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Combining ability studies for yield and other horticultural traits in garden pea (*Pisum sativum* var. *hortense* L.)

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ABSTRACT

A field study with 8 × 8 diallel analysis (without reciprocals) in garden pea revealed highly significant estimates for general combining ability (gca) except number of green pod picking and specific combining ability (sca) for all the traits thereby indicating the importance of both additive and non-additive genetic variance in the inheritance of these traits. The genotypes Palam Priya and DARL-405 were found to be the most promising *per se* for most of the traits, whereas the cross combination VL-7 × PB-89 involving good × good general combiner parents was found with good desirable sca effects. The cross combination Palam Priya × DARL- 405 was found with best sca effects for pod length, number of pods per plant, number of seeds per pod, number of primary branches, total soluble solids and second best for green pod yield per plant. To further improve pod yield, inclusion of F_1 combinations with high SCA and parents with good GCA in multiple crosses, biparental mating, or diallel selective mating could be a worthwhile approach.

Key words: Diallel analysis, garden pea, gene action, general combining ability, specific combining ability.

INTRODUCTION

Garden pea is one of the most popular vegetable crop grown all over the world, both for fresh market and the processing industry. It is potential off-season vegetable crop grown in north-western Himalayan region during rainy-autumn season and the farmers get high price of their produce. However, due to early commencement of low temperature causing damage at flowering and reproductive stage of the crop, resulting low yield. Hence, there is a need to develop varieties suitable for growing in off season. The knowledge of combining ability of parental lines and the nature of gene effects is essential for the selection of best parents for hybridization to develop early maturing and high yielding varieties (Sharma *et al.*, 6). Therefore, the present investigation was undertaken through diallel mating design to generate information regarding combining ability and gene action for earliness and other horticultural traits.

MATERIALS AND METHODS

The eight genetically diverse genotypes, *viz.*, VL-7(P_1), Arkel (P_2), Palam Priya (P_3), PB-89 (P_4) PSM-3 (P_5), DARL-405 (P_6), VP-266 (P_7) and DARL-404 (P_8) were used to produce F_1 crosses manually by using a standard procedure of hand emasculation and pollination in a diallel pattern excluding reciprocals as proposed by Griffing (2) during spring-summer season for two years. The final experiment was laid out in August, *i.e.*, rainy-autumn season at Vegetable Research Block, Hill Campus, Ranichauri (Tehri Garhwal), Uttarakhand. The experimental material comprising eight parents and 28 F_1 crosses were evaluated during 2009-10 in randomized block design with three replications keeping plot size of 2.0 m × 2.0 m. The plants were spaced at 40 cm between row to row and 10 cm plant to plant. The observations were recorded on 10 randomly selected plants tagged in each treatment replication wise for node number at which first flower appears, days to 50 per cent flowering, days to first picking, pod length (cm), number of pods per plant, number of seeds per pod, number of pods per kg, 100-pod weight (g), number of green pod pickings, number of primary branches per plant, plant height (cm), shelling percentage, green pod yield per plant (g), total soluble solids (°Brix), ascorbic acid content (mg per 100 g fresh weight) and protein content (g per 100 g fresh weight). The combining ability estimates were calculated according to Method II Model I of the procedure suggested by Griffing (2).

RESULTS AND DISCUSSION

Analysis of variance showed that significant differences existed among the experimental material studied and highly significant estimates for general combining ability (gca) effects except number of green pod picking and specific combining ability (sca) were obtained in all sixteen traits (Table 1). This shows the presence of both additive and non-additive gene actions in expression of all the characters. Component

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Table 1. Analysis of variance for combining ability in garden pea.

