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Genetic Analysis of Seed Yield and Its Contributing Traits and Pattern of Their Inheritance in Fieldpea (*Pisum sativum* L)

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A B S T R A C T

Aim of the study is analyse the inheritance of seed yield and its contributing traits through combining ability analysis in field pea for this seven genotypes as parents viz., Makyatmubi, Makuchabi, KPMR-851, Prakash, Pant P-217, Rachna and VL-5 in diallel without reciprocals during Rabi 2013-14 were selected. The genetic analysis was carried out following Griffing's Method II with Model I (1956) for twelve quantitative characters. The ANOVA for combining ability revealed highly significant differences among crosses for all the characters studied. The σ2GCA/σ2SCA ratio was shown to be less than unity for most of the character indicating the predominant role of non-additive gene action in the inheritance of those traits. However, for remaining traits days to first flowering, number of nods to first flowering, number of seeds per pod and 100 seed weight, the ratio was found to be more equal to unity indicating the importance of both additive and non-additive gene action in the expression of these gene. In case of GCA effects, Makyatmubi and Makuchabi were identified as the most promising parents for involving in hybridization programme. On the basis of SCA effects, two crosses viz., Makyatmubi x KPMR-851 and Makuchabi x VL-58 were identified as the most promising crosses for improvement of seed yield per plant viz., number of pods/plant, number of seeds/pod, etc. These crosses showing highly significant SCA effects for seed yield per plant also exhibited high per se performance and moreover both the parents involved either as good general combiner or at least one good combiner for seed yield per plant. The manifestation of heterosis for seed yield was evidenced by superiority of hybrids ranging from 42.28 to 192.48% in 19 crosses over standard check variety Rachna. Overall on the basis of results of mean performance, including GCA and SCA effects and standard heterosis, three crosses viz., Makyatmubi x KPMR-851, Makuchabi x VL-58 and Makuchabi x Prakash were identified as the most promising cross combinations for improvement of seed yield and its

Keywords

Genetic analysis, Griffing's method II Model I, GCA, SCA, Field pea.

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Introduction

Pulses (grain legumes) are important group of crops which are grown not only for protein but also have considerable amount of carbohydrates, minerals and vitamin B complex. Among pulses, pea (*Pisum sativum* L.), also known as field pea and garden pea in English, and Matar in Hindi is one of the important rabi (winter) crops grown in the world and India. Pea (2n= 2x=14) belongs to the family Leguminoseae and genus *Pisum*. It is an annual herbaceous, self-pollinated crop. Field pea is one of the important pulse crops in India, grown in an area of 0.68 million hectares producing 0.62 MT of grain. The average national productivity of fieldpea is 911 kg/ha (Anonymous, 2013). It is consumed as both green immature seeds as well as dry seeds. Like other pulses, field pea is used along with cereals such as rice, wheat, maize or millets so as to balance the level of essential amino acids, as pulses are deficient in methionine and rich in lysine, while cereals are rich in methionine and deficient in lysine (Srivastava and Ali, 2004). Field pea is an important pulse crop in Manipur during rabi season. In Manipur, the productivity of pea is lower (767 kg/ha) as compared to national level (911 kg/ha). One of the major constraint in increasing the area and productivity of pea in Manipur is the lack of high yielding varieties which are suitable for cultivation under varied agro-climatic conditions of the state. Development of high yielding genotypes depends on the selection of parents. Combining ability analysis provides a means of selection of parents. Hence, the present investigation was carried out to help selection of parents.

Materials and Methods

The present investigation was conducted at the research field of the Department of Plant Breeding and Genetics, College Of Agriculture, Central Agricultural University, Imphal. The experiment consisted of evaluations of 21 F1s obtained by crossing seven parents in a half diallel fashion. The parents, viz., Makyatmubi, Makuchabi, KPMR-851, Prakash, Pant P-217, Rachna and VL-5 were randomly chosen from a collection maintained at CAU, Imphal. The seven parents along with 21 F1s are evaluated during rabi 2014-15 in a RBD with three replications. Each F1 parent was sown in a plot. Each plot consisted of a single row spaced 30 cm with a with length of 4m. The plant to plant distance was 10 cm and appropriate agronomical practices were followed to raise a good crop.

