Indian Journal of Ecology (2025) 52(3): 586-589
DOI: https://doi.org/10.55362/IJE/2025/4541

Manuscript Number: 4541
NAAS Rating: 5.38

Study on Combining Ability and Gene Action in Pigeonpea (*Cajanas cajan* (L.) Millsp.) For Grain Yield and Quality Traits in Humid South Eastern Plain Climate Zone

Kamal Kumar Sharma, S.C. Sharma and Rajesh Kumar Sharma

Department of Genetics and Plant Breeding
College of Agriculture, Ummedganj-Kota-324 001, India
E-mail: kamalsharmagpb@gmail.com

***Abstract*:** Twenty-eight hybrids developed by utilizing eight parents in 8 x 8 diallel mating design excluding reciprocals were evaluated in randomized block design (Agriculture University, Kota during, 2023-24) for thirteen characters in order to understand the combining ability and gene action in pigeonpea. The analysis of variance for combining ability revealed presence of non- additive gene action. The ratio of gca/sca variance was less than unity which indicated the preponderance of non- additive gene action for action. The estimates of general combining ability suggested that parents ICPL-20338, ICPL-20340 and Pusa-992 were good general combiners for seed yield per plant and attributing characters while, hybrids ICPL-20338 x ICPL-20340, ICPL-20338 x AL-882, ICPL-20340 x AL-882 and Pusa-992 x PA-16 showed the higher order sca effect for seed yield per plant. These cross combinations can be potentially utilized in hybrid breeding programmes.

Keywords: Combining ability, Non-additive gene effect, Pigeonpea, Diallel mating design

Pigeonpea [*Cajanus cajan* (L) Millsp.] is an often-cross-pollinated important grain legume crop mainly grown under rain-fed conditions in India. Therefore, pigeonpea can be improved genetically following breeding methods suitable for both allogamous as well as autogenous crops. Pigeonpea differs from other legumes as it exhibits large variation (20-70%) in natural out crossing, it can be considered as an often-cross-pollinated crop. Selection of parent genotypes together with information on nature and magnitude of gene action controlling grain yield and its attributing characters is prerequisite while improving the plant type. The study on combining ability provides useful information on selection of parents in terms of performance of their hybrids and elucidates the nature and magnitude of various types of gene action involved in the expression of the quantitative traits. The limited studies on the combining ability contribute to limited selection of the best genotypes for specific traits in pigeonpea. The objective of this combining ability analysis in early genotypes of pigeonpea.

MATERIAL AND METHODS

Eight diverse cultivars of pigeonpea, namely, ICPL-20338, ICPL-20340, ICPL-87, Pusa-991, Pusa-992, PA-16, PA-291 and AL-882 were crossed in all possible combinations excluding reciprocals in *Kharif* 2022-23. The resulting F_1's, and eight parents were grown in a randomized block design replicated thrice at the farm attached to the agriculture research station, Agriculture university, Kota during *kharif* 2023-24. Five randomly selected competitive plants from each genotype were used in recording observations on the characters including days to 50% flowering, days to maturity, plant height, primary branches per plant, pod per plant, seed per pod, pod length, 100 seed weight, biological yield per plant, grain yield per plant, harvest index, protein content and carbohydrate content. Combining ability estimates of parents and crosses were estimated according to the Method-2, Model-1 of Griffing (1956).

RESULTS AND DISCUSSION

The significant and high variances observed for all the thirteen characters revealed the genetic variability among the genotypes. The variance due to SCA was higher than the variance due to GCA for all the traits including seed yield per plant showed the predominance of dominance gene action for these traits. these characters could be improved by heterosis breeding. However, σ^2gca/ σ^2sca ratio being less than unity indicating that the non-additive gene action was more important in the expression of all characters in each environment (Table 1) Similar results were reported in earlier studies(Shekhar et al., 2004, Banu et al., 2006, Kumar et al., 2009, Satpute et al., 2019).

The gca effects of parents revealed that the parents ICPL-20338, ICPL-20340 and Pusa-992 were good general combiners for seed yield and its direct components (Table 2). ICPL-20338 was good general combiner for primary branches per plant, pods per plant, seeds per pod, and biological yield per plant. ICPL- 20340 for pods per plant, seeds per pod, 100-seed weight and biological yield per plant and Pusa-992 for pods per plant, 100-seed weight, biological yield per plant and protein content. Pusa-991 and PA-16 were good combiners for earliness and dwarfness.