Source	gca	sca	error	σ^2 gca	σ^2 gca	σ^2gca/ σ^2sca
d.f.	7	28	70			
Node No. at which first flower appears	0.7330**	1.1575**	0.0872	0.0646	1.0703	0.0604
Days to 50 per cent flowering	11.0726**	11.5387**	0.2007	1.0872	11.3380	0.0959
Days to first picking	12.4343**	19.519**	0.2013	1.2233	18.9506	0.0646
Pod length	1.3409**	1.1987**	0.0177	0.1323	1.1810	0.1120
No. of pods per plant	0.9264**	3.6109**	0.0213	0.0905	3.5896	0.0252
No. of seeds per pod	0.6866**	0.6957**	0.0032	0.0683	0.6925	0.0986
No. of pods per kg	1668.4354**	2001.9074**	9.7793	165.8656	1992.1281	0.0833
100-pod weight	5008.4514**	6385.4193**	28.7823	497.9669	6356.6370	0.0783
No. of green pod pickings	0.1198	0.3460**	0.0616	0.0058	0.2844	0.0204
No. of pr. branches per plant	1.5781**	2.5074**	0.0058	0.1572	2.5016	0.0628
Plant height	19.1296**	60.3725**	0.3272	1.8802	60.0453	0.0313
Shelling (%)	8.7170**	19.1236**	0.1139	0.8603	19.0097	0.0453
Green pod yield per plant.	1211.9765**	2768.8511**	0.5736	121.1403	2768.2775	0.04038
Total soluble solids	0.6328**	1.6202**	0.0075	0.0625	1.6127	0.0388
Ascorbic acid content	7.0823**	16.0449**	0.0678	0.7015	15.9771	0.0439
Protein content	0.8062**	1.0118**	0.0018	0.0804	1.0100	0.0796

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

of variation due to sca was higher than gca for all the attributes revealing thereby the preponderance of non-additive gene actions in the expression of all the traits. Raj Narayan (3) also reported significant differences among the progenies and parents for pod yield per plant, dry matter content, total sugar content, and protein content. Variances due to general (gca) and specific (sca) combining abilities were significant for all the characters. All the traits exhibited greater importance of non-additive gene effect.

Among the eight parental genotypes used in obtaining F_1 hybrids, the parent VL-7 was observed to be the best general combiner for node number followed by Arkel and PB-89 at which first flower appears as exhibited by negative significant desirable gca effects (Tables 2 & 3). Negative gca effects for earliness and the cross Green Pearl x Sugar Giant was the most promising for early flowering and green pod picking were also noticed earlier by Sharma *et al.* (5). The parent VL-7 followed by PB-89 and DARL-404 were observed to be the best general combiners for early flowering as showed by their significant gca effects. Days to first picking is very important trait in garden pea as it is related with early produce in the market that fetch remunerative returns to the farmers. For this trait, the parents PB-89, DARL-404 and VP-266 were observed to be the best general combiners as exhibited by their significant desirable gca effects. Early flowering genotypes are not necessarily early maturing. Lesser period from flowering to pod formation and pod formation to maturity determine the span of maturity in different genotypes. The parental genotypes Palam Priya had the highest gca effects for pod length, number of pods per plant, number of seeds per pod, total soluble solids and second highest for pod yield per plant and number of primary branches, while DARL-405 was observed to be the best general combiner for pod yield per plant, shelling percentage and number of primary branches. Sood *et al.* (8) also reported that Palam Priya as the best general combiner for number of pods per plant. DARL-404 was also found good general combiner for less number of pods per kg and 100-pod weight. The dwarf and medium plants are considered desirable as they can be grown without any support for making commercial pea growing a remunerative venture. The parents PB-89, VP-266 and VL-7 were observed as good general combiners for dwarf plant. The parental genotypes Palam Priya followed by DARL-404 and Arkel for total soluble solids and PSM-3, Arkel and Palam Priya for ascorbic acid content were found to be the best general combiners, whereas, Arkel followed by Palam Priya and VP-266 were found to be good general combiners for protein content indicating their importance for use in recombination breeding. Sood *et al.* (5) reported

Table 2. General combining ability (gca) effects of parental garden pea genotypes.