Observations were recorded on five individual plants taken at random (excluding border plants) from each genotype for days to first flowering, number of nodes to first flowering, days to 50% flowering, days to maturity, plant height (cm), number of pods/plant, pod length (cm), number of seeds/pod, seed yield/plant (g), biological yield/plant (g), 100 seed weight (g), harvest index (HI) (%). The analysis of variance was done according to the method given by Griffings (1956). Heterosis was worked out over better parent and its significance was determined by t test as suggested by Rai and Rai (2006).

Results and Discussion

The analysis of variance revealed significant differences among the parents and F1s for all the characters (Table 1). These findings showed that enough genetic variability available in the materials studied. Bisht and Singh (2011), Brar *et al.*, (2012) and Esposito *et al.*, (2013) had also observed significant differences among the genotypes for different characters viz., days to first flowering, nodes to first flowering, days to 50% flowering, days to maturity, plant height, number of pods/plant, pod length, number of seeds/pod, seed yield/plant, biological yield/plant, 100 seed weight and harvest index.

The analysis of variance for combining ability revealed that mean squares due to both general combining ability and specific combining ability were highly significant for all the traits investigated (Table 1). This indicated the importance of both additive and non-additive gene action for the expression of almost all the characters. However, except the few characters viz., days to first flowering, number of nodes to first flowering, number of seeds/plant and 100 seed weight, the ratio of general combining ability and specific combining ability ($\sigma 2g/\sigma 2s$) was shown to be less than unity for all other characters indicating the predominant role of non-additive gene effect for the expression of these traits. These findings are in corroborating with the findings of Singh *et al.*, (1994) and Sharma *et al.*, (2003). The per se performance of the parents was good indicator for their general combining effects (Table 2). The parent Makyatmubi recorded significantly positive gca effects for nodes to first flowering, pod length, seed yield/plant, biological yield/plant and 100 seed weight.

Makuchabi was found to be good general combiners for nodes to first flowering, pod length, number of seeds/pod, seed yield/plant and harvest index. The similar results were reported by Pant and Bajpai (1993), Pandey *et al.*, (1996) and Kumar and Jain (2002). It is evident from table 2 that the significant gca effects for seed yield in positive direction resulted from similar gca effects of some yield components indicating that the combining ability of seed yield was influenced by the combined effects of its components. Therefore, simultaneous improvement in important yield components and associated trait along with seed yield may be better approach for raising yield potential in pea. The estimates of specific combining ability effects of 21 F1 crosses for 12 characters under study are presented in table 3.

The negative and significant specific combining ability effects were found in the cross KPMR-851 x Prakash for days to first flowering, Prakash x Pant P-217 for days to 50% flowering, Prakash x Rachna and KPMR-851 x Rachna for days to maturity, Makuchabi x Pant P-217 for plant height. So these crosses can be utilized for evolving early flowering, maturing and dwarf plants. Makuchabi x VL-58, Makyatmubi x KPMR-851, Pant P-217 x Rachna, Makuchabi x Prakash and Prakash x VL-58 for number of pods/plant, Makyatmubi x VL-58 and Makyatmubi x Prakash for 100 seed weight exhibited highly significant and positive specific combining ability effects. Ranjan *et al.*, (2005) and Zaman and Hazarika (2005) were also obtained similar results while studying combining ability in field pea.

The range of heterosis for different characters over standard check were from 42.28 to 192.75 percent for seed yield, -13.43 to 2.49 percent for days to first flowering, 2.56 to 25.64 percent for number of nodes to first flowering, -11.16 to 1.86 percent for days to 50% flowering, -4.44 to -0.59 percent for days to maturity, -2.03 to 24.63 percent for plant height, 4.35 to 69.57 percent for pods/plant, -3.79 to 22.05 percent for pod length, -6.25 to 25.00 percent for seeds/pod, -0.02 to 59.15 percent for 100 seed weight, 25.96 to 135.52 percent for biological yield/plant and 11.98 to 43.29 percent for harvest index respectively.