The estimation of specific combining ability effects revealed that cross combinations ICPL-20338 x ICPL-20340, ICPL-20338 x AL-882, ICPL-20340 x AL-882 and Pusa-992 x PA-16 exhibited significant and positive sca effects for seed yield per plant resulted from good x good, good x poor, good x poor and good x average parents, respectively. Better performance of hybrids involving high x low or low x low general combiners indicated dominance x dominance type of gene interaction. The crosses showing high sca effects involving one good general combiner indicated additive x dominance type gene interaction which exhibited the high heterotic performance for yield and yield related traits. These

Table 1. Analysis of variance for combining ability for yield and its contributing traits

Characters	Source of variance					
	GCA (7)	SCA (28)	Error (70)	σ^2gca	σ^2sca	σ^2gca/ σ^2sca
Days to 50% flowering	4.76**	10.84**	0.72	0.40	10.12	0.03
Days to maturity	3.72**	6.89**	0.95	0.28	5.94	0.04
Plant height	3.72**	6.89**	0.95	3.34	54.88	0.04
Primary branches per plant	0.76**	2.95**	0.19	0.06	2.75	0.02
No. of pods per plant	1454.19**	1236.34**	38.52	141.57	1197.82	0.11
No. of seed per pod	0.22**	0.22**	0.04	0.02	0.18	0.09
Pod length	0.24**	0.24**	0.05	0.02	0.19	0.10
100- seed weight	0.63**	0.78**	0.10	0.05	0.68	0.07
Biological yield per plant	177.25**	405.88**	17.63	115.96	388.25	0.29
Seed yield per plant	52.73**	86.64**	3.86	4.89	82.78	0.05
Harvest index	16.65**	33.38**	3.28	1.34	30.10	0.04
Protein content	1.43**	4.41**	0.20	0.12	4.21	0.02
Carbohydrate content	22.27**	32.09**	0.49	2.18	31.61	0.06

*,** Significant at 5 and 1 per cent level

Table 2. Estimates GCA effects for different traits in pigeonpea

Parents	DFF	DM	PH	PBPP	NPPP	NSPP	PL	100-SW	BYPP	GYPP	HI	PC	CC
ICPL-20338	-0.28	0.48	0.91	0.34*	17.58**	0.18**	0.12	-0.06	11.0**	2.89**	-0.21	-0.69**	-0.02
ICPL-20340	-0.18	0.71*	3.14*	0.14	9.05**	0.19**	-0.16*	0.22*	6.06**	1.30*	-0.33	0.12	-0.52*
ICPL-87	-0.01	-1.15**	-2.31	0.35*	-18.7**	-0.03	0.13	-0.06	-9.35**	0.66	2.83**	-0.13	1.33**
Pusa-991	-0.61*	-1.05**	-3.34	-0.11	-4.12*	-0.1**	0.21**	-0.39**	-16.86**	-4.37**	0.16	0.10	0.60**
Pusa-992	0.25	0.21	-1.71	0.12	8.30**	0.09	0.06	0.23*	12.39**	1.40*	-1.22*	0.51**	-0.76**
PA-16	-0.75**	-1.14**	3.11	0.02	2.25	0.17*	-0.03	-0.31**	1.97	0.69	-0.10	0.28*	-2.49**
PA-291	1.48**	0.37	-2.19	-0.33*	-14.6**	-0.14*	-0.20**	0.24*	-10.42**	-2.15**	0.24	-0.33*	-0.58**
AL-882	0.11	-0.48	2.38	-0.44**	6.33**	-0.16*	-0.13*	0.13	5.14**	-0.43	-1.37*	0.13	2.45**
SE	0.251	0.288	1.838	0.131	1.836	0.065	0.066	0.097	1.242	0.581	0.535	0.132	0.207
gi-gj	0.380	0.436	2.779	0.199	2.775	0.098	0.100	0.146	1.877	0.879	0.809	0.200	0.312

*,** Significant at 5 and 1 per cent level

DFF	-Days to 50% flowering	100-SW	-100 Seed weight
DM	-Days to maturity	BYPP	-Biological yield per plant
PH	-Plant height	SYPP	-Seed yield per plant
PBPP	-Primary branches per plant	HI	-Harvest index
NPPP	-Number of pods per plant	PC	-Protein content
NSPP	-Number of seeds per pod	CC	-Carbohydrate content
PL	-Pod length		

