Madras Agric. J., 86(7-9): 366 - 370 July - September 1999
https://doi.org/10.29321/MAJ.10.A00619

COMBINING ABILITY ANALYSIS FOR SEED YIELD AND RELATED TRAITS IN PEAS OF INDIAN AND EXOTIC ORIGIN

C.P. SRIVASTAVA, M.K. TYAGI, R.K. AGRAWAL and B. RAI

Department of Genetics and Plant Breeding,
Institute of Agricultural Sciences,
Banaras Hindu University, Varanasi-221005.

ABSTRACT

Seventy five F_1 hybrids produced in a line x tester mating fashion, their 15 lines and five testers were evaluated in two environments to study combining ability for nine yield and related traits in pea. Additive gene action contributed significantly in the inheritance of days to flowering, days to maturity, plant height and seed weight while nonadditive gene action prevailed in the inheritance of pods per plant, seeds per pod, seed yield per plant, biological yield per plant and harvest index. LMR 20 emerged as the most promising parent for seed yield per plant and related traits; Alaska 81 for early flowering; Pusa 10 for early maturity, dwarfness and seed weight; LMR 20 for pods per plant and biological yield per plant. Garifield for seeds per pod and PI 280064 for harvest index were the best general combiners for respective traits. The cross HUP 1 x Pusa 10 was most outstanding hybrid as it exhibited high SCA effect and heterosis over better parent. The correlation coefficient 'r' between the GCA effects and mean of parents was significantly correlated for most of the characters. Implications of genotype x environment interaction on combining ability has been discussed.

KEY WORDS: Pea, Line x tester, Combining ability

Studies on combining ability helps in the identification of suitable parents to be used in hybridization programme and also provides information on genetic basis of traits under consideration. Among various mating designs available, line x tester mating design is the most potent design to assess combining ability of a large number of genotypes. The present investigation was undertaken to study combining ability of 15 pea lines of Indian and exotic origin which were mated with five testers in a line x tester fashion.

MATERIALS AND METHODS

Fifteen lines viz., Garifield, Alaska 81 and Tracer from USA ; S 143 from U.K.; Trapper and PI 280064 from Canada; 5064 from Sweden and EC 33866; HFP 4, LMR 20, PP-3, HUP 1, HUP 2, HP 11 and KPSD 1 from India were crossed with five testers viz., T 163, HUP 12, PG 3, FC 1 and Pusa 10 in a line x tester mating design. The 75 F_1s alongwith their replications under two dates of sowing i.e., on 14 November, 1994 (E_1) and 25 November, 1994 (E_2) which represented timely and late conditions in the area. Each plot consisted of 3 m long row spaced at a distance of 45 cm and 15 cm between plants within the row, respectively. The observations were recorded on ten random plants from each plot for nine yield and related traits. The combining ability analysis was done by the procedure as described by Kempthorne (1957).

RESULTS AND DISCUSSION

The mean sum of squares for parents; hybrids and parents Vs. hybrids were significant for all the characters showing genotypic variation. The parents x environment; hybrids x environment and (parents Vs. hybrids) x environment were also significant. Hence pooled analysis over environments for combining ability was not done. The mean sum of square due to female and male were highly significant for all the characters, except for the seeds per pod (Table 1).

Although the variances due to both general and specific combining ability were important in the inheritance of traits in both the environments, the contribution of latter was comparatively higher for most of the traits, except for days to flowering. The σ^2A/σ^2D ratio indicated that additive gene action was mainly responsible for expression of days to flowering, days to maturity, plant height and seed weight in both environments which supports the earlier findings of Gritton (1975), Venkateswarlu and Singh (1983), Kumar and Agrawal (1982) and Panda et al. (1996). Preponderance of nonadditive gene action was

Table 1. Analysis of variances for combining ability in a line x tester mating design for seed yield and related traits evaluated over two environments, E_1 (upper values) and E_2 (lower values) in pea.

