Himachal Journal of Agricultural Research 37 (1):27-34, 2011

Identification of potential heterotic combinations and breeding for higher pod yield and earliness in garden pea (*Pisum sativum* L.)

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Manuscript Received: 24.09.2010; Accepted: 12.05.2011

Abstract

A field experiment was conducted during *Rabi*, 2008-09 to find out the heterotic combinations for higher pod yield and earliness in garden pea amongst twenty one cross-combinations developed through diallel mating design (excluding reciprocals). The analysis of variance for days to 50% flowering, days to first picking, duration of availability of marketable pods, pod length, seeds per pod, shelling percentage, pods per plant, plant height and pod yield per plant indicated significant differences among genotypes which showed the genetic diversity amongst the genotypes evaluated. For pod yield per plant, the cross combination, Azad Pea-1 x Pb-89 displayed the highest heterotic response to the extent of 41.39, 86.22 and 41.39 per cent over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. The other heterotic combinations DPP-3 × Pb-89, Palam Priya × Pb-89, Azad Pea- 1 × Pb-89 and Azad Pea- 1 × DPPLMR-41 also displayed standard heterosis for earliness and yield contributing traits. Both additive and non-additive gene actions in the inheritance of days to 50% flowering and non-additive gene action for all other traits were observed. Based upon the nature of gene action as inferred from combining ability variances, a line of improvement of a particular trait was suggested.

Key words: Garden pea, *Pisum sativum*, heterosis, gene action.

Introduction

Garden pea (*Pisum sativum* L.), a member of the family Leguminosae, is one of the most common and principal vegetable crops grown on commercial scale as winter season crop. In Himachal Pradesh, it is also cultivated as off-season vegetable during rainy season in temperate wet areas and summer in temperate dry areas, in addition to winter season crop. The green pods from hilly areas are available at a time (April-September), when these cannot be grown in the plains due to high temperature. As a result, these sell at a higher premium, bringing lucrative returns to the growers.

In the past, several high yielding varieties have been identified, developed and made available to the growers for commercial cultivation. Keeping in view the diverse agro-climatic conditions prevailing in the state and the ever increasing demand of the vegetable growers for high yielding varieties, there is an urgent need for the identification and development of location specific improved varieties. Hence, it becomes imperative to study the genetic architecture of important horticultural traits in the available germplasm for its rational manipulation in the development of high yielding varieties through appropriate breeding methodologies. In order to exploit heterosis, identification of best parents for hybridization is a pre-requisite and one of the critical and difficult tasks for a plant breeder. The choice is relatively straight forward when some qualitative character is under consideration but complex traits such as yield, do not allow an easy handling. The appropriate selection of the parents for hybridization requires the complete

information regarding the general combining ability of the parents and the performance of a specific combination. Further, the knowledge about the gene action helps in formulating an efficient breeding programme aiming to improve yield potential through its components. Diallel analysis, developed by Jinks and Hayman (1953) and Hayman (1954), is an effective method for obtaining useful information on differential parental combinations, through an assessment of the overall genetic architecture of the parental lines, in relation to the character studied. Based upon all these considerations, the present investigation was executed to identify the best heterotic combinations for earliness, pod yield and its contributing traits for future exploitation.

Materials and Methods

The experimental material consisted of seven diverse genotypes of garden pea, namely Palam Priya, Azad Pea-1, Lincoln, DPP 9418-06, DPP-3, DPPLMR-41 and Pb-89 which were crossed in a diallel mating design (excluding reciprocals). The resultant 21 F_1 hybrids along with their seven parents were evaluated during Rabi, 2008-2009, in RBD with three replications at the experimental farm of Department of Vegetable Science and Floriculture, CSK HPKV, Palampur (HP). Each experimental plot comprised of two rows of 1.8m length for each parent and F_1, accommodating 18 plants per row,with an intra and inter row distance of 10 and 45cm, respectively. The data recorded on ten competitive plants selected at random from each treatment and each replication for all the traits investigated (Table 1) were subjected to statistical analysis as per the method outlined by Panse . and Sukhatme (1984). For computation of standard heterosis, Palam Priya (SC1) and PB 89 (SC2) were taken as standard checks. The combining ability analysis was carried out as per the method given by Griffing (1956).

