	47.62	-1.23	-3.98**	7.33

	Characters											
Hybrids	**Harvest index (%)**			**100 seed weight (g)**			**Protein content (%)**			**ODAP content (%)**		
	MP	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**	**MP**	**BP**	**SV**
Pusa-24 x Prateek	43.99	59.87	3.13	-10.40**	-14.76**	-6.60**	21.44**	93.14**	-1.31	-20.31**	-15.00**	0.00
Pusa-24 x Ratan	25.51	94.68	25.58	-7.73**	-5.11**	3.87	37.89**	118.15	11.47*	-40.58**	-31.67**	-50.00**
Pusa-24 x Mahateora	19.01	51.75	-2.12	-0.32	-4.67*	4.45**	-24.19**	12.09**	-42.70**	-7.46**	3.33**	0.00
Pusa-24 x RLS-3004	-4.49	72.28	11.14	-13.24**	-17.34**	-9.47**	33.16**	107.81	6.21	-0.93**	-11.67**	0.00
Pusa-24 x Siraha Local	-13.13	16.17	-25.07	-13.05**	-12.27**	-3.87	-19.55**	20.70**	-38.30**	-4.76**	16.67**	0.00
Prateek x Ratan	-23.97	3.48	-18.51	-6.40**	1.60**	0.43	5.17	4.76	16.77**	-10.96**	-4.41**	0.00
Prateek x Mahateora	-4.24	8.69	-14.42	6.57**	7.16**	5.88**	-20.83**	-24.89**	-16.27**	-2.82**	1.47**	0.00
Prateek x RLS-3004	-40.39	-6.53**	-26.40	22.43**	22.64**	21.23**	-4.19	-5.50	5.30	-0.87**	-16.18**	0.00
Prateek x Siraha Local	25.85	49.25	17.53	-13.46**	-7.93**	-9.04**	14.62**	9.88**	22.48**	-14.84**	-2.94**	0.00
Ratan x Mahateora	-10.58	-22.32	5.33	-8.43**	-14.67**	-1.29	-5.85	-10.36*	-0.86	-11.84**	-14.10**	0.00
Ratan x RLS-3004	-30.98	-22.69	4.85	-3.60	-10.50**	3.59**	3.35	2.32	13.15**	-2.40**	-21.79**	0.00
Ratan x Siraha Local	-6.92	-16.38	13.38	-22.63**	-24.05**	-12.05*	1.44	-2.39	7.93	-17.58**	-12.82**	0.00
Mahateora x RLS-3004	13.92	52.76	52.77	-3.46	-3.83	-3.87	10.78**	15.43	15.46**	-28.93**	-41.89**	-50.00**
Mahateora x Siraha Local	3.91	8.08	8.08	-6.27**	-0.86**	-0.86	-1.10	0.00	0.00	-13.04**	-5.41**	0.00
RLS-3004 x Siraha Local	-27.01	-40.06	0.82	8.38**	15.09	14.20**	-41.85**	-43.50**	-38.76**	-31.34**	-2.13**	0.00

Genetic variability: The mean values, coefficient of variability are presented in Table 1. Number of pods per plant showed the maximum genotypic variability and Pod length showed the minimum genotypic variability. For all traits, phenotypic coefficients of variation were higher than the genotypic coefficient of variation. Coefficients of genotypic and phenotypic variation suggest that there is good scope for yield improvement through selection for pods per plant, seeds per plant and yield per plant.

Table 2. Genetic parameters of variation for seed yield, its components and Neurotoxin (ODAP) content in grasspea

S. No.	Characters	Mean	Range		Coefficient of variation		h^2_{bs}(%)	Genetic advance (GA)	Genetic advance as % of mean
			Minimum	Maximum	Genotypic	Phenotypic			
1.	Days to flower initiation	48.71	45	59.66	7.54	7.69	96.12	7.38	15.15
2.	Days to 50% flowering.	55.42	51.33	65.67	6.47	6.64	94.84	7.17	12.93
3.	Days to pod initiation	56.46	52.33	66.67	6.49	6.62	96.16	7.35	13.03
4.	Days to 50% pod formation	62.90	58.33	72.67	5.54	5.69	94.66	6.99	11.11
5.	Days to maturity	106.15	98.67	110.67	4.02	4.12	94.98	8.65	8.15
6.	Plant height (cm)	58.77	47.93	67.93	4.59	18.61	6.09	1.35	2.30
7.	Number of primary branches plant^{-1}	3.87	3.33	6.13	11.71	20.10	33.92	0.54	14.16
8.	Number of pods plant^{-1}	60.59	31.47	101.53	27.78	46.94	35.02	21.79	35.96
9.	Pod length (cm)	3.08	2.95	3.35	2.28	5.96	14.70	0.06	2.01
10.	Number of seeds pod^{-1}	3.07	2.53	3.73	5.80	15.05	14.88	0.14	4.64
11.	Number of seeds plant^{-1}	129.54	74.40	226.20	23.16	34.24	45.77	43.60	33.65
12.	Seed yield plant^{-1} (g)	7.81	4.68	13.92	22.46	47.15	22.70	1.83	23.46
13.	Biological yield plant^{-1} (g)	19.10	11.82	28.45	18.34	44.60	16.91	3.06	16.03
14.	Harvest index (%)	43.17	26.76	63.37	11.17	39.65	7.94	2.79	6.47
15.	100 seed weight (g)	6.99	6.13	8.45	8.52	8.96	90.49	1.16	16.59
16.	Protein content (%)	21.12	11.27	27.02	22.04	22.66	94.58	9.26	43.85
17.	ODAP content (%)	0.02	0.01	0.03	18.19	22.02	68.28	0.006	31.28

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