Journal of Food Legumes 23(2): 113-116, 2010

Genetic analysis for yield and yield traits in pea

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(Received: September, 2009; Accepted: September, 2010)

ABSTRACT

All possible crosses excluding reciprocals were made among 10 diverse genotypes of field and table pea. General and specific combining ability variances were significant for all the traits in both F_1 and F_2 generations. Higher values of variance due to gca for days to flowering, days to maturity, plant height, pod length, number of developed ovules per pod, shelling percentage and green pod yield per plant showed presence of additive gene action while it was non additive for number of productive branches per plant and number of pods per plant based on both the generations. Parents 'KS-226', 'KS-225', 'KS-136', 'Azad P-1' and 'Azad P-3' were good general combiners for green pod yield based on both the generations. The average performance of table pea parents were better than field pea parents. Cross combinations namely 'KPMR-184 × KS-136', 'Rachna × KS-225', 'KS-195 × AP-3', 'KPMR-184 × Mutant pea' and 'Mutant × KS-136' in F_1, 'KS-195 × KS-225', 'KPMR-184 × AP-3', 'Mutant × KS-226', 'KS-226 × AP-1' and 'KPMR-65 × KS-226' in F_2 were found as good specific combinations for green pod yield. The majority of these crosses falls in the high x low general combiners. The crosses between table x field pea gave higher yield than table x table or field x field pea.

Key words: Combining ability, Field pea, Gene action, Green pod yield, *Pisum sativum* L., Table pea

Peas are major source of protein in vegetarian diet of India. It also plays an important role in soil improvement by virture of its ability to fix atmospheric nitrogen through its symbiotic association with *Rhizobium*. Exploitation of hybrid vigour and selection of parents on the basis of their combining ability have opened a new avenue in crop improvement. Among various techniques developed, diallel analysis is a very convenient one for gathering information about combining ability effects which helps in selection of parents for hybridization and ultimately the isolation and development of superior genotypes. The present study was undertaken to understand the genetic architecture of yield and its components through diallel analysis.

MATERIALS AND METHODS

A total of 10 diverse genotypes of field and table peas namely 'Rachna', 'KPMR-65', 'KPMR-184', 'mutant of 'P-43', 'KS-136', 'KS-195', 'KS-225', 'KS-226', 'Azad P-1' and 'Azad P-3' were crossed in all possible combinations excluding reciprocals. The F_0 seeds were advanced to get F_1. The final experiment including 10 parents 45 F_1s and 45 F_2s each were planted in a randomized complete block design with three replications at Vegetable Research Farm, Kalyanpur, Kanpur in the year 2003-04. Each parents and F_1s were sown in single row of five meter length while F_2s in two rows each spaced at 45 cm x 5 cm between rows and plants, respectively. The recommended package of practices was adopted to raise a good crop. Observations were recorded on ten randomly selected plants in parents and F_1s and 20 plants each in F_2s for days to flowering, days to maturity, plant height, number of productive branches per plant, number of pods per plant, pod length, number of developed ovules per pod, shelling percentage and green pod yield per plant. The mean data were used for diallel analysis following Griffing (1956) method 2 model 1.

RESULTS AND DISCUSSION

Analysis of variance for combing ability showed highly significant differences both for gca and sca for all the characters based on both the generations. It indicates the role of both additive and non-additive genet effects for controlling these traits (Table 1). A perusal of the table revealed higher the magnitude of s^2gca for characters namely days to flowering, days to maturity, plant height, pod length and yield /plant (F_2) indicating that these traits were under control of additive gene action. Similar results were also reported by Singh *et al.* (2006). The characters number of branches per plant, pods per plant, shelling percentage and green pod yield per plant (F_1s only) showed higher the value of sca variances than corresponding gca variance revealing the presence of non additive gene action. The ratio of s^2 gca/s^2sca also showed similar pattern. These results are in accordance with Kumar *et al.* (2006) and Singh and Singh (2003).