Sources of variation	e.e.	Days to flowering	Days to maturity	Plant height	Pods per plant	Seeds per pod	Seed weight per plant	Seed yield per plant	Biological yield	Harvest index
Replications	2	1.21	3.42	138.10	189.18**	0.95	0.12	82.30**	101.40**	23.30**
	2	11.54	6.90	242.58	245.48**	0.04	0.13	81.96**	173.74**	27.14**
Males	14	207.46**	175.72**	6651.99**	1955.62**	2.22**	9.72**	182.28**	1122.10**	40.55**
Females	4	1254.36**	172.49**	32735.94**	139.01**	1.74	2.80**	271.34**	2304.78**	210.44**
	4	719.67**	255.39**	32231.08**	689.60**	2.53**	11.12**	171.51**	1140.46**	255.84**
Males x females	56	44.04**	28.56**	2491.21**	276.49**	0.61	0.71**	19.44**	382.14**	32.65**
	56	49.50**	30.96**	2303.70**	185.10**	0.46**	0.67**	49.71**	240.98**	42.12**
Error	188	1.33	1.26	40.45	18.45	0.75	0.08	7.23	18.17	3.64
	188	1.84	1.07	41.30	12.12	0.08	0.05	3.26	9.21	3.43
σ^2 gca		22.89	4.85	573.42	46.54	0.04	0.35	5.24	44.38	3.09
		14.93	5.59	558.83	19.80	0.07	0.25	2.92	22.37	4.24
σ^2 sca		14.26	9.08	815.44	85.28	0.18	0.22	20.45	120.45	9.84
		15.97	9.72	751.91	57.66	0.13	0.20	15.50	77.09	13.02
σ^2A		45.79	9.70	1146.80	93.09	0.09	0.70	10.49	88.76	6.19
		29.86	11.19	1117.66	39.59	0.04	0.50	5.85	44.75	8.49
σ^2D		14.26	9.08	815.44	85.28	0.18	0.22	20.45	120.45	9.84
		15.97	9.72	751.91	57.44	6.13	0.20	15.50	77.09	13.02
σ^2A/σ^2D		3.21	1.07	1.41	0.86	0.50	3.18	0.51	0.74	0.63
		1.87	1.15	1.49	0.69	0.31	2.50	0.38	0.58	0.61

* P = 0.05 ; ** P = 0.01

evidenced for pods per plant, seeds per pod, seed yield per plant, biological yield per plant and harvest index. Greater contribution of nonadditive gene action towards the genetic control of seed yield and yield contributing traits, pods per plant, seeds per pod were also reported by Gritton (1975), Kumar and Agrawal (1982) and Katiyar *et al.* (1987), but Venkateswarlu and Singh (1981) and Panda *et al.* (1996) observed importance of additive gene action for these traits which contradicts the present finding. The ambiguity in results might be due to differences in genotypes and/or environments.

In the present case, selection in the early generation would be effective for the characters days to flowering, days to maturity, plant height and seed weight which were governed by additive genes. However, for rest of the traits showing preponderance or nonadditive genes for expression of the traits, the selection could be delayed to later generation.

The estimates of general combining ability effects of parents have shown that among lines, five parents, LMR 20 Garifield, Tracer, Trapper and HUP 1 were found to be good general combiner for seed yield and most of other related characters in both the environments. LMR 20 was also good general combiner for pods per plant, seeds per pod and biological yield per plant. PG 3 was promising parent among testers having high general combining ability effects for seed yield, seeds per pod, biological yield per plant and earliness traits i.e. days to flowering and days to maturity in both the environments. The most outstanding parents reflecting highest desirable GCA effects for various traits in both the environments were Alaska 81 for early flowering; Pusa 10 for early maturity, dwarfness and seed weight; LMR 20 for pods per

Table 2. Promising crosses based on high SCA effect for seed yield per plant, GCA effects of their parents, heterosis over better parents (HBP) and performance of these crosses for desirable SCA effects in related traits from line x tester mating design in two environments (E_1 and E_2) in pea

