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Short Communication

Combining ability for yield and its components in fieldpea

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The knowledge of combining ability is useful in the selection of parents and hybrids which can provide superior progenies for the characters of interest. It also provides information about nature of gene action and the relative magnitude of fixable and non-fixable genetic variation to follow up the sound breeding programme. Studies based on combining ability analysis have been made earlier in fieldpea to study gene effects and genetic worth of parents (Bhardwaj and Kohli 1998, Kumar *et al.* 2006). The line x tester analysis was adopted in the present study on fieldpea to gather information on general and specific combining abilities and estimating various types of gene effects involved in various quantitative characters.

Sixty F_1 hybrids of fieldpea developed by line x tester mating design involving 20 diverse and homozygous lines of fieldpea and three testers (Table 2) were grown along with twenty-three parents in a randomized complete block design with two replications at Punjab Agricultural University, Ludhiana during *rabi* 2006-07. Observations were taken on five competitive and randomly taken plants on different traits (Table 2). The data was subjected to line x tester analysis as per procedure given by Kampthorne (1957). The average degree of dominance was also calculated as $(s^2 \text{ sca}/2s^2 \text{ gca})^{0.5}$.

Variation due to lines and lines x testers were highly significant for all the characters, whereas variation due to testers was found to be significant for all the characters except days to maturity and primary branches per plant (Table 1). The estimates of *sca* variances were much higher than the *gca* variances for all the characters indicating importance of non-additive gene effects than additive gene effects. The higher magnitude of *sca* variance as compared to *gca* variance has been reported earlier (Bhardwaj and Kohli 1998, Kumar *et al.* 2006). The average degree of dominance indicated over dominance for all the characters studied except plant height as their average degree of dominance values were greater than unity indicating predominance of non-additive gene action in the inheritance of these characters. Predominance of non-additive gene action has been reported earlier for yield and its components by Kumar *et al.* (2006); Singh and Singh (2003); Singh and Singh (1990) and Singh *et al.*(1987).

For days to flowering 'DDR 23', 'LFP 41', 'EC 334160' and 'LFP 446' have significant negative *gca* effects. For days to maturity the genotype 'DDR 23', followed by 'LFP 202', 'KPMR 752', 'EC 502159', 'EC 385246' and 'NDDP 5-12' have high significant *gca* effects indicating their usefulness for getting short duration recombinants. For plant height, genotype 'EC 389374' followed by 'DDR 23', 'LFP 362', 'EC 385246', 'LFP 363', 'LFP 305', 'KPMR 752', 'IFPD 5-8', 'NDDP 5-12' and 'LFP 210A' have high negative *gca* effects showing their importance for developing dwarf pure lines from their progenies. Genotypes 'P 2005', 'EC 389374', 'LFP 207A', 'LFP 210A' and 'PG 3' have shown significant positive *gca* effect for primary branches per plant. The genotypes 'DDR 23', 'LFP 207A', 'LFP 202', 'EC 334160', 'P 289', 'LFP 446', 'PG 3' and 'HFP 8909' appeared to be good general combiners for number of pods per plant. For seeds per pod 'LFP 413', 'LFP 363',

Table 1. Analysis of variance, estimates of combining ability variance and degree of dominance in fieldpea

Source of variation	DF	Days to flowering (no)	Days to maturity (no)	Plant height (cm)	Primary branches/ plant (no)	Pods/ plant (no)	Seeds/ pod (no)	100-seed weight (g)	Seed yield/ plant (g)
Replications	1	47.75*	50.98*	160.02*	4.72*	520.68*	0.02	0.35	79.67*
Parents	22	112.30**	55.95**	1700.86**	3.60**	323.26**	0.29**	29.11**	105.22**
Lines	19	125.52**	64.57**	1962.89**	3.81**	220.19**	0.34**	32.96**	114.84**
Testers	2	31.17**	2.00	10.17	2.00**	151.17*	0.01	6.13**	26.17**
Lines *vs* testers	1	25.45**	0.06	103.70**	2.74**	2625.67**	0.01	1.85	80.55**
Parents *vs* crosses	1	222.78**	5.31	1062.22**	0.62	3412.92**	0.34**	45.28**	1120.24**
Crosses	51	43.22**	32.80**	1807.90**	2.96**	699.61**	0.31**	23.06**	196.95**
Lines	19	88.57**	84.43**	5024.11**	7.32**	917.50**	0.60**	58.71**	284.99**
Testers	2	19.41**	1.58	280.03**	0.41	1377.32**	0.29**	9.11**	56.15**
Lines × testers	28	21.79**	8.63**	280.21**	0.91**	554.99**	0.16**	5.97**	160.33**
Error	82	1.00	1.27	8.90	0.17	29.71	0.04	0.52	3.70
σ^2 gca		1.40	1.49	103.12	0.13	25.76	0.018	1.21	0.45
σ^2 sca		10.40	3.68	135.66	0.37	262.64	0.057	2.72	78.31
$(\sigma^2 \text{ sca}/2\ \sigma^2 \text{ gca})^{0.5}$		1.93	1.11	0.81	1.19	2.26	1.54	1.06	9.33