The gca effect and mean performance of the parents are listed in Table 2 which revealed that none of the parents showed desirable gca effects for all the characters hence it is

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Table 1. Analysis of variance for combining ability for yield and related traits in peas

Source of variation		d.f.	Mean sum of squares								
			Days to flowering (no)	Days to maturity (no)	Plant height (cm)	Productive branches/ plant (no)	Pods/ plant (no)	Pod length (cm)	Developed ovules/pod (no)	Shelling percent	Green pod yield/ plant (g)
gca	F_1	9	325.45**	374.81**	16403.86**	0.48**	143.10**	5.46**	3.00**	40.14**	2741.37**
	F_2	9	332.40**	348.65**	12635.93**	0.48**	64.08**	5.05**	2.53**	20.95**	2881.16**
sca	F_1	45	5.87**	9.39**	1256.25**	0.20**	74.02**	0.08**	0.46**	9.29**	761.23**
	F_2	45	8.13**	12.20**	516.30**	0.06**	7.85**	0.16**	0.30**	6.03**	134.86**
Error	F_1	108	0.55	0.36	8.80	0.01	2.14	0.004	0.006	0.02	14.33
	F_2	108	0.41	0.52	10.37	0.003	0.58	0.005	0.006	0.02	8.30
$\sigma^2 g$	F_1		26.63	30.45	1262.30	0.02	5.75	0.44	0.21	2.57	165.01
	F_2		27.02	28.03	1009.96	0.03	4.68	0.40	0.18	1.41	228.85
$\sigma^2 s$	F_1		5.32	9.03	1247.45	0.19	71.88	0.07	0.45	9.27	746.90
	F_2		7.72	11.68	505.93	0.05	7.27	0.15	0.29	6.01	126.56
$\sigma^2 g/\sigma^2 s$	F_1		5.00	3.37	1.01	0.10	0.07	6.28	0.46	0.27	0.22
	F_2		3.50	2.39	1.99	0.60	0.64	2.66	0.62	0.23	1.80

** Significant at P = 0.01

Table 2. Estimates of general combining ability effects of the parents for yield and yield related traits in peas

Parent	Days to flowering (no)			Days to maturity (edible pods) (no)			Plant height (cm)			Productive branches/plant (no)		
	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
Rachna	6.99**	7.05**	71.40	7.10**	7.25**	104.83	62.46**	42.62**	203.67	-0.37**	-0.12**	3.00
KPMR-65	4.29**	4.71**	64.50	4.85**	4.85**	97.50	43.26**	48.68**	184.83	0.36**	-0.42**	3.70
KPMR-184	6.64**	6.29**	68.83	7.37**	6.92**	101.67	42.04**	44.25**	180.97	0.04**	-0.02**	2.63
Mutant of P-43	-4.04**	-3.73**	48.27	-4.35**	-3.65**	81.20	12.55**	3.42**	98.37	0.07**	-0.14**	2.23
KS-136	-4.40**	-4.64**	45.23	-5.28**	-4.78**	75.37	-28.84**	-21.49**	86.00	-0.09**	-0.04**	2.90
KS-195	-1.61**	-1.20**	52.27	-2.04**	-1.57**	82.50	-22.72**	-23.97**	85.63	-0.07**	-0.13**	2.73
KS-225	0.40**	0.21**	56.10	0.19**	0.05	85.97	-27.42**	-20.86**	93.70	0.19**	0.21**	3.53
KS-226	3.55**	3.60**	61.93	4.21**	3.36**	92.17	-13.23**	-16.62**	92.27	0.09**	0.15**	3.23
Azad P-1	-3.48**	-3.64**	46.70	-3.64**	-3.97**	76.83	-31.71**	-29.27**	64.13	-0.16**	-0.23**	2.60
Azad P-3	-8.34**	-8.65**	32.37	-8.42**	-8.47**	62.40	-36.41**	-26.77**	37.47	-0.07**	-0.10**	2.93
S.E. (g i) ±	0.04	0.03		0.03	0.04		0.66	0.78		0.0009	0.0003	
S.E. (gi – gj) ±	0.09	0.07		0.06	0.09		1.47	1.73		0.002	0.0006	

**Significant at P = 0.01

Table 2. Cont…..