Results and Discussion

The analysis of variance for design of experiment revealed significant differences for all the traits studied *viz*., days to 50% flowering, days to first picking, duration of availability of marketable pods, pod length, seeds per pod, shelling percentage, pods per plant, plant height and pod yield per plant (Table 1), which reflected that genotypes evaluated in the present study were genetically diverse. Significant variation among genotypes for different horticultural traits in pea has also been observed earlier by Tyagi and Srivastava (2001) and Kaur *et al.* (2003). The variances due to general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters studied (Table 2), which indicated the presence of both additive and non-additive gene actions in the manifestation of these traits. The involvement of both additive and non-additive gene actions in the inheritance of different horticultural traits in pea has also been reported by Sharma *et al.* (1999) and Narayan *et al.* (1999).

The estimates of combining ability variances (σ^2gca and σ^2sca) and their ratio (σ^2sca/σ^2gca) have also been presented in Table 2. A glance of the values indicated that the estimates of σ^2sca were higher in magnitude as compared to σ^2gca for all the characters studied except for days to 50% flowering. Further the ratio of specific combining ability variances (σ^2sca) to general combining ability variance (σ^2gca) was more than unity for days to first picking,duration of availability of marketable pods, pod length, seeds per pod, shelling % age, yield per plant which confirmed the predominant role of non-additive gene action in the inheritance of these traits. However, both additive

Table 1. Analysis of variance for design of experiment (RBD)

Source of variation	Mean squares		
Character	Replication	Treatment	Error
df	2	27	54
Days to 50% flowering	9.705	48.224*	12.207
Days to first picking	8.905	147.783*	25.141
Duration of availability of marketable pods	0.035	67.687*	6.430
Pod length	0.003	1.714*	0.138
Seeds per pod	0.125	1.063*	0.078
Shelling percentage	3.726	27.492*	3.541
Pods per plant	12.520*	30.381*	3.432
Plant height	61.466*	168.247*	17.583
Pod yield per plant	309.625	1327.565*	99.212

*Significant at 5% level of significance

Table 2. Analysis of variance for combining ability

Source of variation	Mean Squares			Components		
	GCA	SCA	Error			
Character df	6	21	54	σ^2gca	σ^2sca	σ^2sca/σ^2gca
Days to 50% flowering	43.301*	8.296*	4.069	4.359	4.227	0.970
Days to first picking	99.680*	34.855*	8.380	10.144	26.475	2.610
Duration of availability of marketable pods	64.763*	10.505*	2.143	6.957	8.362	1.202
Pod length	1.592*	0.279*	0.046	0.171	0.233	1.356
Seeds per pod	0.901*	0.198*	0.026	0.097	0.172	1.770
Shelling percentage	12.637*	8.171*	1.180	1.273	6.991	5.492
Pods per plant	27.989*	5.023*	1.144	2.982	3.897	1.301
Plant height	64.692*	53.622*	5.861	6.536	47.761	7.307
Pod yield per plant	1252.992*	210.958*	33.070	135.546	177.888	1.312

*Significant at 5% level of significance

and non-additive genetic variances were equally important in the manifestation of days to 50% flowering. The ratio of σ^2sca to σ^2gca was close to the unity which further confirmed the involvement of both additive and non-additive gene actions in the inheritance of days to 50% flowering.