Table 2. Estimates of general combining ability (gca) effects of parents in fieldpea

Parents	Days to 50% flowering (no)	Days to maturity (no)	Plant height (cm)	Primary branches/ plant (no)	Pods/ plant (no)	Seeds/ pod (no)	100- seed weight (g)	Seed yield/ plant (g)
Females (Lines)								
LFP 413	1.99** (83.50)	5.71** (146.50)	-18.56** (55.50)	-1.07 (2.50)	-9.41** (33.00)	0.53** (3.40)	0.93** (23.00)	-5.80** (21.00)
LFP 305	0.99* (80.00)	3.54** (140.50)	-16.89** (61.00)	-6.07** (2.00)	5.09* (52.50)	-0.02 (4.74)	0.92** (21.25)	-7.72** (20.50)
LFP 362	-1.68* (78.00)	0.21 (140.00)	-23.39** (23.00)	-0.40* (2.00)	-17.91** (44.50)	-0.20* (4.15)	0.52 (20.50)	-7.22** (37.00)
LFP 363	-0.34 (80.00)	0.04 (140.00)	-20.56* (53.00)	0.10 (2.00)	- 4.41* (44.50)	0.38** (3.55)	0.25 (20.50)	-0.55 (28.75)
LFP 202	1.99** (82.00)	-3.29** (143.00)	46.11** (132.50)	-0.73** (2.00)	12.76** (44.50)	0.17* (4.00)	-1.62** (22.20)	3.61** (30.00)
KPMR 752	2.99** (85.00)	-1.46** (140.00)	-15.23** (65.00)	-0.07 (2.50)	-5.74** (37.00)	0.80** (3.40)	3.58** (23.75)	3.45** (28.00)
IFPD 5-8	8.16** (90.00)	3.21** (142.50)	-13.39** (58.50)	0.10 (3.00)	-9.24** (12.00)	0.38** (4.15)	1.52** (24.00)	-1.55* (24.00)
NDDP 5-12	-0.34 (84.00)	-1.63** (142.00)	-11.06** (70.00)	-0.40* (4.00)	-11.58** (33.00)	-0.04 (3.30)	0.02 (16.50)	-5.22** (16.00)
KPMR 760	4.99** (86.00)	2.54** (143.00)	2.61* (75.50)	-0.57** (3.50)	-7.24** (52.50)	-0.30** (4.05)	1.85** (24.50)	0.11 (25.50)
LFP 207A	-0.68 (89.00)	0.71 (143.00)	57.78** (119.00)	0.43** (2.00)	10.26** (60.50)	-0.27** (3.50)	1.02** (23.00)	2.61** (36.50)
LFP 41	-5.84** (78.00)	1.21** (143.00)	38.11** (123.00)	0.10 (3.00)	2.42 (41.00)	-0.15 (3.05)	-0.82** (18.20)	1.11 (20.50)
DDR 23	-9.68** (54.00)	-11.96**(119.00)	-31.89** (40.00)	-1.07** (1.00)	24.42** (22.50)	0.20* (3.35)	-2.82** (22.75)	9.45** (17.50)
EC 334160	-3.68** (71.00)	-0.63 (141.00)	28.77** (115.00)	-0.57** (1.50)	15.42** (42.50)	-0.40** (3.25)	-0.48 (19.75)	11.45** (26.00)
EC 502159	-1.34* (79.00)	-2.46** (140.50)	39.44** (119.50)	-0.73** (2.50)	-4.08 (48.00)	-0.22** (3.60)	1.18** (19.00)	-2.55** (31.00)
EC 385246	-1.68** (77.00)	-1.79** (131.00)	-22.89** (64.50)	-0.73** (2.50)	-1.41 (36.50)	-0.32** (3.45)	1.02** (24.50)	0.11 (24.00)
EC 389374	1.82** (82.00)	-1.13* (141.50)	-38.39** (47.50)	0.93** (3.00)	5.42* (33.00)	-0.18* (3.30)	1.52** (21.10)	6.95** (17.00)
P 2005 (local collection)	1.66** (79.00)	4.71** (146.50)	32.77** (112.50)	4.10** (7.50)	-16.41** (49.00)	0.03 (3.30)	-10.23** (7.75)	-18.39** (11.00)
LFP 446	-3.01** (68.00)	-0.46 (110.50)	-11.89** (75.00)	0.43** (2.00)	8.59** (49.00)	-0.12 (3.60)	1.10** (21.75)	5.11** (27.00)
P 289 (Germplasm line)	1.82** (81.00)	-0.476 (139.00)	-12.89** (95.50)	-0.23 (2.00)	19.42** (67.50)	-0.08 (3.50)	-4.32** (1.00)	7.11** (17.00)
LFP 210A	1.82** (81.00)	3.38** (142.00)	-8.56** (57.50)	0.43** (4.50)	-16.41** (33.50)	-0.19* (3.50)	4.85** (22.00)	2.05** (25.00)
SE (gi) female	0.40	0.45	1.19	0.17	2.17	0.08	0.29	0.77
SE (gi-gi)	0.58	0.65	1.72	0.24	3.15	0.12	0.42	1.11
Males								
LFP 48	0.33* (74.00)	0.23** (139.00)	2.43** (77.00)	-0.06 (4.50)	-6.70** (56.00)	-0.01 (3.60)	0.45** (23.00)	1.35** (31.00)
PG 3	-0.80** (76.00)	-0.12 (140.00)	0.38 (81.50)	0.12* (3.50)	4.22** (69.00)	0.09** (3.58)	-0.50** (19.50)	0.51* (31.50)
HFP 8909	0.47** (81.50)	-0.12 (141.00)	-2.82** (19.00)	-0.06 (2.50)	2.47** (72.50)	-0.08** (3.60)	0.052 (1.25)	0.85** (25.00)
SE (gi) males	0.13	0.15	0.17	0.05	0.70	0.03	0.09	0.25
SE (gi-gi)	0.22	0.25	0.39	0.09	1.22	0.05	0.16	0.43