Similar results were reported by Pant and Bajpai (1991) and Sharma *et al.*, (1998) in field pea. The list of best crosses for different characters showing heterosis over standard check (SC) is given in table 4. Most of the hybrids showed negative heterosis for days to 50 percent flowering and days to maturity indicating that they had the tendency to flower and mature early. High magnitudes of heterosis were observed for 100 seed weight. This finding is corroboration with the results of Bora (2009). Plant breeders can give emphasis on yield contributing characters for the improvement of seed yield in field pea.

From the table 5, it is revealed that most of the good specific cross combinations for different characters involved parents of low x low, low x average, average x average, average x high and high x high general combining ability. The classification of low, average and high of the parents was done based on their seed yield.

Table.1 Analysis of variance for combining ability for different characters in 7- parent half-diallel of field pea

Source of variation	d.f.	Mean sum of squares					
		Days to first flowering	Nodes to first flowering	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of pods/plant
GCA	6	20.728**	3.442**	13.350**	2.888*	228.780**	3.008**
SCA	21	4.939	0.432	6.161**	2.371	238.886	3.347**
Error	54	3.162	0.338	2.645	1.087	22.189	0.866
σ^2gca		1.952	0.345	1.189	0.2	22.955	0.238
σ^2sca		1.778	0.093	3.515	1.285	216.697	2.48
σ^2gca/σ^2sca		1.098	3.695	0.338	0.156	0.106	0.096

Source of variation	d.f.	Mean sum of squares					
		Pod length (cm)	Number of seeds/pod	seed yield/plant (g)	biological yield/plant (g)	100 seed weight (g)	Harvest index (%)
GCA	6	0.456**	0.904**	8.293**	34.246**	25.009**	26.847**
SCA	21	0.092	0.117	7.962**	31.635**	1.996**	12.508**
Error	54	0.041	0.134	1.352	6.523	0.757	3.517
σ^2gca		0.046	0.086	0.771	3.08	2.695	2.592
σ^2sca		0.051	0.017	6.61	25.112	1.24	8.992
σ^2gca/σ^2sca		0.903	5.018	0.117	0.123	2.174	0.288

, * Significant at 5% and 1% levels, respectively

Table.2 Estimates of general combining ability effects for days to first flowering, nodes to first flowering, and days to 50% flowering, days to maturity, plant height and Number of pods/plant in a half-diallel crosses of field pea

	Days to first flowering		Number of nodes to first flowering		Days to 50% flowering		Days to maturity		Plant Height (cm)		Pods/plant	
Parent	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean
1.Makyatmubi	0.905	63.00	0.561*	15.33	1.037*	69.00	0.317	110.33	0.089	111.27	-0.111	6.67
2. Makuchabi	0.349	63.67	0.635*	15.67	0.407	69.33	-0.016	110.67	-3.193*	105.53	0.333	7.33
3. KPMR-851	-1.947*	62.33	-0.069	15.33	-1.889*	67.00	-0.831*	110.00	0.156	109.27	1.148*	8.67
4. Prakash	1.423*	70.33	0.561*	15.33	1.074*	74.67	0.577	114.00	-4.844*	58.73	-0.593*	6.00
5. Pant P-217	-1.614*	61.67	-0.143	14.33	-1.259*	68.67	-0.608	110.00	10.704*	132.07	-0.259	7.67
6. Rachna	1.868*	67.00	-0.624*	13.00	1.074*	71.67	0.651*	112.67	-1.556	111.53	-0.333	7.67
7. VL-58	-0.984	61.67	-0.921*	13.67	-0.444	70.67	-0.090	112.33	-1.356	104.33	-0.185	7.33
Mean		64.24		14.67		70.14		111.43		104.68		7.33
SE(gi)	0.549		0.179		0.501		0.322		1.453		0.287	
SE(gi-gj)			0.274		0.767		0.491		2.22		0.439	