Parent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P_1	-0.42**	-1.28**	-0.43*	-0.84**	-0.07	-0.61**	29.87**	-49.47**	-0.03	-0.53**	-0.76**	-0.15	-5.77**	0.06	-0.91**	-0.06**
P_2	-0.15	0.98**	0.10	-0.02	0.06	0.09**	-5.36**	3.65	-0.03	-0.04	1.30**	0.59**	-0.45	0.22**	0.68**	0.43**
P_3	0.48**	1.88**	2.60**	0.36**	0.39**	0.22**	-6.19**	14.46**	0.14	0.32**	0.49*	0.57**	3.72**	0.27**	0.27*	0.19**
P_4	-0.15	-0.88**	-0.73**	-0.04**	-0.57**	-0.04	2.27*	-9.60**	-0.16	-0.65**	-2.67**	-0.26*	-3.93**	0.07	-0.54**	0.01
P_5	0.22*	0.38*	0.30	0.13**	-0.11*	0.02	0.64	-3.73	-0.06	0.01	0.92**	-0.65**	-0.22	-0.18**	1.44**	-0.56**
P_6	-0.08	-0.38*	-0.57**	0.10**	0.36**	0.13**	-6.59**	15.18**	0.07	0.41**	1.09**	1.34**	3.99**	-0.30**	0.04	-0.09**
P_7	0.02	0.02	-0.60**	0.07**	-0.11*	0.00	-2.22*	9.10**	-0.09	0.20**	-1.09**	-1.74**	0.22	-0.37**	-1.11**	0.13**
P_8	0.08	-0.72**	-0.67**	0.26-	0.06	0.19	-12.43**	20.41**	0.14	0.29**	0.73**	0.30*	2.45**	0.24**	0.14	-0.05**
SE (gi)	0.09	0.13	0.13	0.01	0.04	0.02	0.93	1.59	0.07	0.02	0.17	0.10	0.22	0.03	0.08	0.01
CD (gi) @ 5%	0.18	0.26	0.26	0.02	0.08	0.04	1.85	3.16	NS	0.04	0.34	0.20	0.44	0.06	0.16	0.02
CD (gi) @ 1%	0.24	0.34	0.34	0.03	0.11	0.05	2.45	4.19	NS	0.05	0.45	0.26	0.58	0.08	0.21	0.03
SE (gi-gj)	0.13	0.20	0.20	0.02	0.07	0.03	1.40	2.40	NS	0.03	0.26	0.15	0.34	0.04	0.12	0.02
CD (gi-gj) @ 5%	0.26	0.40	0.40	0.04	0.14	0.06	2.80	4.78	NS	0.06	0.52	0.30	0.68	0.08	0.24	0.04
CD (gi-gj) @ 1%	0.34	0.53	0.53	0.05	0.18	0.08	3.69	6.33	NS	0.08	0.69	0.40	0.90	0.11	0.32	0.05

*,**Significant at 5 and 1%, respectively; 1 = Node No. at which first flower appears, 2 = Days to 50 per cent flowering, 3 = Days to first picking, 4 = Pod length, 5 = No. of pods per plant, 6 = No. of seeds per pod, 7 = No. of pods per kg, 8 = 100-pod weight, 9 = No. of green pod pickings, 10 = No. of primary branches per plant, 11 = Plant height, 12 = Shelling percentage, 13 = Green pod yield per plant, 14 = Total soluble solids, 15 = Ascorbic acid content, and 16 = Protein content.

Table 3. Specific combing ability (sca) effects of cross combinations of garden pea genotypes.