Table 3. Estimates SCA effects for different traits in pigeonpea

Crosses	DFF	DM	PH	PBPP	NPPP	NSPP	PL	100-SW	BYPP	GYPP	HI	PC	CC
ICPL-20338 × ICPL-20340	5.81**	1.63	11.60*	1.16**	34.83**	0.43*	0.73**	1.44**	16.4**	10.49**	4.55 **	0.61	-0.70
ICPL-20338 × ICPL-87	-5.34**	-0.33	0.16	-0.01	14.64*	0.18	0.16	-0.14	11.85**	6.12**	1.65	1.07*	5.79**
ICPL-20338 × Pusa-991	1.25	1.86*	6.29	2.22**	-20.9**	-0.13	-0.21	-0.15	4.29	-5.67**	-5.13**	-1.33**	6.17**
ICPL-20338 × Pusa-992	-1.28	-0.86	1.09	-0.03	15.79**	-0.37	-0.51*	-0.65*	-6.40	5.53**	5.19 **	-2.19**	-7.41**
ICPL-20338 × PA-16	-4.48**	0.83	-11.96*	-0.45	-55.5**	-0.33	-1.19**	1.40**	-14.27**	-12.85**	-6.47 **	-1.29**	0.40
ICPL-20338 × PA-291	2.05*	1.49	-12.71*	-3.70**	40.31**	0.70**	0.30	0.17	22.52**	8.61**	2.30	1.51**	2.40**
ICPL-20338 × AL-882	2.15**	0.97	8.71	1.19**	29.45**	0.93**	0.45*	1.46**	15.40**	11.14**	5.25**	2.54**	3.45**
ICPL-20340 × ICPL-87	-0.78	-6.22**	5.35	-3.71**	-41.1**	-0.35	-1.09**	1.08**	-0.63	-11.70**	-9.19 **	-0.19	3.64**
ICPL-20340 × Pusa-991	-2.18**	0.97	-11.34	0.93*	40.05**	0.31	0.20	-0.43	11.92**	12.81**	6.89 **	0.07	8.16**
ICPL-20340 × Pusa-992	0.95	0.23	-14.04*	0.67	33.65**	0.50*	-0.04	-0.90	8.63*	6.93**	3.60*	3.94**	-5.00**
ICPL-20340 × PA-16	2.75**	3.60**	-12.07*	-3.33**	-67.3**	-0.08	0.52*	-1.02**	-46.89**	-10.25**	0.83	0.46	-2.44**
ICPL-20340 × PA-291	0.28	0.27	6.08	-0.18	1.39	-0.32	-0.38	-0.91**	-13.42**	-6.61**	-2.90	-1.12**	-9.44**
ICPL-20340 × AL-882	3.05**	1.35	11.70**	0.46	45.51**	0.83**	0.92**	1.67**	20.69**	13.33**	5.77**	-1.10*	8.01**
ICPL-87 × Pusa-991	1.31	0.99	-7.48	1.08*	19.33**	-0.06	0.19	-0.08	5.32	-6.05**	-7.44 **	3.43**	2.66**
ICPL-87 × Pusa-992	2.45**	0.93	3.93	0.26	-17.58**	-0.14	-0.19	0.27	12.54**	-7.34**	-7.44 **	0.05	0.05
ICPL-87 × PA-16	0.91	1.96*	9.85	0.57	68.90**	0.61**	0.20	0.06	37.72**	11.61**	0.78	0.45	1.34*
ICPL-87 × PA-291	2.78**	2.63**	5.34	-0.01	-24.90**	-0.03	0.20	-0.86	-20.03**	0.98	6.15**	-0.22	6.15**
ICPL-87 × AL-882	-4.11**	-5.56**	-1.40	0.42	-34.68**	-0.7**	0.24	-0.22	-21.29**	-9.38**	-4.43*	-1.21**	-0.71
Pusa-991 × Pusa-992	2.71**	1.13	-4.27	-1.17**	0.68	0.08	0.14	0.14	13.19**	-0.93	-3.12	4.37**	-3.36**
Pusa-991 × PA-16	-0.81	0.83	5.54	0.08	-8.87	-0.20	-0.15	0.36	-14.16**	-5.23**	-2.22	1.81**	0.57
Pusa-991 × PA-291	-0.61	0.83	-4.93	0.14	-24.39**	0.03	-0.19	0.37	-14.6**	-2.02	0.52	-2.93**	-1.79**
Pusa-991 × AL-882	0.48	1.63	-9.39	-3.75	2.81*	0.08	-0.11	-0.29	20.40**	-5.91**	-7.56 **	-1.01*	-0.61
Pusa-992 × PA-16	-0.01	0.76	6.93	-1.64**	41.05**	0.50*	0.45*	0.87**	14.51**	8.85**	3.77*	-0.82	4.57**
Pusa-992 × PA-291	-3.48**	-2.23*	17.27**	-0.14	19.43**	0.32	0.33	0.90**	14.90**	7.75**	3.12	-0.99*	-7.29**
Pusa-992 × AL-882	-4.38**	-0.76	6.01	1.84**	3.38	0.15	0.14	0.60	-1.72	4.76*	3.94*	-2.17**	6.06**
PA-16 × PA-291	2.98**	-0.20	-12.64*	1.17**	-4.21	0.09	0.48*	0.55	-9.31*	-0.16	1.82	2.25**	5.52**
PA-16 × AL-882	3.75**	-0.06	-6.43	0.21	-11.35	-0.54*	-0.47*	-1.69**	1.84	-8.34**	-5.61 **	-2.25**	-5.25**
PA-291 × AL-882	4.95**	3.60**	2.94	-0.22	13.33*	-0.24	-0.32	0.44	16.84**	1.08	-1.77	-1.20**	3.34**
S.E	0.77	0.88	5.63	0.40	5.62	0.19	0.20	0.29	3.80	1.78	1.64	0.40	0.55
gi-gj	1.14	1.30	8.33	0.59	8.32	0.29	0.30	0.44	5.63	2.63	2.42	0.60	0.63

*,** Significant at 5 and 1 per cent level

combinations also had the higher order sca effects for the number of pods per plant, number of seeds per pod, pod length, 100- seed weight, biological yield per plant and harvest index.

