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Heterosis and combining ability in garden pea (*Pisum sativum* L.) for yield and its contributing traits

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Abstract : Combining ability and heterosis studies for earliness and quality traits in pea were conducted at Punjab Agricultural University, Ludhiana. Eighteen genotypes including fifteen females and three males were crossed in line x tester fashion during winter 2008 and Forty-five hybrids along with eighteen parents were evaluated in 2009. Significant mean squares due to lines, testers, hybrids, line x tester and parents vs. hybrids were observed for yield and its contributing traits. The SCA/GCA variance ratios were less than unity for days taken to 50% flowering, plant height, pod length, number of pods per plant, green pod yield, days taken to maturity and shelling percentage indicating predominance of additive gene effects for these characters, therefore, it is suggested that selection in early generation may be fruitful either following mass selection or progeny selection or simple recurrent selection. Among the females, Arkel and MA-6 were found to be the best general combiner for earliness i.e. days taken to 50% flowering and days taken to maturity. Some of the crosses were observed superior for the sca effects as well as for heterosis which includes Arkel x C-96 for days taken to 50% flowering and days taken to maturity, C-308 x C-400 for plant height, MA-6 x C-400 for pod length, Arkel x C-400 for number of pods per plant, JM-5 x C-96 and NDVP-10 x C-400 for shelling percentage. These findings can be further utilized to develop and enhance the yield potential of pea cultivars.

Keywords: Heterosis, Combining ability, Pea, Yield

Introduction

An improvement in yield of self-pollinated crops like garden pea is effected mainly through selection of genotypes with desirable characters from the variation through recombination followed by selection. Heterosis in F_1 generation is of great importance in vegetable crops as heterotic crosses may give transgressive segregants for economic traits in advanced generations. Important steps for exploitation of heterosis in any crop are to study the general combining ability of the parents and specific combining ability of hybrids. The ability of parents to combine well depends on the complex interactions among genes and it cannot be estimated by mere yield performance of the parents. Therefore, the knowledge of combining ability and nature of gene effects is necessary for the selection of best parents for hybridization in order to improve the existing cultivars. Although, some information on additive and non-additive effects associated with yield and yield attributing traits in garden pea is available but that is relevant to the specific region, genetic material involved and particular environmental conditions. Therefore the present investigations were carried out to obtain information regarding general and specific combining ability effects and finding out heterotic combinations for yield and yield attributing characters in garden pea.

Materials and Methods

The present investigation was carried out at the Vegetable Research Farm of Department of Vegetable Crops, Punjab Agricultural University, Ludhiana during 2008-2009. The experimental material consisted of 18 genetically divergent genotypes of garden pea. Fifteen genotypes viz. IC-36, PMR-19, C-308, JP-501A/2, PB-88, PB-87, MA-6, AP-1, PMR-4, Arkel, JM-5, KS-268, P-1, P-2, NVDP-10 were selected as lines and three genotypes viz. PB-89, C-96, C-400 as testers for line x tester cross. All the parents along with their 60 F_1's were grown in a randomized block design with three replications. The distance between the plants was maintained at 10 cm while the rows were spaced 45 cm apart. The standard plant protections and other cultural practices were followed to maintain uniform experimental conditions.

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Observations were recorded on eight individual plants taken at random (excluding border plants) from each genotype for days taken to 50% flowering, plant height (cm), pod length (cm), number of pods per plant, green pod yield per plant (g), number of grains per pod, days taken to maturity and shelling percentage. The analysis of variance was done for all characters as per the method given by Kempthorne (1957) and as modified by Arunachalam (1974). Heterosis was worked out over better parent and their significance was determined by t test as suggested by Rai and Rai (2006).

Table 1. Analysis of variance for yield and its components in garden pea for combining ability analysis.