The genotypes which flower early are more desirable for getting early produce, which fetches better returns to the farmers; hence heterosis in the negative direction is desirable for earliness (days to 50 % flowering and days to first picking). All parental lines and their hybrid combinations were genetically diverse with respect to days to 50% flowering and days to first picking. As many as one hybrid each over better parent and standard check 2 (Pb-89) and eight crosses over standard check 1 (Palam Priya) displayed significant negative heterosis for days to 50% flowering. Since, the standard heterosis is of great importance to the breeders, the crosses, Azad Pea-1 x Pb-89 (-18.04%), DPP 9418-06 x Pb-89 (-15.05%), Palam Priya x Pb-89 (-13.12%), Azad Pea-1 x DPP9418-06 (-11.65%),

DPP-3 x Pb-89 (-9.04%), Azad Pea-1 x DPP-3 (-8.66%), Lincoln x DPP 9418-06 (-8.45%) and Palam Priya x Azad Pea-1 (-7.23%) exhibited significant negative standard heterosis over Palam Priya (Table 3). However, the cross, Azad Pea-1 x Pb-89 had the highest (-9.05%) negative standard heterosis over Pb-89. For days to first picking, the cross, Azad Pea-1 x Pb-89 displayed -16.00, -17.10 and -16.00 per cent significant negative heterosis over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. The hybrid vigour for earliness (days to 50% flowering and days to first picking) has also been reported by Tyagi and Srivastava (2001), Kaur *et al.* (2003) and Singh *et al.* (2005). The results obtained clearly suggested that the most heterotic cross combinations *viz.*, Azad Pea-1 x Pb-89, DPP9418-06 x Pb-89, Palam Priya x Azad Pea-1 and Palam Priya x Pb-89 can further be exploited and the selection especially in the later filial generations may prove effective in evolving early maturing genotype(s) of garden pea.

Duration of availability of marketable pods has great significance because extended duration of availability of marketable pods will increase marketable yield. Hence, main emphasis is given towards significant positive heterosis for this trait. The heterobeltiosis to the extent of 13.57 per cent and economic heterosis to the tune of 32.50 and 13.57% over standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively was recorded in the cross, Azad Pea-1 x Pb-89 (Table 3). The other crosses viz., Palam Priya x Pb-89, Azad Pea-1 x DPP 9418-06, Azad Pea-1 x DPPLMR-41 and DPP 9418- 06 x Pb-89 displayed significant positive heterosis over standard check 1 (Palam Priya). The results are in conformity with the findings of Sarawat *et al.* (1994) who has reported heterosis for duration of availability of marketable pods in garden pea. The magnitude of heterosis for pod length ranged from -22.60 (Lincoln x DPP-3) to 13.06% (Azad Pea-1 x DPP 9418-06), -15.56 (Lincoln x DPP-3) to 14.95% (DPP-3 x PB-89) and -22.68 (Lincoln x DPP-3) to 5.26% (DPP-3 x Pb-89) over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. Out of the 21 crosses, one over better parent and two over standard check 1 (Palam Priya) had significant positive heterosis (Table 4). The hybrids exhibiting maximum significant positive heterosis over better parent and standard check 1 (Palam Priya) were Azad Pea-1 x DPP 9418-06 (13.06%) and DPP-3 x Pb-89 (14.95%), respectively. Significant positive heterosis for pod length in pea has also been reported by Pandey *et al.* (2006). The presence of substantial heterosis and the involvement of non-additive genetic effects in the expression of this character (Table 2) further supported that heterosis breeding can be an important tool for the improvement of these traits.

Wide divergence amongst parental lines was observed for seeds per pod, which was evident from their significant mean squares. The maximum heterobeltiosis of 11.05% and standard heterosis of 28.89% over standard check 1 were recorded in the crosses, Azad Pea-1 x DPP-3 and Palam Priya x Pb-89, respectively (Table 4). As many as four crosses over better parent and twelve over standard check 1 (Palam Priya) possessed significant positive heterosis

Table 3. Estimation of heterosis for days to 50% flowering, days to first picking and duration of availability of marketable pods over better parent (BP) and standard checks, Palam Priya (SC1) and PB-89 (SC2)