Cross	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$P_1 \times P_2$	-0.45	-0.94*	-1.11*	2.07**	3.64**	1.77**	-77.69**	157.34**	1.02**	2.78**	10.80**	9.86**	37.01**	1.69**	4.83**	-1.23**
$P_1 \times P_3$	-0.75**	-3.17**	-4.61**	-0.43	-1.70**	-0.40**	23.14**	157.34**	-0.14	-0.51	1.61**	1.01**	-10.57**	0.92**	0.18	0.21**
$P_1 \times P_4$	-1.12**	-4.41**	-6.28**	0.43**	2.27**	0.16**	-6.66*	2.50	0.49*	1.03**	3.00**	1.08**	8.22**	1.32**	6.02**	1.87**
$P_1 \times P_5$	-0.15	-1.67**	-1.64**	-0.35**	-0.20	0.07	-4.03	-5.65	0.39	0.00	-1.49**	-1.15**	-3.17**	-2.40**	0.08	0.37**
$P_1 \times P_6$	0.15	2.09**	2.56**	-0.47**	-1.00**	-0.01	1.54	-21.67**	-0.41	-1.40**	-1.72**	-3.65**	-8.26**	-2.38**	-0.42	0.19**
$P_1 \times P_7$	0.38	2.03**	4.59**	-1.36**	-1.20**	-1.05**	108.51**	-132.15**	-0.58*	-1.29**	-5.01**	0.86**	-14.95**	-0.25**	-6.75**	0.60**
$P_1 \times P_8$	0.31	0.76	4.99**	0.62**	-1.36**	0.60**	-30.29**	39.76**	-0.81**	-0.98**	-6.37**	-0.42	-3.56**	0.38**	-3.92**	-0.19**
$P_2 \times P_3$	-1.02**	-4.44**	-4.14**	-0.45**	-0.83**	0.11*	-12.29**	15.80**	-0.14	-1.97**	-13.62**	0.35	-3.43**	0.82**	-6.57**	-0.33**
$P_2 \times P_4$	0.61**	0.33	2.19**	0.57**	2.14**	0.24**	-13.76**	39.86**	0.49*	1.10**	12.04**	-1.05**	11.76**	0.45**	4.76**	1.74**
$P_2 \times P_5$	0.58*	0.39	3.49**	-0.10*	-1.00**	-0.46**	21.21**	-42.70**	-0.61*	2.01**	5.32**	-8.35**	-7.98**	-0.80**	4.99**	-0.36**
$P_2 \times P_6$	-1.12**	-3.17**	-4.31**	-0.02	1.54**	0.30**	-15.56**	24.89**	0.26	0.21**	0.05	2.79**	11.64**	-1.35**	-1.17**	0.16**
$P_2 \times P_7$	0.58**	-3.24*	-4.28**	0.00	0.67**	0.21**	3.41	-19.57**	0.42	0.72**	8.56**	4.45**	-0.65	-0.22*	3.95**	1.14**
$P_2 \times P_8$	0.05	1.49**	-1.21**	-0.59**	-1.16**	-0.63**	39.61**	-74.78**	-0.14	-0.58**	-8.26**	-1.49**	-12.37**	0.75**	2.29**	0.03
$P_3 \times P_4$	-0.35	-3.57**	-3.64**	-0.13**	-1.20**	-0.47**	17.07**	-42.77**	-0.34	-0.45**	-6.27**	-7.69**	-10.06**	0.07	0.55*	-0.42**
$P_3 \times P_5$	-0.05	-0.84*	0.32	-2.08**	-1.66**	-1.50**	96.71**	-144.19**	-0.78**	-2.35**	-8.17**	-2.35**	-23.96**	-0.68**	1.10**	-0.21**
$P_3 \times P_6$	0.58**	-0.07	1.19**	2.60**	3.87**	2.20**	-54.06**	127.31**	0.76**	3.52**	13.42**	3.18**	35.19**	1.91**	5.27**	0.68**
$P_3 \times P_7$	-2.19**	-4.47**	-7.44**	0.42**	1.00**	-0.05	-2.76	-16.53**	0.26	-0.44**	-4.30**	-2.80**	1.49*	0.04	2.81**	1.28**
$P_3 \times P_8$	-0.25	-2.74**	-3.71**	0.01	0.84**	-0.10	-2.23	-7.43	0.36	0.43**	0.15	-3.67**	1.11	1.30**	-2.33**	-1.51**
$P_4 \times P_5$	-1.09**	-2.07**	-3.01**	0.37**	1.30**	-0.03	-3.76	0.85	0.19	-0.28**	-5.71**	-2.66**	3.73**	-0.04	-1.29**	1.36**
$P_4 \times P_6$	0.21	1.69**	-0.48	-0.80**	-2.16**	-0.74**	42.47**	-80.31**	-0.61*	-1.98**	-7.78**	-2.14**	-18.58**	0.31**	-3.92**	-0.61**
$P_4 \times P_7$	0.45	1.29**	3.56**	0.51**	-1.03**	0.85**	-39.89**	74.44**	-0.44	0.03	-1.44**	5.45**	1.32	-1.69**	-0.61*	-0.49**
$P_4 \times P_8$	-1.29**	-1.64**	-3.04**	-1.74**	-0.86**	-1.00**	59.97**	-100.81**	-0.34	0.10	-2.33**	4.11**	-14.95**	0.30**	-4.15**	0.76
$P_5 \times P_6$	-0.49	0.76	-1.51**	0.30**	1.37**	0.40**	-22.23**	33.11**	0.62*	1.59**	4.60**	2.76**	8.54**	-0.88**	0.13	0.01
$P_5 \times P_7$	-0.25	-1.64**	-2.48**	0.68**	-0.16	0.42**	-23.59**	32.04**	-0.21	-0.53**	-2.16**	-2.20**	0.89	1.09**	-0.55*	-0.41**
$P_5 \times P_8$	0.35	-0.24	2.92**	1.60**	2.67**	1.04**	-46.06**	110.53**	0.89**	1.37**	9.75**	5.23**	25.05**	0.89**	3.20**	-0.07
$P_6 \times P_7$	1.05**	1.79**	2.72**	0.44**	1.37**	-0.09	-48.03**	99.82**	0.32	2.37**	10.37**	-2.62**	17.81**	0.21*	2.58**	-0.33**
$P_6 \times P_8$	-0.69*	-1.47**	-1.54**	0.79**	1.20**	-0.04	-22.83**	43.00**	0.76**	0.61**	6.35**	-2.78**	9.80**	0.50**	3.40**	1.44**
$P_7 \times P_8$	-1.45**	-2.54**	-3.51**	1.23**	1.67**	0.85**	-38.19**	81.69**	0.59*	0.38**	-1.64**	3.44**	16.95**	-0.13**	5.28**	0.51**
SE (Sij)	0.27	0.41	0.41	0.04	0.13	0.05	2.84	4.87	0.23	0.07	0.52	0.31	0.69	0.08	0.24	0.04
CD (Sij) @ 5%	0.54	0.82	0.82	0.08	0.26	0.10	5.65	9.69	0.46	0.14	1.03	0.62	1.37	0.16	0.48	0.08