Parent	Pods/plant (no)			Pod length (cm)			Developed ovules/pod (no)			Shelling percent			Green pod yield/plant (g)		
	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
Rachna	0.96**	0.69**	26.87	-0.33**	-0.52**	6.90	-0.47**	-0.31**	5.83	2.60**	1.31**	53.30	-6.44**	-13.53**	81.47
KPMR-65	6.89**	5.34**	32.40	-0.88**	-0.80**	6.33	-0.66**	-0.72**	4.60	1.40**	-0.64**	53.30	-9.38**	-4.45**	85.33
KPMR-184	1.80**	-0.53**	25.07	-0.45**	-0.39**	7.03	-0.41**	-0.41**	4.93	0.68**	0.80**	55.67	-11.74**	-13.52**	78.50
Mutant of P-43	3.27**	-0.97**	21.43	-1.19**	-1.11**	5.27	-0.45**	-0.52**	3.63	1.93**	1.81**	54.03	-28.37**	-29.07**	44.23
KS-136	-3.94**	-1.74**	23.13	0.71**	0.56**	9.27	0.94**	0.62**	6.57	0.18**	0.53**	50.90	9.78**	7.40**	130.27
KS-195	-1.43**	1.39**	28.13	0.08**	0.12**	7.93	0.03**	0.06**	5.53	-0.77**	-0.71**	47.80	-0.74	7.84**	119.03
KS-225	-0.57**	-0.24**	26.73	0.49**	0.49**	8.63	0.14**	0.24**	5.90	-2.71**	-1.81**	45.03	17.01**	13.98**	134.60
KS-226	0.25	0.93**	27.93	0.60**	0.64**	8.90	0.17**	0.22**	6.03	-2.91**	-2.52**	48.23	23.92**	24.20**	148.77
Azad P-1	-4.27**	-2.24**	23.60	0.49**	0.52**	8.67	0.49**	0.48**	6.30	0.40**	0.71**	52.80	0.96	5.49**	118.77
Azad P-3	-2.97**	-2.64**	19.53	0.48**	0.49**	8.97	0.23**	0.34**	6.07	-0.80**	0.52**	51.33	5.00**	1.65	106.13
S.E. (g i) ±	0.16	0.04		0.0003	0.0003		0.0005	0.0004		0.001	0.001		1.07	0.62	
S.E. (gi – gj) ±	0.36	0.10		0.0007	0.0008		0.001	0.001		0.003	0.003		2.39	1.38	

**Significant at P = 0.01

Table 3. Ranking of top five desirable crosses for yield and yield related traits in peas