	Pod length (cm)		**Number of seeds/pod**		**Seed yield/plant (g)**		**Biological yield/plant (g)**		**100 seed weight(g)**		**Harvest index(%)**	
Parent	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean	GCA effect	Mean
1.Makyatmubi	0.348*	7.27	-0.212	5.00	1.269*	8.70	3.768*	21.47	3.039*	23.51	-0.519	40.43
2. Makuchabi	0.286*	6.82	0.455*	6.33	0.876*	6.60	0.648	16.46	0.490	18.43	1.842	40.11
3. KPMR-851	-0.110	6.37	-0.249*	5.67	0.082	7.73	0.223	20.96	-0.608*	18.46	0.333	36.76
4. Prakash	-0.075	6.37	-0.323*	5.00	-0.149	6.77	-1.022	15.78	1.074*	20.93	1.283	43.17
5. Pant P-217	-0.047	6.61	0.418*	6.33	0.199	7.70	-0.345	18.14	-1.340*	17.42	1.662	42.42
6. Rachna	-0.223*	5.99	-0.101	5.33	-1.634*	5.29	-2.542*	15.72	-1.747*	15.76	-2.961*	33.44
7. VL-58	-0.179*	6.49	0.011	6.00	-0.643	6.21	-0.730	18.48	-0.909*	18.25	-0.974	33.50
Mean		6.56		5.67		7.00		18.14		18.97		38.55
SE(gi)	0.062		0.113		0.359		0.788		0.268		0.578	
SE(gi-gj)	0.096		0.173		0.548		1.204				0.884	

, * Significant at 5% and 1% levels, respectively

Table.3 Estimates of specific combining ability effects for days to first flowering, nodes to first flowering, and days to 50% flowering, days to maturity, plant height and Number of pods/plant in a half-diallel crosses of field pea

Parent	Days to first flowering		Number of nodes to first flowering		Days to 50% flowering		Days to maturity		Plant Height (cm)		Pods/plant	
	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean
Makyatmubi x Makuchabi	0.556	64.67	0.185	16.33	-0.861	68.33	-0.694	109.33	2.679	118.07	0.611	10.00
Makyatmubi x KPMR851	-1.148	60.67	0.556	16.00	0.102	67.00	-0.213	109.00	1.931	120.67	2.796**	13.00
Makyatmubi X Prakash	1.815	67.00	0.259	16.33	1.139	71.00	0.380	111.00	15.064**	128.80	0.537	9.00
Makyatmubi x Pant P 217	0.519	62.67	0.296	15.67	-0.861	66.67	-0.435	109.00	5.182	134.47	1.204	10.00
Makyatmubi x Rachna	3.037	68.67	0.111	15.00	3.139*	73.00	1.306	112.00	-4.358	112.67	-0.722	8.00
Makyatmubi x VL 58	-1.444	61.33	0.074	14.67	-1.009	67.33	-0.287	109.67	-5.692	111.53	0.13	9.00
Makuchabi x KPMR851	-1.259	60.00	0.815	16.33	-0.602	65.67	0.120	109.00	1.012	116.47	0.019	10.67
Makuchabi X Prakash	-1.963	62.67	-0.148	16.00	-2.231	67.00	-1.287	109.00	9.945*	120.40	1.426	10.33
Makuchabi x Pant P 217	1.407	63.00	0.556	16.00	0.769	67.67	0.898	110.00	-10.036*	115.97	-0.907	8.33
Makuchabi x Rachna	1.259	66.33	0.704	15.67	2.102	71.33	0.639	111.00	4.656	118.40	0.167	9.33
Makuchabi x VL 58	-0.222	62.00	-1.000	13.67	-0.713	67.00	-1.620	108.00	0.890	118.83	3.685**	13.00
KPMR851 X Prakash	-4.000*	58.33	-0.444	15.00	-1.935	65.00	-1.139	108.33	18.331**	132.13	0.278	10.00
KPMR851 x Pant P 217	-1.296	58.00	-0.407	14.33	0.398	65.00	-0.287	108.00	1.049	130.40	2.611**	12.67
KPMR851 x Rachna	-0.444	62.33	-0.926	13.33	-2.269	64.67	-1.880*	107.67	-2.758	114.33	1.685*	11.67
KPMR851 x VL 58	1.407	61.33	-0.63	13.33	-1.75	63.67	-0.472	108.33	-0.492	116.80	-1.796*	8.33
Prakash x Pant P 217	-2.667	60.00	0.63	16.00	-3.565*	64.00	-1.361	108.33	14.649**	139.00	-0.315	8.00
Prakash x Rachna	-2.815	63.33	0.778	15.67	-2.565	67.33	-1.954*	109.00	18.375**	130.47	0.426	8.67
Prakash x VL 58	0.37	63.67	0.407	15.00	-0.380	68.00	-0.880	109.33	23.775**	136.07	1.611	10.00
Pant P 217 x Rachna	-1.111	62.00	0.148	14.33	-1.898	65.67	-0.435	109.33	-1.906	125.73	0.093	8.67
Pant P 217 x VL 58	-0.926	59.33	-0.556	13.33	-1.713	64.33	-1.361	107.67	6.727	134.57	-0.722	8.00
Rachna x VL 58	-0.741	63.00	0.593	14.00	-2.046	66.33	-0.954	109.33	-6.314	109.27	0.019	8.67
Mean		59.4		**15.05**		**67.00**		109.16		**123.10**		**9.78**
SE(si)	1.596		0.521		1.459		0.935		4.227		0.835	
SE(si-sj)	1.874		0.613		1.714		1.099		4.965		0.981	