Character	GCA	SCA	SCA/GCA
Days taken to 50 % flowering	90.24**	10.23**	0.11
Plant height	1742.32**	965.75**	0.55
Days taken to maturity	23.43**	2.95**	0.12
Pod length	0.46**	0.19**	0.41
Number of pods per plant	96.76**	48.32**	0.50
Number of grains per pod	0.25**	0.42**	1.71
Shelling percentage	16.87**	10.94**	0.64
Green pod yield	251.73**	148.54**	0.42

** Significant at five per cent level.

Results and Discussion

Assessment of gene action

The mean squares due to lines as well as testers were highly significant for all characters. A perusal of the table 1 revealed that both the GCA and SCA variance were significant and GCA variance was greater than SCA for all of the characters except number of seeds per pod indicated predominance of additive gene action. The SCA/GCA variance ratios for days taken to 50% flowering, plant height, pod length, number of pods per plant, green pod yield, days taken to maturity and shelling percentage were 0.11, 0.55, 0.41, 0.50, 0.59, 0.12 and 0.64 respectively indicated predominance of additive gene action for these characters whereas, it was 1.71 for number of seeds per pod. The present studies corroborate the views of many workers as Bhullar *et al* (1975), Kumar and Aggarwal (1982), Gupta and Dahiya (1984), Wang *et al* (1997) and Narayan *et al* (1999). In the present case, as all the traits (except number of

Table 2. GCA of parents for pod yield and its components in garden pea

Parents	Days taken to 50% flowering	Plant height (cm)	Days taken to maturity	Pod length (cm)	No. of pods per plant	No. of grains per pod	Shelling (%)	Green pod yield per plant
LINES								
IC-36	-9.20**	-23.47**	-15.41**	-0.47**	10.29**	-1.21**	-15.38**	14.09**
PMR-19	9.45**	-11.71**	-7.03**	0.45**	7.90**	0.63**	4.06**	16.56**
C-308	24.30**	36.96**	11.32**	-1.25**	0.42	0.89**	3.76**	-6.03**
JP-501A/2	7.13**	-38.37**	2.45	1.31**	3.72**	0.83**	3.46**	-10.46**
PB.88	-2.84**	-40.08**	3.57	1.03**	-1.21	-1.44**	3.47**	15.45**
PB.87	8.82**	-10.37**	2.87	0.75**	2.52**	0.64**	1.76 *	-21.31**
MA-6	-24.07**	-28.13**	-20.23**	0.93**	0.58	0.32**	-4.59**	10.52**
AP-1	-5.31**	35.87**	4.67	0.35**	0.35**	2.21**	-6.65**	19.87**
PMR-4	5.36**	7.52**	10.44**	0.01	-1.44 *	-1.60**	-2.07*	-12.03**
ARKEL	-14.77**	-51.14**	-17.43**	0.95**	1.81**	-0.36**	-3.03**	-19.17**
JM-5	-9.77**	11.80**	14.51**	-2.76**	-7.20**	-0.07	2.51 *	-3.94 *
KS-268	5.38**	33.31**	0.54	-0.48**	2.98**	0.17	2.06**	-32.81**
P-1	4.57**	21.94**	-5.73*	-0.96**	-4.87**	-1.09**	3.68**	20.40**
NVDP-10	3.71**	11.67**	-4.52	-0.36**	-7.50**	-0.98**	9.24**	5.68**
P-2	-2.75**	44.19**	-6.08*	0.51**	-8.33**	1.06**	-2.27*	13.40**
SE	0.812	3.98	4.98	0.124	1.32	0.176	1.87	3.17
TESTERS								
PB.89	-2.08**	-51.67**	-4.19**	-0.48**	-5.69**	0.23**	-3.14**	-6.11**
C-96	-7.01**	103.86**	-3.22**	0.38**	-4.62**	-0.12**	2.69**	-10.03**
C-400	9.09**	-52.19**	5.66**	0.11**	10.07**	-0.01	-0.45	15.14**
SE	0.345	1.65	1.87	0.065	0.432	0.054	0.687	1.23