Character/cross	*sca* effect	Mean value	*gca* status	
			P_1	P_2
Days to flowering (no)				
F_1				
Rachna x KS195	4.37**	55.93	L	H
Rachna x KS225	3.41**	58.90	L	L
Rachna x Mutant	3.34**	54.53	L	H
Mutant x KS226	0.10	51.30	H	L
KPMR184 x Mutant	2.73**	54.80	L	H
F_2				
Rachna x KS225	6.26**	53.37	L	L
KPMR184 x Mutant	4.30**	50.63	L	H
Mutant x KS195	4.25**	43.20	H	H
Rachna x KS136	4.24**	50.53	L	H
Mutant x KS226	3.04**	49.20	H	L
Days to maturity (no)				
F_1				
Rachna x KS195	5.01**	85.93	L	H
Mutant x KS226	4.58**	81.17	H	L
KS195 x KS225	4.49**	79.53	H	L
Rachna x KS225	4.37**	88.80	L	L
KPMR184 x Mutant	4.20**	84.70	L	H
F_2				
Rachna x KS225	6.78**	83.27	L	L
KPMR184 x Mutant	5.46**	80.57	L	H
Rachna x KS136	4.81**	80.40	L	H
Mutant x KS195	4.46**	73.07	H	H
Rachna x Mutant	3.75**	82.60	L	H
Plant height (cm)				
F_1				
KPMR65 x KPMR184	34.76**	195.47	L	L
Rachna x KPMR184	33.10**	216.33	L	L
KS195 x Azad P-1	32.80**	57.70	H	H
KPMR184 x Mutant	31.52**	168.00	L	L
Rachna x KPMR65	29.21**	221.43	L	L
F_2				
KPMR65 x Mutant	26.90**	158.80	L	L
Rachna x KPMR65	24.13**	200.77	L	L
KS136 x KS225	22.08**	69.17	H	H
KS136 x KS195	18.79**	69.33	H	H
KPMR65 x KPMR184	18.75**	207.77	L	L
Productive branches/plant (no)				
F_1				
KPMR184 x Mutant	1.05**	4.57	H	H
KPMR184 x Azad P-3	0.60**	3.97	H	L
KPMR65 x KS225	0.54**	4.50	H	H
KS195 x KS226	0.50**	3.93	L	H
KPMR65 x Azad P-1	0.49**	4.10	H	L
F_2				
KPMR65 x Mutant	0.41**	3.67	H	L
Rachna x Mutant	0.38**	3.10	L	L
Rachna x KS226	0.33**	3.33	L	H
KPMR65 x KPMR184	0.30**	3.67	H	L
KPMR184 x Mutant	0.29**	3.10	L	L
Pods/plant (no)				
F_1				
KPMR184 x Mutant	19.30**	62.27	H	H
KPMR65 x Mutant	12.04**	60.10	H	H
KPMR184 x Azad P-3	11.30**	48.03	H	L
KPMR184 x KS136	9.84**	45.60	H	L
Rachna x Azad P-3	9.27**	45.17	H	L
F_2				
KPMR65 x Azad P-3	7.26**	37.93	H	L
Rachna x Azad P-3	5.58**	31.60	H	L
KPMR65 x Mutant	4.42**	36.77	H	L
KPMR184 x Azad P-3	4.13**	28.93	L	L
Mutant x KS226	3.26**	31.20	L	H
Pod length (cm)				
F_1				
KS195 x Azad P-3	0.50**	8.67	H	H
Rachna x KPMR65	0.35**	6.73	L	L
Azad P-1 x Azad P-3	0.30**	8.87	H	H
KPMR184 x KS136	0.27**	8.13	L	H
Rachna x KS225	0.24**	8.00	L	H
F_2				
KPMR184 x Mutant	0.59**	6.60	L	L
Rachna x Mutant	0.42**	6.30	L	L
Rachan x KPMR65	0.41**	6.60	L	L
KS225 x Azad P-3	0.41**	8.90	H	H
KS195 x KS225	0.38**	8.50	H	H
Developed ovules/pod (no)				
F_1				
KS136 x KS225	1.37**	8.17	H	H
KS195 x Azad P-3	1.35**	7.33	H	H
Mutant x KS136	1.13**	7.33	L	H
KS136 x KS226	1.10**	7.93	H	H
KS195 x Azad P-1	0.80**	7.03	H	H
F_2				
KS136 x Azad P-3	0.22**	7.83	H	H
Mutant x KS226	0.99**	6.33	L	H
Azad P-1 x Azad P-3	0.89**	7.37	H	H
KS195 x Azad P-1	0.88**	7.07	H	H
KPMR184 x KS225	0.66**	6.13	L	H
Shelling (%)				
F_1				
KPMR65 x KS225	6.83**	56.37	H	L
KS195 x Azad P-3	5.96**	184.57	L	L
KS136 x Azad P-3	4.13**	153.33	H	L
Mutant x Azad P-1	3.95**	108.10	H	H
KS225 x Azad P-1	2.93**	168.80	L	H
F_2				
Rachna x KPMR65	3.76**	55.37	H	L
KPMR184 x KS226	3.38**	52.60	H	L
KS195 x Azad P-3	2.49**	53.23	L	H
Mutant x KS225	2.46**	53.40	H	L
Rachna x KS136	2.40**	55.17	H	H
Green pod yield/plant (g)				
F_1				
KPMR184 x KS136	57.65**	198.23	L	H
Rachna x KS225	44.20**	197.30	L	H
KS195 x Azad P-3	37.77**	184.57	L	H
KPMR184 x Mutant	36.68**	139.10	L	L
Mutant x KS136	35.82**	159.77	L	H
F_2				
KS195 x KS225	18.02**	144.80	H	H
KPMR184 x Azad P-3	15.90**	109.00	L	H
Mutant x KS226	15.44**	115.53	L	H
KS226 x Azad P-1	15.04**	149.70	H	H
KPMR65 x KS226	14.05**	138.77	L	H