Parent	Pod length (cm)		Number of seeds/pod		Seed yield/plant (g)		Biological yield/plant		100 seed weight (g)		Harvest index (%)	
	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean	SCA effect	Mean
Makyatmubi x Makuchabi	-0.227	7.04	0.269	6.33	1.025	13.80	0.99	30.52	1.376	25.08	1.462	45.12
Makyatmubi x KPMR851	0.258	7.13	-0.028	5.33	3.505**	15.49	7.911**	37.02	0.010	22.61	0.030	41.52
Makyatmubi X Prakash	0.403*	7.31	0.38	5.67	0.269	12.02	4.433	32.29	1.619*	25.90	-5.656**	37.45
Makyatmubi x Pant P 217	0.341	7.27	0.306	6.33	1.676	13.77	3.189	31.73	0.212	22.08	-0.175	43.31
Makyatmubi x Rachna	-0.429*	6.33	-0.176	5.33	1.931	12.20	5.193*	31.53	-0.254	21.21	0.058	38.92
Makyatmubi x VL 58	0.240	6.56	0.046	5.67	0.531	11.79	0.651	28.80	2.524**	24.83	6.021**	46.87
Makuchabi x KPMR851	-0.053	6.75	-0.028	6.00	1.829	13.42	1.892	27.88	-0.337	19.72	3.970*	47.81
Makuchabi X Prakash	0.273	7.11	0.38	6.33	2.553*	13.91	4.277	29.02	1.415	23.15	454	47.92
Makuchabi x Pant P 217	0.054	6.92	-0.361	6.33	0.896	12.60	1.640	27.06	1.091	20.41	1.025	46.87
Makuchabi x Rachna	0.267	6.96	0.157	6.33	0.751	10.62	2.007	25.23	0.949	19.86	0.958	42.18
Makuchabi x VL 58	0.450*	7.19	0.38	6.67	4.501**	15.36	9.095**	34.13	0.957	20.71	1.961	45.17
KPMR851 X Prakash	-0.012	6.43	-0.25	5.00	1.170	11.73	1.119	25.43	0.433	21.07	2.905	46.19
KPMR851 x Pant P 217	-0.300	6.17	-0.324	5.67	0.523	11.43	0.805	25.80	0.193	18.42	0.803	44.47
KPMR851 x Rachna	0.189	6.49	0.194	5.67	-0.585	8.49	-0.798	22.00	0.190	18.01	-0.11	38.93
KPMR851 x VL 58	-0.008	6.33	-0.25	5.33	-0.312	9.76	-1.734	22.87	0.495	19.15	2.233	43.27
Prakash x Pant P 217	0.065	6.57	0.417	6.33	0.72	11.40	1.513	25.26	0.085	19.99	-0.17	45.11
Prakash x Rachna	0.101	6.43	-0.065	5.33	0.256	9.10	-0.482	21.07	0.532	20.03	2.37	43.03
Prakash x VL 58	-0.616**	5.76	-0.509	5.00	2.152*	11.99	3.718	27.08	-1.300	19.04	1.57	44.22
Pant P 217 x Rachna	-0.008	6.35	0.528	6.67	2.619*	11.81	4.750*	26.98	0.725	17.81	2.838	43.88
Pant P 217 x VL 58	-0.305	6.10	0.083	6.33	0.221	10.41	0.664	24.70	-2.170*	15.75	2.157	45.18
Rachna x VL 58	0.278	6.51	-0.065	5.67	-0.826	7.53	-2.045	19.80	-0.299	17.22	-0.163	38.24
Mean		6.65		5.87		11.84		27.44		20.57		43.60
SE(sij)	0.182		0.328		1.043		2.292		0.781		1.683	
SE(sii-gjj)	0.214		0.386		1.226		2.692		0.917		1.978	