Trait	Days to 50% flowering			Days to first picking			Duration of availability of marketable pods		
	% Increase over			% Increase over			% Increase over		
Cross	BP	SC1	SC2	BP	SC1	SC2	BP	SC1	SC2
Palam Priya × Azad Pea-1	-1.43	-7.23*	2.94	-12.75*	-11.66*	-10.49*	-2.34	4.17	-10.71*
Palam Priya × Lincoln	0.63	0.63	11.67*	2.08	2.08	3.43	-10.00	-10.00	-22.86*
Palam Priya × DPP 9418-06	4.56	-5.42	4.95	1.74	2.38	3.74	-10.40*	-6.67	-20.00*
Palam Priya × DPP-3	-2.12	-2.78	7.89*	-1.01	2.35	3.71	-15.57*	-14.17*	-26.43*
Palam Priya × DPPLMR-41	-4.75	-4.75	5.69	3.09	3.09	4.46	-3.33	-3.33	-17.14*
Palam Priya × Pb-89	-3.59	-13.12*	-3.59	-10.58*	-11.75*	-10.58*	5.00	22.50*	5.00
Azad Pea-1 × Lincoln	3.84	-2.27	8.45*	-1.47	-0.24	1.08	-15.63*	-10.00	-22.86*
Azad Pea-1 × DPP 9418-06	-2.32	-11.65*	-1.96	-14.69*	-14.15*	-13.02*	10.16*	17.50*	0.71
Azad Pea-1 × DPP-3	-2.95	-8.66*	1.35	1.03	2.29	3.65	-15.63*	-10.00	-22.86*
Azad Pea-1 × DPPLMR-41	0.49	-5.42	4.95	0.59	1.84	3.19	9.38	16.67*	0.00
Azad Pea-1 × Pb-89	-9.05*	-18.04*	-9.05*	-16.00*	-17.10*	-16.00*	13.57*	32.50*	13.57*
Lincoln × DPP 9418-06	1.21	-8.45*	1.59	2.25	2.88	4.25	-4.80	-0.83	-15.00*
Lincoln × DPP-3	-1.74	-2.40	8.31*	-0.75	2.62	3.98	-2.46	-0.83	-15.00*
Lincoln × DPPLMR-41	-6.67	-5.26	5.13	-1.63	2.05	3.40	-9.32	-10.83*	-23.57*
Lincoln × Pb-89	4.06	-6.22	4.06	1.60	0.27	1.60	-9.29*	5.83	-9.29*
DPP 9418-06 × DPP-3	8.65*	-1.72	9.05*	1.42	2.05	3.40	-13.60*	-10.00	-22.86*
DPP 9418-06 × DPPLMR-41	9.67*	-0.80	10.08*	0.86	1.49	2.83	-1.60	2.50	-12.14*
DPP 9418-06 × Pb-89	-5.74	-15.05*	-5.74	-14.45*	-13.92*	-12.77*	0.00	16.67*	0.00
DPP-3 × DPPLMR-41	-4.91	-5.55	4.81	-1.41	1.93	3.28	-1.64	0.00	-14.29*
DPP-3 × Pb-89	0.93	-9.04*	0.93	3.01	1.67	3.01	-5.71	10.00	-5.71
DPPLMR-41 × Pb-89	8.87*	-1.89	8.87*	4.13	2.77	4.13	-10.71*	4.17	-10.71*
SE(±)	2.85	2.85	2.85	4.09	4.09	4.09	2.07	2.07	2.07

for this trait. Positive heterosis for seeds per pod has also been reported by Sarawat. *et al.* (1994) and Sharma *et al.* (1998). For shelling percentage, significant positive heterosis to the maximum extent of 10.91, 12.96 and 10.91% over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89) was recorded in the cross, Palam Priya x Pb-89. As many as two hybrids over better parent, five over standard check 1 (Palam Priya) and two over standard check 2 (Pb-89) displayed significant positive heterosis (Table 4). Other cross combinations exhibiting significant positive standard heterosis over standard check 1 were Palam Priya x Lincoln, Azad Pea-1 x Pb-89, DPP-3 x DPPLMR-41 and DPPLMR-41 x Pb-89. Heterosis for shelling percentage was also reported earlier by Bhardwaj and Vikram (2002). The presence of substantial heterosis coupled with non-additive gene actions (Table 2)

clearly suggested taking up heterosis breeding programme for effecting desirable improvement in seeds per pod and shelling percentage. Alternatively, selection in later generations may be carried out for advancing generations