E_1							E_2						
S No. Cross	SCA effect	GCA effect of parent P_1	GCA effect of parent P_2	HBP	Other related traits showing desirable SCA effect for the cross.		Sl. No. Cross	SCA effect	GCA effect of parent P_1	GCA effect of parent P_2	HBP	Other related traits showing desirable SCA effect for the cross.	
1. LMR 20 x PG 3	11.92**	5.26**	1.98**	88.93**	PH,PP,BY		1. HFP 4 x HUP 12	12.25**	-0.68	0.32	98.49**	DF,PP,SW,BY	
2. HUP 1 x Pusa 10	11.05**	2.56**	-3.81**	42.82**	DF,PP,SW,BY		2. HUP 1 x Pusa 10	7.57**	2.74**	-3.43**	77.34**	DF,PP,SW,BY	
3. HFP 4 x HUP 12	10.52**	0.39	2.29**	61.38**	DF,PP,SW,BY		3. LMR 20 x PG 3	5.91**	1.63**	1.21**	84.20**	PH,PP,BY	
4. EC 33866 x HUP 12	8.21**	-5.91**	2.29**	37.72**	PP,SP,BY		4. HUP 2 x FC 1	5.48**	0.33	1.19**	42.99**	DF,PP,SW,BY	
5. Garifield x PG 3	7.09**	2.95**	1.98**	41.41**	PP,SP,BY,HI		5. Alaska 81 x FC 1	5.47**	0.18	1.19**	57.22**	DF,BY,HI	
6. HUP 11 x PUSA 10	6.10**	1.87**	2.56**	14.76**	PH,SW,BY		6. HUP 11 X HUP 12	4.52**	0.72	0.32	51.07**	DF,DM,PH, SW,BY,HI	
7. S 143 x T 163	4.50**	-5.74**	0.18	-6.06	PH,BY		7. IP 2 x T 163	4.35**	0.54	0.70	10.26	PP,SP,SW,BY	
8. 5064 x HUP 21	4.39**	-0.15	2.29**	44.42**	DF,PH, PP,SP,HI		8. 5064 x PG 2	4.28**	-1.29**	1.21**	50.98***	DF,PP,SW,BY	
9. Alaska 81 x FC1	4.33**	-0.23	-0.64	34.51**	DF,HI		9. Garifield x PG 3	4.21**	3.09**	1.21**	51.73**	PP,HI	
10. HUP 2 x T 163	3.78**	0.37	0.18	3.27	PH,SW,HI		10. HUP 2 x T 163	3.95**	0.33	0.70**	7.98	PH,SP,BY,HI	
11. EC33866 x FC 1	3.77**	-5.91**	-0.64	45.98**	PH,SW,BY		11. EC33866 x HUP 12	3.19**	-6.34**	0.32	50.90**	BY	
12. HUP 2 x FC 1	3.26**	0.37	-0.64	30.17**	SP,SW,BY		12. HUP 11 x Pusa 10	2.85**	-3.43**	0.32	79.16**	BY	
13. IP 3 x T 163	3.00**	-3.37	0.18	3.40	PP,SP,BY		13. S 143 x T 163	2.53**	-4.19**	0.70**	-14.26	DF,SW,SY	
14. HUP 11 x HUP 12	2.83**	1.87**	2.29**	23.93**	DF,PH,PP,SP,HI		14. 5064 x HUP 12	2.05**	-1.29**	0.32	34.19**	DF,PH,PP,SP,H	
15. 5064 x PG 3	2.56**	-0.15	1.98**	36.34**	DF,PP,SP,SW,BY		15. EC 33866 x FC 1	1.85**	-6.34**	1.19**	20.16**	PH,PP,BY	

*,** Significant at P = 0.05 and 0.01 respectively.

where, DF = days to flowering, DM = Days to maturity, PH = Plant height, PP = Pods per plant, SP = Seeds per pod, SW = Seed weight BY = Biological yield per plant, HI - Harvest Index plant and biological yield per plant; Garifield for seeds per pod and PI 280064 for harvest index.

Specific combining ability effect (SCA) which represents dominance and epistatic component of variation has been described as an appropriate indicator for judging potentiality of heterosis in a cross. Fifteen out of 75 hybrids possessed significant SCA effect in both the environments for seed yield per plant (Table 2). Twelve of these 15 F_1s reflected high heterosis over better parent (HBP) for seed yield in both the environments which shows usefulness of SCA effect in predicting heterosis for the crosses. The cross combination LMR 20 x PG 3 in E_1 and HFP 4 x HUP 12 in E_2 were the most striking crosses as their highest SCA effects were translated into highest heterosis over better parent. However, HUP 1 x Pusa 10 was most outstanding hybrid which exhibited high SCA effects and heterosis in both the environments. The crosses showing significant SCA effect for seed yield per plant also had significant SCA effect for one or more traits.