not possible to pickup a good general combiner for all the characters. However, for days to flowering and maturity parents namely 'AP-3', 'KS-136', 'Azad P-1', mutant of 'P-43' and 'KS-195' showed significant negative gca effects along with less number of days taken. These genotypes might be useful for getting early recombinants. Parents 'AP-3', 'AP-1', 'KS-136', 'KS-225', 'KS-195' and 'KS-226' with significant negative gca effects were good general combiners for plant height and might be possessing favourable genetic system for reducing height in their progenies. For number of productive branches per plant, only three parents i.e. 'KPMR-65', 'KS-225' and 'KS-226' possess desirable positively significant gca effects based on both the generations. For number of pods per plant 'KPMR-65' followed by 'Rachna', 'KS-226' based on both the generations; 'KPMR-184' and 'Mutant P-43' based on F_1 generations possessed significant positive gca effects. Similarly for pod length; parents 'KS-136' followed by 'KS-226', 'AP-1', 'KS-225', 'AP-3' and 'KS-195', for number of developed ovules per plant six parents, 'KS-136', 'KS-195', 'KS-225', 'KS-226', 'AP-1' and 'AP-3'; for shelling percentage 'Rachna', 'KPMR-184', 'Mutant P-43', 'Azad P-1', 'KS-136' were found promising. For green pod yield, parents 'KS-226', 'KS-225', 'KS-136', 'Azad P-3' and 'Azad P-1' expressed positive and significant gca effects based on both the generations which may produce high yielding recombinants in their progenies and may be utilized in future pea improvement programme.

Five top ranking desirable cross combinations selected on the basis of sca effect and *per se* performance have been presented in Table 3. None of the selected cross combinations exhibited significant and desirable sca/ *per se* performance in both the generations for all the characters under study. However, some crosses showed significant sca effect for other yield traits along with green pod yield in either of the generation eg. 'KPMR-184 × KS-136' having significant sca effect for green pod yield, pod length and number of pods per plant. Similarly 'KPMR-184 × Mutant' had significant sca effects for number of pods per plant, number of productive branches per plant, plant height, days to flowering and days to maturity (earliness) besides green pod yield. These heterotic crosses showed high × low and low × low gca status. The combination of high × low general combiners can produce transgressive segregants if additive effect of one parent and complementary effect of other parent works in same direction as also stated by Redden and Jenson (1974) in self pollinated crops. The cross combination showed that low × low general combiners might be produced due to non-additive gene effects and as such could not be exploited in self pollinated crops like pea but assumed that they can be intermated in F_2 by any suitable design to produce transgressive segregants after breaking the tight linkage if any as also reported by Pederson (1974). In present study desirable and promising crosses like 'KS-195 × KS-225' and 'KS-226 × Azad P-1' in F_2 generations showed high × high gca status for green pod yield per plant. These crosses might have asisen due to additive and/or additive × additive type of gene interaction which is fixable in nature and can be handled by simple pedigree or modified pedigree method as suggested by Brim (1966). Other yield contributing traits also showed such type of gca effects like 'KPMR × Mutant', 'KPMR-65 × KS-225' for number of productive branches per plant and number of pods per plant: 'KS-165 × AP-3', 'AP-1 × AP-3' for pod length, 'KS-136 × KS-225', 'KS-195 × AP-3', 'KS-136 × KS-226', 'KS-195 × AP-1' (both in F_1 and F_2) for number of developed ovules per pod and 'Mutant × AP-1' for shelling percentage.

It is also notable that majority of the crosses for yield contributing traits showing high sca effects and *per se* performance involved one parents of field pea and other of table pea genotypes.

For utilization of genetic variation related to non-additive or non-fixable in nature, population improvement programmes such as biparental mating followed by recurrent selection method of Frey (1975) and Rachie and Gardner (1975) would be more appropriate.

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