, * Significant at 5% and 1% levels, respectively

Table.4 Top crosses showing significant desirable sca effects, their gca effects and mean *per se* performance

Character	Sca effects	Gca effects	*Per se* performance
Days to first flowering	KPMR-851 X Prakash(-4)	H X L	KPMR-851 X Prakash(58.33)
Nodes to first flowering			
Days to 50% flowering	Prakash X Pant P-217(-3.56)	L X H	Prakash X Pant P-217(64)
Days to maturity	Prakash X Rachna(-1.95)	A X L	Prakash X Rachna(109)
	KPMR-851 X Rachna(-1.88)	H X L	KPMR-851 X Rachna(107.67)
Plant height (cm)	Makuchabi X Pant P-217(-10.03)	L X H	Makuchabi X Pant P-217(115.97)
Number of pods/plant	Makuchabi X VL-58(3.68)	A X A	Makuchabi X VL-58(13)
	Makyatmubi X KPMR-851(2.79)	A X H	Makyatmubi X KPMR-851(13)
	KPMR-851 X Pant P-217(2.61)	H X A	KPMR-851 X Pant P-217(12.67)
	KPMR-851 X Rachna(1.68)	H X A	KPMR-851 X Rachna(11.67)
Pod length (cm)	Makuchabi X VL-58(0.45)	H X L	Makyatmubi X Prakash(7.31)
	Makyatmubi X Prakash(0.403)	H X A	Makuchabi X VL-58(7.19)
Number of seeds/pod			
Seed yield/plant (g)	Makuchabi X VL-58(4.5)	H X A	Makyatmubi X KPMR-851(15.49)
	Makyatmubi X KPMR-851(3.5)	H X A	Makuchabi X VL-58(15.36)
	Pant P-217 X Rachna(2.62)	A X L	Makuchabi X Prakash(13.91)
	Makuchabi X Prakash(2.55)	H X A	Prakash X VL-58(11.99)
	Prakash X VL-58(2.12)	A X A	Pant P-217 X Rachna(11.81)
Biological yield/plant (g)	Makuchabi X VL-58(9.09)	A X A	Makyatmubi XKPMR-851(37.02)
	Makyatmubi X KPMR-851(7.91)	H X A	Makuchabi X VL-58(34.13)
	Makyatmubi X Rachna(5.19)	H X L	Makyatmubi X Rachna(31.53)
	Pant P-217 X Rachna(4.75)	A X L	Pant P-217 X Rachna(26.98)
100 seed weight (g)	Makyatmubi X VL-58(2.52)	H X L	Makyatmubi X Prakash(25.9))
	Makyatmubi X Prakash(1.62)	H X H	Makyatmubi X VL-58(24.83)
Harvest index (%)	Makyatmubi X VL-58(6.02)	A X A	Makuchabi X KPMR-851(47.81)
	Makuchabi X KPMR-851(3.97)	H X A	Makyatmubi X VL-58(46.87)