Table 3. Crosses showing significant desirable *sca* effects for eight metric traits in fieldpea

Character	Crosses	*sca* effects	*gca* of parents
Days to 50% flowering (no)	DDR 23 x LFP 48	-10.33**	H x L
	LFP 305 x LFP 48	- 3.99**	L x L
	P 2005 x PG 3	- 3.53**	L x H
	KPMR 760 x LFP 48	- 2.99**	L x L
Days to maturity (no)	P 2005 x LFP 48	- 4.23**	L x M
	LFP 305 x LFP 48	- 2.57**	L x M
	DDR 23 x LFP 48	- 2.57**	H x M
	NDDP 5-12 x HFP 8909	- 2.55**	M x M
Plant height (cm)	EC 334160 x LFP 48	-29.05**	L x L
	LFP 207A x HFP 8909	-22.85**	L x H
	LFP 202 x HFP 8909	-14.18**	L x H
	LFP 202 x LFP 48	-13.43**	L x L
Branches/plant (no)	EC 385246 x HFP 8909	1.06**	L x M
	EC 389374 x LFP 48	0.89**	H x M
	LFP 207A x HFP 8909	0.89**	H x M
	P 2005 x LFP 48	0.73**	H x M
Pods/plant (no)	LFP 202 x HFP 8909	46.69**	H x H
	LFP 207A x HFP 8909	20.69**	H x H
	LFP 413 x HFP 8909	19.36**	L x H
	P 289 x PG 3	16.78**	H x H
Seeds/pod (no)	LFP 413 x HFP 8909	0.65**	H x L
	P 2005 x LFP 48	0.47**	M x M
	LFP 305 x PG 3	0.43**	M x H
	LFP 446 x LFP 48	0.42**	M x M
100-seed weight (g)	LFP 202 x HFP 8909	2.85**	L x M
	KPMR 752 x HFP 8909	2.80**	H x M
	NDDP 5-12 x HFP 8909	2.61**	M x M
	LFP 207A x PG 3	2.17**	H x L
Seed yield/plant (g)	LFP 202 x HFP 8909	29.99**	H x H
	EC 334160 x LFP 48	14.35**	H x H
	LFP 207A x PG 3	12.33**	H x M
	LFP 413 x HFP 8909	8.90**	L x H