Pods per plant is a direct component which contributes towards higher pod yield in pea. The magnitude of heterobeltiosis, standard heterosis over Palam Priya and Pb-89 varied from -19.31 (DPPLMR-41 x Pb-89) to 31.75% (Palam Priya x Azad Pea-1), -10.28 (Palam Priya x DPP-3) to 53.64% (Azad Pea-1 x Pb-89) and -33.79 (Palam Priya x DPP-3) to 13.38% (Azad Pea-1 x Pb-89), respectively (Table 5). As many as seven crosses over standard check 1 (Palam Priya), one over standard check 2 (Pb-89) and four over better parent had significant positive heterosis. The cross combination namely, Azad Pea-1 x Pb-89 displayed the highest significant positive heterosis to the extent of 53.64 and 13.38 per cent over standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. Heterosis for pods per plant has also been reported earlier by many researchers (Kaur *et al.*, 2003 and Pandey *et al.*, 2006). In order to make commercial pea growing a remunerative venture, the genotypes with dwarf and medium plant heights are preferred as these can be grown successfully without staking, thereby reducing the input cost.

Table 4. Estimation of heterosis for pod length, seeds per pod and shelling percentage over better parent (BP) and standard checks, Palam Priya (SC1) and PB-89 (SC2)

Trait	Pod length % Increase over			Seeds per pod % Increase over			Shelling percentage % Increase over		
Cross	BP	SC1	SC2	BP	SC1	SC2	BP	SC1	SC2
Palam Priya × Azad Pea-1	-6.24	-6.24	-14.14*	8.62*	8.62*	-11.27*	3.70	3.70	1.82
Palam Priya × Lincoln	-13.44*	-13.44*	-20.74*	5.17	5.17	-14.08*	8.64*	8.64*	6.67*
Palam Priya × DPP 9418-06	-11.48*	-11.48*	-18.94*	-10.70*	-4.02	-21.60*	-4.29	-3.70	-5.45
Palam Priya × DPP-3	-11.51*	-3.47	-11.60*	4.97	9.20*	-10.80*	-14.21*	-3.09	-4.85
Palam Priya × DPPLMR-41	-9.54*	-2.43	-10.65*	9.60*	11.49*	-8.92*	-12.35*	-12.35*	-13.94*
Paiam Priya × Pb-89	-3.99	4.85	-3.99	6.10	29.89*	6.10	10.91*	12.96*	10.91*
Azad Pea-1 × Lincoln	-2.23	-10.55*	-18.10*	-1.18	-4.02	-21.60*	-4.32	-4.32	-6.06*
Azad Pea-1 × DPP 9418-06	13.06*	2.70	-5.96	8.02*	16.09*	-5.16	-7.36*	-6.79*	-8.48*
Azad Pea-1 × DPP-3	-11.79*	-3.78	-11.89*	11.05*	15.52*	-5.63	-14.75*	-3.70	-5.45
Azad Pea-1 × DPPLMR-41	-15.54*	-8.90*	-16.58*	3.39	5.17	-14.08*	-0.62	-1.23	-3.03
Azad Pea-1 × Pb-89	2.65	12.10*	2.65	1.41	24.14*	1.41	5.45	7.41*	5.45
Lincoln × DPP 9418-06	-2.95	-11.21*	-18.69*	0.01	7.47	-12.21*	-0.61	0.01	-1.82
Lincoln × DPP-3	-22.60*	-15.56*	-22.68*	-16.57*	-13.22*	-29.11*	-12.02*	-0.62	-2.42
Lincoln × DPPLMR-41	-20.00*	-13.71*	-20.99*	1.69	3.45	-15.49*	-1.23	-1.23	-3.03
Lincoln × Pb-89	-10.79*	-2.58	-10.79*	-4.23	17.24*	-4.23	0.01	1.85	0.01
DPP 9418-06 × DPP-3	-21.12*	-13.94*	-21.20*	1.07	8.62*	-11.27*	-9.29*	2.47	0.61
DPP 9418-06 × DPPLMR-41	-9.11*	-1.96	-10.23*	3.21	10.92*	-9.39*	-4.91	-4.32	-6.06*
DPP 9418-06 × Pb-89	-7.09*	1.46	-7.09*	0.47	22.99*	0.47	1.21	3.09	1.21
DPP-3 × DPPLMR-41	-6.18	2.35	-6.28*	-6.63	-2.87	-20.66*	-6.01*	6.17*	4.24
DPP-3 × Pb-89	5.26	14.95*	5.26	-13.62*	5.75	-13.62*	-8.20*	3.70	1.82
DPPLMR-41 × Pb-89	-5.26	3.47	-5.26	-2.35	19.54*	-2.35	4.24	6.17*	4.24
SE(±)	0.30	0.30	0.30	0.23	0.23	0.23	1.54	1.54	1.54