Table.5 Best crosses for different characters showing heterosis over standard check (SC)

Characters	Best Crosses
Days to first flowering	KPMR-851 X Pant P-217 (-13.43), KPMR-851 X Prakash (-12.94)
Number of nodes to first flowering	Makyatmubi X Makuchabi (25.64), Makyatmubi X Prakash (25.64) and Makuchabi X KPMR-851 (25.64)
Days to 50% flowering	KPMR-851 X VL-58 (-11.16), Prakash X Pant P-217 (-10.70) and Pant P-217 X VL-58 (-10.23).
Days to maturity	KPMR-851 X Rachna (-4.44) and Pant P-217 X VL-58 (-4.44)
Number of pods per plant	Makuchabi X VL-58 (69.57) and Makyatmubi X KPMR-851 (69.57)
Pod length (cm)	Makyatmubi X Prakash (22.05) and Makyatmubi X Pant P-217 (21.49)
Number of seeds/plant	Makuchabi X VL-58 (25.00) and Pant P-217 X Rachna (25.00)
Seed yield/plant (g)	Makyatmubi X KPMR-851 (192.75) and Makuchabi X VL-58 (190.42)
Biological yield/plant (g)	Makyatmubi X KPMR-851 (135.52) and Makuchabi X VL-58 (117.14)
100 seed weight (g)	Makyatmubi X Prakash (64.40) and Makyatmubi X Makuchabi (59.15)
Harvest index (%)	Makuchabi X Prakash (43.29) and Makuchabi X KPMR-851 (42.99)

However in majority of cases, the crosses exhibiting high sca effects were found to have either or both of the parents as good general combiner for the character under reference. Present finding is similarity with the result of Kumar *et al.,* (2006) and Patil and Navale (2006) that most of the promising cross is the one that involves parents with high gca and shows high sca effects. The major part of such variance would be fixable in later generations. Such crosses were Makyatmbi x Prakash for 100 seed weight and pod length, Makuchabi x VL-58 for seed yield/plant and Makyatmubi x KPMR-851 for seed yield/plant and biological yield/plant. Recombination breeding through multiple crosses involving these hybrids would be desirable to breed genotypes having these characters. The present findings are in tune with Singh *et al.,* (2005) and Brar *et al.,* (2012).

In conclusion, over all it can be concluded from combining ability analysis that there is predominant role of both additive and non-additive type of gene action for seed yield and its components. On the basis of GCA effects Makyatmubi and Makuchabi were identified as most promising parents for involving in hybridization programme for generating desirable segregants. The manifestation of heterosis for seed yield was evidenced by superiority of hybrids ranging from 6.17 to 119.48% in the 13 crosses (Makyatmubi x KPMR-851, Makuchabi x VL-58 and Makuchabi x Prakash, etc.) over better parent and from 42.28 to 192.75% in 19 crosses over standard check variety Rachna.

The crosses which exhibited superiority over better parent or standard parent for seed yield also exhibited significant heterosis for three to four yield components (pod length, seeds/pod, number of pods/plant and seed weight).

Further on the basis of results of mean performance, SCA effects and standard heterosis, three crosses viz., Makyatmubi x KPMR-851, Makuchabi xVL-58 and Makuchabi Prakash were identified as the most promising cross combinations to give transgressive segregants in later generations.

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