'KPMR 752', 'IFPD 5-8', 'FP 289' and 'PG 3' were found to be good general combiners. The genotypes 'LFP 210A', 'KPMR 752', 'LFP 413', 'LFP 305', 'IFPD 5-8', 'EC 502159', 'EC 385246', 'EC 389394' and 'LFP 48' showed significant positive *gca* effects for 100-seed weight. The *gca* effects of the genotypes 'EC 334160', 'DDR 23', 'EC 389374', 'P 289', 'LFP 446', 'LFP 210A', 'PG 3' and 'HFP 8909' were positive and significant and might be useful for identifying high yielding recombinants.

The crosses 'DDR 23 × LFP 48', 'LFP 305 × LFP 48', 'P 2005 × PG 3' and 'KPMR 760 × LFP 48' showed significant desirable negative *sca* effects for days to flowering (Table 3). The crosses 'P 2005 × LFP 48', 'LFP 305 × LFP 48', 'DDR 23 x LFP 48' and 'NDDP 5-12 × HFP 8909' showed significant desirable *sca* effects alongwith desirable low mean values for days to maturity. The crosses 'EC 334160 × LFP 48', 'LFP 207A × HFP 8909', 'LFP 202 × HFP 8909' and 'LFP 202 × LFP 48' showed significant *sca* effects alongwith desirable low mean values for plant height. The crosses important for branches per plant were 'EC 385248 × HFP 8909', 'EC 389374 × LFP 48', 'LFP 207A × HFP 8909' and 'P 2005 × LFP 48' with significant positive *sca* effects. The crosses 'LFP 202 × HFP 8909', 'LFP 207A × HFP 8909', 'LFP 413 × HFP 8909' and 'P 289 × PG 3' recorded significant *sca* effects as well as high *per se* performance for pods per plant. For seeds per pod, the crosses 'LFP 413 × HFP 8909', 'P 2005 × LFP 48', 'LFP 305 × PG 3' and 'LFP 446 × LFP 48' had significant positive *sca* effects for seeds per pod. The crosses 'LFP 202 × HFP 8909', 'KPMR 752 × HFP 8909', 'NDDP 5-12 × HFP 8909' and 'LFP 207A × PG 3' showed significant and positive *sca* effects for 100-seed weight. For seed yield per plant the cross combinations *viz.* 'LFP 202 × HFP 8909', 'EC 334160 × LFP 48', 'LFP 207A × PG 3' and 'LFP 413 × HFP 8909' recorded the significant positive *sca* effects.

The parents namely 'DDR 23', 'LFP 305', 'LFP 48' and 'KPMR 760' for earliness, 'LFP 202', 'LFP 413' and 'LFP 207A' for pods per plant, 'LFP 413' for seeds per pod, 'KPMR 752' and 'NDDP 5-12' for 100-seed weight and 'EC 334160', 'LFP 202', 'LFP 207A' for seed yield per plant were found good general combiners. The cross combination 'LFP 202 × HFP 8909' was best for pods per plant, 100-seed weight, seed yield per plant and plant height. The desirable cross combinations included high × high and high × medium types of general combiners. The crosses like 'LFP 202 × HFP 8909' and 'EC 334160 × LFP 48' for seed yield and crosses 'LFP 202 × HFP 8909' and 'LFP 207A × HFP 8909' for pods per plant with high *sca* involving parents with good gca can be exploited effectively by conventional breeding methods like pedigree selection. However, those crosses which involved one good combiner and other medium combiner could be exploited through selection followed by intermating of segregants in early generation.

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