Contd...

Table 3 Contd...

Cross	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CD (Sij) @ 1%	0.71	1.08	1.08	0.11	0.34	0.13	7.49	12.85	0.61	0.18	1.37	0.82	1.82	0.21	0.63	0.11
SE (Sij-Sik)	0.40	0.60	0.60	0.06	0.20	0.08	4.20	7.20	0.33	0.10	0.77	0.45	1.02	0.12	0.35	0.06
CD (Sij-Sik) @ 5%	0.80	1.19	1.19	0.12	0.40	0.16	8.36	14.33	0.66	0.20	1.53	0.90	2.03	0.24	0.70	0.12
CD (Sij-Sik) @ 1%	1.06	1.58	1.58	0.16	0.53	0.21	11.08	18.99	0.87	0.26	2.03	1.19	2.69	0.32	0.92	0.16
SE (Sij-Skl)	0.37	0.57	0.57	0.05	0.19	0.07	3.96	6.79	0.31	0.10	0.72	0.43	0.96	0.11	0.33	0.05
CD (Sij-Skl) @ 5%	0.74	1.13	1.13	0.10	0.38	0.14	7.88	13.51	0.62	0.20	1.43	0.86	1.91	0.22	0.66	0.10
CD (Sij-Skl) @ 1%	0.98	1.50	1.50	0.13	0.50	0.18	10.45	17.91	0.82	0.26	1.90	1.13	2.53	0.29	0.87	0.13

*,** Significant at 5 and 1%, respectively; 1 = Node No. at which first flower appears, 2 = Days to 50 per cent flowering, 3 = Days to first picking, 4 = Pod length, 5 = No. of pods per plant, 6 = No. of seeds per pod, 7 = No. of pods per kg, 8 = 100-pod weight, 9 = No. of green pod pickings, 10 = No. of primary branches per plant, 11 = Plant height, 12 = Shelling percentage, 13 = Green pod yield per plant, 14 = Total soluble solids, 15 = Ascorbic acid content, and 16 = Protein content.

that the varieties Palam Priya and JI-2437 were good general combiner for protein content.

The cross combination Palam Priya × VP-266 showed significantly desirable negative sca effects for node number, days to 50 per cent flowering and early maturity, involving poor × poor general combiners parents, which may be due to epistatic interaction. The parents of such crosses with low gca effects have a relatively high magnitude of non-additive gene effects and, thus results in high sca effects after crossing. Such crosses may be advanced through biparental breeding methodology in early generations followed by single plant selection. The cross combination Palam Priya × DARL-405 had exhibited significant highest sca effects for pod length, number of pods per plant, number of seeds per pod, number of primary branches per plant and total soluble solids and second best for less number of pods per kg, green pod yield per plant and ascorbic acid content. Another cross combination VL-7 × Arkel was reported as the best specific combiner for number of pods per kg, number of green pod picking, 100-pod weight, shelling percentage, green pod yield per plant and second best for pod length, number of pods per plant and number of seeds per pod. The cross Palam Priya × DARL-405 and VL-7 × Arkel had exhibited highest estimates of sca effects in F_1 generations for most of the characters involving good x good and poor × poor general combining parents. The parental genotype Palam Priya was found with highest estimates of gca effects along with *per se* performance for number of seeds per pod, which also revealed both significant gca effect as well as mean performance for most of horticultural traits, indicating its good specific combing ability in a cross Palam Priya × DARL-405. Mean performance of the parents was good indicator of their general combining ability. So parents showing high mean performance with positive gca effect for trait indicates good possibility of obtaining transgressive segregants in crosses involving these parents. The cross combinations, *viz*., VL-7 × Arkel, Palam Priya × DARL-405 and PSM-3 × DARL-404 involving poor × poor, good × good and poor × good general combining parents were recorded with highest significant sca effects for green pod yield per plant. Crosses having both the parents as poor general combiners like VL-7 × Arkel may involve dominance × dominance or epistatic interaction. Such crosses may not give good transgressive segregants in later generation (Ranjan *et al*., 6).