** Significant at five per cent level.

Table 3. Magnitude of heterosis (over better parent) in three best F_1 and top three best crosses showing good SCA effects and ranking on the basis of their GCA for yield and its components in garden pea

Character	Best heterotic	Heterosis (%)	Best SCA	Ranking on GCA basis
Days taken to 50 % flowering	P-1 x C-400	-7.68**	P-1 x C-400	Average x Poor
	ARKEL x C-96	-2.34**	KS-268 x C-400	Good x Poor
	C-308 x C-96	3.13**	C-308 x C-96	Poor x Good
Plant height	C-308 x C-400	40.97**	KS-268 x PB.89	Poor x Good
	PB-87 x C-400	38.49**	C-308 x C-400	Good x Poor
	ARKEL x C-400	36.43**	PMR-19 x C-400	Good x Poor
Days taken to maturity	ARKEL x C-96	-21.66**	MA-6 x PB.89	Good x Good
	NDVP-10 x C-400	1.01	-	-
	PB-88 x C-400	2.08	-	-
Pod length	MA-6 x C-400	14.11**	C-308 x PB.89	Good x Poor
	P-1 x PB-89	12.13**	JM-5 x PB.89	Poor x Poor
	MA-6 x C-96	7.94	MA-6 x C-400	Poor x Poor
Number of pods per plant	ARKEL x C-400	125.78**	ARKEL x C-400	Poor x Good
	PMR-19 x C-96	122.76**	MA-6 x PB.89	Poor x Poor
	P-1 x PB-89	110.31**	IC-36 x C-400	Good x Good
Number of grains per pod	P-1 x PB-89	7.95**	C-308 x C-96	Good x Poor
	KS-268 x PB-89	7.62**	PMR-4 x PB.89	Poor x Good
	PMR-19 x C-400	7.39**	PB.88 x PB.89	Poor x Good
Shelling percentage	JM-5 x C-96	14.91**	P-2 x PB.89	Poor x Poor
	NDVP-10 x C-400	14.66**	JM-5 x C-96	Poor x Good
	PMR-19 x PB-89	13.36**	NVDP-10 x C-400	Good x Poor
Green pod yield	KS-268 x C-400	117.31**	P-1 x C-96	Good x Poor
	P-1 x C-400	105.37**	PMR-4 x PB.89	Poor x Good
	MA-6 x C-400	103.46**	KS-268 x PB.89	Poor x Good

** Significant at five per cent level.

seeds per pod) are under the control of additive gene action, it is suggested that selection in early generation may be fruitful either following mass selection or progeny selection or simple recurrent selection.

Identification of best general combiners

In any breeding programme, the choice of parent is the secret of success in developing high yielding varieties/ hybrids. The broad principles governing the choice of the parents are their per se performance and general combining ability effects in desired magnitude and direction. Among the female parents, IC-36, MA-6 and Arkel were good general combiner for days taken to 50% flowering and days taken to maturity, whereas, AP-1, P-2 and C-308 were good general combiner for plant height and number of grains per pod (table 2). Moitra *et al* (1988) and Pant and Bajpai (1993) observed significance of gca effects for days to flowering and days taken to maturity. The female parents, IC-36, PMR-19 and JP-501A/2 were good general combiners for number of pods per plant, whereas, P-1, AP-1 and PMR-19 for green pod yield per plant. Similar results have been reported by Bhardwaj and Kohli (1998). Among the male parents, PB-89 was good general combiner for days taken to maturity and number of grains per pod, whereas, C-96 for days taken to 50% flowering, plant height, pod length and shelling percentage. Female parent C-400 was good combiner for number of pods per plant and green pod yield per plant.