In hybrids, the range of heterobeltiosis, standard heterosis over Palam Priya and Pb-89 existed between -24.37 (DPP-3 x Pb-89) to 18.82% Azad Pea-1 x Lincoln), -14.23 (Azad Pea-1 x Pb-89) over better parent standard DPPLMR-41) to 15.38% (Azad Pea-1 x DPP-3) and -25.90 (Azad Pea-1 x DPPLMR-41) to -0.32% (Azad Pea-1 x DPP-3), respectively (Table 5). Seventeen hybrids over better parent, seven over standard check 1 (Palam Priya) and nineteen over standard check 2 (Pb-89) exhibited significant negative heterosis. Significant desirable negative heterosis to the extent of -25.90% over standard check 2 (Pb-89) was observed in the cross, Azad Pea-1 x DPPLMR-41. However, the cross, DPP-3 x Pb-89 displayed the maximum heterobeltiosis to the extent of -24.37 per cent. These results are in conformity with those of Tyagi and Srivastava (2001) and Singh *et al.* (2005). The higher magnitude of exploitable heterosis and predominant role of specific combining ability variances (Table 2), it is concluded that either heterosis breeding or delayed selection may be opted for evolving an ideal genotype having more number of pods per plant with desirable plant height.

Yield being a complex trait is dependent upon the other horticultural traits and its improvement is easier if progress is made through its component traits. Increase in yield has always been the first and

Table 5. Estimation of heterosis for pods per plant, plant height and pod yield per plant over better parent (BP) and standard checks, Palam Priya (SC1) and PB-89 (SC2)