The cross combinations Palam Priya × DARL-405 followed by Arkel × VP-266 and VL-7 × PB-89 were found with highest significant sca effects which involved good × poor, good × poor, poor × poor general combiners for total soluble solids. Bisht and Singh (1) reported Arkel and VL-7 were also reported as one of the parents in best specific combiner in cross combinations, *viz*., PMR-62 × Arkel, Nepal Pea × VL-7, and PMR-32 × VL-7. In our study, the cross combinations, *viz*., VL-7 × PB-89, DARL-405 × DARL-404 and Palam Priya × DARL-405 exhibited highest sca effects for ascorbic acid content involving poor × poor, poor × poor and good × poor general combiners. Crosses having both the parents as poor general combiners may involve dominance × dominance or epistatic interaction. Such crosses may not give good transgressive segregants in later generations. Non-additive gene action was in preponderance as revealed by higher values of sca variances for protein content. The crosses VL-7 × PB-89, Arkel × PB-89 and PB-89 × PSM-3 were found with highest significance sca effects which involved poor x poor, good x poor, poor x poor general combining parents, respectively for protein content in green pods. In previous study, cross combination Azad P-I × Azad P-3 was also found good specific combiner protein content in both the generations by Singh *et al.* (7).

It can be concluded from the present study that the sufficient genetic variability has been generated through hybridization involving different genotypes of garden pea. Palam Priya was found with highest mean performance values for green pod yield per plant and second best general combiner after DARL-405 for this trait. Palam Priya was observed the best general combiner with highest mean performance values for pod length, number of pods per plant, number of seeds per pod and total soluble solids. The genotypes Palam Priya, DARL-405, DARL-404 and PSM-3 were found to be most promising for one or more traits as such might be involved in recombination breeding. The cross combinations Palam Priya × VP-266, VL-7 × PB-89 and VL-7 × Palam Priya were reported with highest desirable sca effects for earliness. The specific cross combination VL-7 × PB-89 involving good × good general combining parents was found potential value for earliness in future breeding programme. In the autogamous crop like pea, exploitation of non-additive genetic variance as such would be impractical. However, using biparental or recurrent selection in segregating material, followed by conventional selection as transgressive segregants is likely to lead to substantial trait improvement. Further, advancement of segregating material through bulk, pedigree, single seed descent or single pod descent methods could be adopted in future breeding programmes.

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REFERENCES

1. Bisht, B. and Singh, Y.V. 2011. Combining ability for yield and yield contributing characters in pea (*Pisum sativum* L.). *Veg. Sci*. **38**: 17-21.

2. Griffing B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian J. Biol. Sci.* **9**: 463-93.

3. Raj Narayan. 2006. Combining ability for quality attributes in garden pea (*Pisum sativum* var. *hortense* L.). *Env. Ecol.* **24**: 464-67.

4. Ranjan, S., Kumar, M. and Pandey, S.S. 2005. Genetic studies in pea involving tall and dwarf genotypes. *Legume Res.* **28**: 202-05.

5. Sharma, A.G., Singh, S., Sharma, S. and Sood, S. 2007. Combining ability and heterosis for pod yield and its related horticultural traits in garden pea (*Pisum sativum* L.) under mid-hill sub-temperate and high-hill dry-temperate conditions of Himachal Pradesh. *Indian J. Genet. Pl. Breed*. **67**: 47-50.

6. Sharma, B.B., Sharma, V.K., Dhakar, M.K. and Punetha, S. 2013. Combining ability and gene action studies for horticultural traits in garden pea: a review. *African J. Agri. Res.* **8**: 4718-25.

7. Singh, K.P., Singh, J.D., Singh, H.C. and Srivastava, J.P. 2012. Genetic analysis of quality attributes in table pea (*Pisum sativum* L.). *Veg. Sci*. **39**: 169-72.

8. Sood, M., Kalia, P. and Gautam, G. 2006. Heterosis, inbreeding depression and residual heterosis for pod yield, components traits and protein content in garden pea. *Indian J. Hort*. **63**: 460-63.

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