Table 3. Correlation coefficient 'r' between general (GCA) and specific (SCA) combining ability with *per se* performance of parents and the F_1 hybrids, respectively for nine yield and related traits in pea in two environments E_1 (upper values) and E_2 (lower values)

Character	Correlation coefficient between	
	GCA and means of parent	SCA and mea of mean of the F_1 hybrids
Days to flowering	0.301	0.231
	0.287	0.187
Days to maturity	0.318	0.343
	0.246	0.321
Plant height	0.851**	0.619**
	0.846**	0.615**
Pods per plant	0.830**	.565**
	0.817**	0.640**
Seeds per pod	0.632**	0.688**
	0.620**	0.596**
Seed weight	0.819**	0.418**
	0.892**	0.493**
Seed yield per plant	0.606**	0.718**
	0.672**	0.752**
Biological yield per plant	0.301	0.679**
	0.315	0.698**
Harvest index	0.504*	0.751**
	0.588	0.720**

*,** Significant at P = 0.05 and 0.01, respectively.

Majority of the crosses exhibiting high SCA effects for seed yield involved poor x poor general combiners as their parents (Table 2) which demonstrated importance of nonadditive gene action in control of seed yield. A few crosses e.g. LMR 20 x PG 3 showing high SCA effect in both the environments involved parents with high gca effect. Additive portion of genetic variability of such crosses could be exploited by handling them through simple conventional breeding programme like pedigree method. A number of crosses such as HUP 1 x Pusa 10 (in both environments) had one good and the other poor combiner in their parentage. Transgressive segregants could be obtained from progenies of these hybrids.

Correlation coefficient 'r' were computed between GCA and *per se* performance of parents and the SCA with mean performance of hybrids for all the nine traits (table 3). GCA effects were positively and significantly correlated with the mean of parents for all the characters except for days to flowering, days to maturity and biological yield per plant in both the environments; the strongest correlation was established for plant height followed by seed weight and seeds per pod. Sarawat *et al.* (1994) also found strong association between GCA and per se performance of parents for plant height, pods per plants, seeds per pod and seed yield per plant. A correspondence between GCA effect and *per se* performance of parents was also reported by kumar and Agrawal (1981) and Venkateswarlu and Singh (1983) for most of the yield and yield contributing traits in pea. Positive correlation coefficient were noted between SCA effects and mean of the F_1s for harvest index, seed yield per plant, biological yield per plant, seeds per pod, plant height, pods per pod and seed weight.

The basic task for the breeders in self-pollinated crop is to develop pure lines that are productive in diverse environments. Cultivars with high mean performance show greatest benefit in high yielding environment. However, increasing mean performance has tended to decrease area adaptation and stability owing to genotype x environment interaction. In the present investigation, the sum of squares for the parents, hybrids and parents vs. hybrids interacted significantly with the environment for almost all the characters. The general and specific combining ability variances and their effects were also effected by change in environment i.e. timely vs. late sown.

To maintain production in diverse environment it would be desirable to increase the genetic diversity within the cultivar which can be achieved by postponing the selection in early generation to maintain within line variation. Thereafter, selection can be done for performance and uniformity (Baenziner and Peterson, 1991). An alternative approach to widen genetic diversity is to develop multilines.

ACKNOWLEDGEMENT

The first author is grateful to Dr. B. Snoad (England), Dr. S. Blixt (Sweden), Dr. A.E. Slinkard (Canada) and Dr. J.M. Kraft (USA) for providing pea germplasm lines.

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(Received: March 1998 Revised: September 1998)

Madras Agric. J., 86(7-9): 370 - 372 July - September 1999

PREDATION POTENTIAL OF *Coccinella septempunctata* var *divaricata* OLIVE ON MUSTARD APHID (*L. erysimi* Kalt.) INFESTING MUSTARD CROP

SEEMA KUMARI and I.P. SINGH

Department of Entomology & Agril. Zoology
Rajendra Agricultural University
Pusa, Samastipur, Bihar - 848 125

An experiment was conducted to study the predation potential of *Coccinella septempunctata* var *divaricata* on mustard aphid during February-March, 1996. The larva of the predatory Coccinellid consumed 116.61 aphids per individual with minimum and maximum of 155.5 and 167.71 aphids per individual in February while 141 aphids per individual with minimum and maximum of 114.25 and 168.75 aphids per individual in March. Adult of the Coccinellid consumed 518.0 aphids per individual with minimum and maximum of 428 and 636 aphids per individual in March.

KEY WORDS: *C. septempunctata var. divaricata,* Mustard aphid, Mustard

Among the oilseeds, mustard (*Brassica juncea* L.) is very important crop extensively cultivated throughout India. As many as 38 insect pests are reported to be associated with this crop but mustard aphid (*Lipaphis erysimi* Kalt) is recorded as key pest of this crop in India (Bakhetia,