Identification of best heterotic and specific combiners

The top three crosses selected separately on the basis of heterosis over better parent and high sca effects is presented in table 3. Majority of crosses showed significant positive and negative heterosis for all the traits under study. Some of the crosses were observed superior for the sca effects as well as for heterosis. For days taken to 50 % flowering, the cross P-1 and Arkel x C-96 showed maximum significant heterosis indicating early flowering for these crosses. Moreover, the cross Arkel x C-96 also exhibited significant maximum negative heterosis for days taken to maturity indicating that the cross 'Arkel x C-96' is early in maturity and

can be exploited for early yield. Katiyar (1994) also revealed significant heterobeltiosis for days to 50 percent flowering. The cross combination C-308 x C-400 exhibited maximum significant positive heterosis (40.97%) over better parent and also recorded high sca effects for plant height. This suggests that sca indicates the nature of heterotic performance of the hybrid. Present findings are in tune with those of Srivastava *et al* (1986) and Mishra *et al* (1993). The cross combination(s) MA-6 x C-400 for pod length; Arkel x C-400 for number of pods per plant; JM-5 x C-96 and NDVP-10 x C-400 for shelling percentage exhibited highest significant maximum positive heterosis and high sca effect. Regarding heterosis, cross combinations P-1 x PB-89, KS-268 x PB-89, PMR-19 x C-400 for number of grains per plant and Ks-268 x C-400, P-1 x C-400, MA-6 x C-400 for green pod yield per plant exhibited significant and positive heterosis. Regarding the specific combining ability effects, the crosses C-308 x C-96, PMR-4 x PB-89, PB-88 x PB-89 for number of grains per plant, whereas, P-1 x C-96, PMR-4 x PB-89, KS-268 x PB-89 for green pod yield per plant exhibited high sca effects.

सारांश

मटर में अर्लीनेस एवं गुणवत्ता के लक्षण के लिये भिन्नाश्रय एवं संयोजन की क्षमता का अध्ययन पंजाब कृषि विश्वविद्यालय लुधियाना में किया गया। 15 मटर एवं 3 नर सहित अठारह जीनोटाइप लाइन ग परीक्षण फैशन में सर्दियों के दौरान 2008 और 18 माता–पिता के साथ–साथ 45 संकर 2009 में मुल्यांकन किया गया। महत्वपूर्ण मतलब लाइनों के कारण चौराहों, परीक्षक, संकर, लाइन x परीक्षण और माता–पिता बनाम संकर उपज और उसके योगदान लक्षण के लिये बनाया गया। एसीए/बीसीए विचरण अनुपात कम से कम इन वर्णो के लिये 50% फुल, पौधों की उचाई, फली लम्बाई, हरी फली उपज, परिपक्वता के लिये लिया गया और दिनों प्रतिशत एडिटिव ग्रीन प्रभाव के संकेत प्रबलता से लिंग प्रति फली की संख्या के लिये ले जाया दिनों के लिये एकता थे। इसलिए यह सुझाव दिया गया है कि जल्दी पीढ़ी में चयन उपयोगी या तो निम्न द्रव्यमान चयन या संतान चयन या साधारण आवर्तक चयन हो सकता है। मादा के अलावा, अर्केल और एमए 6–50% फूल और परिपक्वता के लिये ले गया दिनों के अलावा ले जाया अर्लीनेस यानी दिनों के लिये सबसे अच्छा सामान्य कम्बाइनर होना पाया गया। पार के कुछ एसीए के रूप में भिभाश्रय के लिये अच्छी तरह से प्रभाव है। 50% फूल, सी–308 x पौधों की उचाई के लिये सी–400ए एम ए–6 परिपक्वता के लिये किया गया दिनों के लिये ले जाया दिनों के लिये अर्किल x सी–96 के लिये बेहत्तर मनाया गया x फली लम्बाई के लिये सी–400 अर्केल x संयत्र प्रति फली की संख्या के लिये सी–400, जेएम–5 x सी–96 और एनडीवीपी–10 x प्रतिशत सेलिंग के लिये सी–400, इन निष्कर्षो को आगे मटर कल्टीवर की उपज क्षमता को विकसित करने और बढ़ाने के लिये उपयोग कर सकते है।

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