The hybrids Pusa-991 x Pusa-992 (4.37), ICPL-20340 x Pusa-992 (3.94) and ICPL-87 x Pusa-991 (3.43) exhibiting significant and positive sca effects for protein content resulted from average x good, average x good and poor x average parents, respectively. Hybrids ICPL-20340 x Pusa-991(8.16), ICPL-20340 x AL-882 (8.01) and ICPL-20338 x Pusa-991 (6.17) exhibited significant and positive sca effects for carbohydrate t resulted from poor x average, average x good and poor x average parents, respectively. The estimation of specific combining ability effects revealed that cross combinations ICPL-87 x AL-882 and Pusa-992 x PA-291 exhibited significant and negative sca effects for days to 50% flowering and days to maturity (Table 3). These finding were also in confirmation with earlier studies (Mhasal et al., 2015, Yamanura et al., 2016, Moses et al., 2020, Patel et al., 2020, Chandra et al., 2024).

CONCLUSION

The variance due to SCA was higher than the variance due to GCA for all the traits including seed yield per plant showed the predominance of dominance gene action for these traits. However, σ^2gca/ σ^2sca ratio being less than unity indicating that the non-additive gene action was more important in the expression of all characters in each environment. The gca effects of parents revealed that the parents ICPL-20338, ICPL-20340 and Pusa-992 were good general combiners for seed yield and its related traits. Involving these parents in multiple crossing programmes may be developed for isolating high yielding lines. The estimation of specific combining ability effects revealed that cross combinations ICPL-20338 x ICPL-20340, ICPL-20338 x AL-882, ICPL-20340 x AL-882 and Pusa-992 x PA-16 exhibited significant and positive sca effects for seed yield per plant and yield contributing traits. These crosses may be further studies for commercial exploitation of hybrid vigour.

Received 27 February, 2025; Accepted 22 May, 2025

REFERENCES

Banu MR, Muthaiah AR and Ashok S 2006. Combining ability studies in pigeonpea. *Crop Research* **31**(3): 396-398.

Chandra D, Verma SK, Gaur AK, Bisht C, Gautam A, Chauhan C and Yadav H 2024. Heterosis, Combining Ability, Genetic Diversity and their Interrelationship in Pigeonpea [*Cajanus cajan* (L.) Millsp]. *Legume Research* **47**(2): 183-189.

Griffing B 1956. Concept of general and specific combining ability in relation to diallel crossing systems. *Australian Journal of Biological Sciences* **9:** 463-493

Kumar CVS, Sreelakshmi CH and Varma PK 2009. Studies on combining ability and heterosis in pigeonpea [*Cajanus cajan* (L.) Millsp]. *Legume Research* **32**: 92-97.

Mhasal GS, Marawar MW, Solanke AC and Tayade SD 2015. Heterosis and combining ability studies in medium duration pigeonpea F_1 hybrids. *Journal of Agriculture Research* **53**(1): 11-22.

Moses N, Sharma MB, Seyie K, Shah P and Ozukum C 2020. Combining Ability Study in Vegetable-Type Pigeonpea [*Cajanus cajan* (L.) Millsp]. *International Journal Recent Sciences Research* **11**(02): 37318-37321.

Patel HS, Patel AM, Chaudhary HB and Kugashiya KG 2020. Exploitation of heterosis in hybrids development using cytoplasmic genetic male sterility (CGMS) systems in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Journal of Pharmacognosy and Phytochemistry* **9**(4): 1147-1151.

Satpute RG, Khare D and Bargale M 2019. Diallel analysis in pigeonpea. *Indian Society of Genetic and Plant Breeding* **19**: 5200.

Sekhar MR, Singh SP, Mehara RB and Govil JN 2004. Combining ability and heterosis in early maturing pigeonpea hybrids. *Indian Journal of Genetics* **64**(3): 212-216.

Yamanura Muniswamy S and Ramesh 2016. Implications of hybrid vigour, combining ability and *per se* performance in pigeonpea [*Cajanus cajan* (L.) Millsp]. *Journal of Applied and Natural Science* **8**(2): 597-603.