Trait	Pods per plant % Increase over			Plant height % Increase over			Pod yield per plant % Increase over		
Cross	BP	SC1	SC2	BP	SC1	SC2	BP	SC1	SC2
Palam Priya × Azad Pea-1	31.75*	39.63*	3.03	-9.20*	-9.20*	-21.55*	31.96*	34.59*	2.18
Palam Priya × Lincoln	8.22	8.22	-20.14*	-2.97	-2.97	-16.17*	-6.74	-6.74	-29.19*
Palam Priya × DPP 9418-06	-2.48	2.80	-24.14*	-9.68*	-7.63	-20.20*	-3.77	-1.25	-25.03*
Palam Priya × DPP-3	-18.23*	-10.28	-33.79*	-7.72*	8.37*	-6.38	-24.38*	-19.71*	-39.04*
Palam Priya × DPPLMR-41	1.31	1.31	-25.24*	-14.71*	-6.27	-19.02*	-8.69	-8.69	-30.68*
Palam Priya × Pb-89	1.52	37.57*	1.52	-22.02*	-9.73*	-22.02*	8.78	43.28*	8.78
Azad Pea-1 × Lincoln	-9.70	-4.30	-29.38*	18.82*	4.12	-10.05*	-6.54	-4.68	-27.63*
Azad Pea-1 × DPP 9418-06	27.51*	35.14*	-0.28	2.78	5.11	-9.19*	17.91*	20.99*	-8.14
Azad Pea-1 × DPP-3	0.34	10.09	-18.76*	-1.76	15.38*	-0.32	4.89	11.38	-15.44*
Azad Pea-1 × DPPLMR-41	21.87*	29.16*	-4.69	-21.95*	-14.23*	-25.90*	22.93*	25.38*	-4.81
Azad Pea-1 × Pb-89	13.38*	53.64*	13.38*	-12.83*	0.91	-12.83*	41.39*	86.22*	41.39*
Lincoln × DPP 9418-06	-0.89	4.49	-22.90*	-13.79*	-11.84*	-23.83*	-10.05	-7.70	-29.92*
Lincoln × DPP-3	-14.65	-6.36	-30.90*	-17.91*	-3.59	-16.71*	-30.11*	-25.78*	-43.65*
Lincoln × DPPLMR-41	2.46	1.12	-25.38*	-17.64*	-9.48*	-21.80*	4.86	-3.79	-26.96*
Lincoln × Pb-89	-15.72*	14.21	-15.72*	-20.77*	-8.29*	-20.77*	-10.82	17.46	-10.82
DPP 9418-06 × DPP-3	-3.07	6.36	-21.52*	-21.59*	-7.92	-20.45*	-4.06	1.88	-22.65*
DPP 9418-06 × DPPLMR-41	-1.77	3.55	-23.59*	-8.48*	0.58	-13.11*	-3.52	-0.99	-24.83*
DPP 9418-06 × Pb-89	2.90	39.44*	2.90	-12.61*	1.15	-12.61*	-2.54	28.36*	-2.54
DPP-3 × DPPLMR-41	0.17	9.91	-18.90*	-15.91*	-1.24	-14.68*	5.48	12.01	-14.96*
DPP-3 × Pb-89	3.59	40.37*	3.59	-24.37*	-11.18*	-23.26*	3.80	36.72*	3.80
DPPLMR-41 × Pb-89	-19.31*	9.35	-19.31*	-17.10*	-4.04	-17.10*	-14.88*	12.12	-14.88*
SE(±)	1.51	1.51	1.51	3.42	3.42	3.42	8.13	8.13	8.13

foremost objective in any crop improvement programme. The magnitude of heterosis for this trait ranged from -30.11 (Lincoln x DPP-3) to 41.39% (Azad Pea-1 x Pb-89), -25.78 (Lincoln x DPP-3) to 86.22% (Azad Pea-1 x Pb-89) and -43.65 (Lincoln x DPP-3) to 41.39% (Azad Pea-1 x Pb-89) over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. As many as four crosses over better parent, seven over standard check 1 (Palam Priya) and one over standard check 2 (Pb-89) displayed significant positive heterosis (Table 5). The hybrid combination, Azad Pea-1 x Pb-89 displayed the highest heterotic response to the extent of 41.39, 86.22 and 41.39% over better parent, standard check 1 (Palam Priya) and standard check 2 (Pb-89), respectively. Significant desirable heterosis for pod yield in garden pea has also been reported earlier by many workers (Singh and Mishra, 1996 and Sharma *et al.*, 1999).

The highest heterotic response observed in the crosses, Azad Pea-1 x Pb-89, DPP-3 × Pb-89, Palam Priya × Pb-89, Azad Pea- 1 × Pb-89 and Azad Pea- 1 × DPPLMR-41 coupled with non-additive gene action favours the development of hybrids but it is not economically feasible in pea due to cleistogamous flowers, where male and female organs are covered by keel which need manual emasculation for hybridization, few seeds per pollination and more seed rate requirement, thereby making hybrid breeding uneconomical. The findings revealed that either heterosis breeding or delayed selection of desirable segregants in later filial generations may be carried out for effecting improvement in marketable pod yield.

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