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Research Article

Combining ability studies for seed yield and contributing characters of F_1 and F_2 generations in cowpea [*Vigna unguiculata* (L.) Walp.].

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Abstract
Combining ability analysis was carried out in diallel model using ten genotypes *viz.*, IT 389561, RC 101, Pusa Phalguni, KM 5, GC 1, GC 2, GC 4, GC 5, Pant Lobia 1 and Pant Lobia 2. The estimates of *gca* effects indicated that the parents, IT 389561 and RC 101 were observed to be the best general combiners for seed yield per plant along with branches per plant and number of pods per plant in both generations. The crosses, GC 2 x GC 5 had recorded significant sca effects in both F_1 and F_2 generations for seed yield per plant followed by IT 389561 x KM 5, IT 389561 x GC 4 and KM 5 x GC 5. The cross, GC 2 x GC 5 was also found to be best specific combiner for number of pods per cluster, number of pods per plant, number of seeds per pod and harvest index with high *per se* performance for seed yield per plant. These crosses were considered very important to get good transgressive segregants and promising progenies for making use of them in future breeding programme.

Key words
Combining ability, F_1 and F_2 generation, Seed yield, Cowpea

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important grain legume, which is tolerant to drought and other soil stresses. Cowpea has the unique ability to fix nitrogen in very poor soils. Cowpea is primarily used in the form of dry seeds, fodders, green pods, green manure and cover crops. Many constraints are identified for low productivity of cowpea. This crop exhibits rich genetic diversity for various traits and has a great scope for its improvement. In cowpea, seed yield is complex quantitative character and influenced by its contributing traits, *i.e.* number of pods per plant, pod length, seeds per pod and 100 seed weight. The selection of parents on the basis of *per se* performance does not necessarily lead to desirable results. The knowledge of combining ability is the pre-requisite in any plant breeding programme for selection of superior parents and better cross combinations besides elucidating the nature and magnitude of gene action involved. Hence attempts have been made to study the general combining ability and specific combining ability effect for different traits in cowpea.

Materials and method

Ten diverse lines of cowpea *viz.*, GC 1, GC 2, GC 4, GC 5, RC 101, KM 5, IT 389561, Pusa Phalguni, Pant Lobia 1 and Pant Lobia 2 were crossed in diallel fashion without reciprocals. The 45 F_1's and 45 F_2's and 10 parents were grown in randomized block design with three replications at Instructional Farm, Junagadh Agricultural University, Junagadh (Gujarat) during summer 2014. Each parent and F_1 were planted in one row plot of 2.0m long and three rows each for F_2 progenies with inter and intra row distance of 0.45m x 0.15m. Observations were recorded on five randomly selected plants from each parent and F_1 and twenty plants in F_2 from each replication, for eleven traits *viz.*, plant height (cm), branches per plant, number of pods per plant, number of clusters per plant, number of pods per cluster, pod length (cm), number of seeds per pod, 100-seed weight (g), seed yield per plant (g), protein content (%) and harvest index (%), while days to 50% flowering and days to maturity were recorded in 50% and 80% on the plot basis respectively. Mean value were used for statistical analysis. Combining ability analysis was carried out as per the method described by Kempthorne (1957). The analysis was done using the WINDOSTAT 7.5 statistical package.

Result and discussion

Selection of the parents in the hybridization programme is very important for getting desirable transgressive segregants in crop improvement. The results of analysis of variance for different characters are presented in Table 1. The analysis of variance for combining ability indicated that general and specific combining ability variances were highly significant for all the traits in both the generations (F_1 and F_2), suggesting that both additive and non-additive gene effects were involved in the expression of these characters in both the generations. The magnitudes of general combining ability (GCA) and specific combining ability (SCA) variances revealed that the SCA variances ($\sigma^2 s$) were higher than their respective GCA variances ($\sigma^2 g$) for all the traits in both the generations studied except for branches per plant in F_2 generation. Also, the GCA and SCA ratio (σ^2GCA/ σ^2SCA) was less than unity for all the traits except for branches per plant in F_2 generation. This indicated that non-additive components play relatively greater role in the inheritance of most of the traits. As non-additive gene action was found to be predominant, all these traits can be improved through heterosis breeding. However, since cowpea is being a completely self pollinated crop and hybrid seed production is also very difficult without CMS, resorting to heterosis breeding will not be feasible, hybridization followed by selection at later generations will be useful to improve all the traits and identify superior and stable cowpea varieties. Rangiah (2000) and Nagaraj *et al.* (2002) also reported the importance of non-additive gene action for yield contributing traits in cowpea.

The general combining ability effect (Table 2) revealed that among the parents used in the present study, none of the parents was a good general combiners for all the traits studied. Estimates of gca effects indicated that the parents, IT 389561 and RC 101 were observed to be the best general combiners for seed yield per plant along with branches per plant and number of pods per plant in both the generations. While the parent, Pusa Phalguni was also a good general combiner for days to 50 per cent flowering in F_1 and F_2 generations. The parent, KM 5 was found to be a good general combiner for the traits like days to 50 per cent flowering, days to maturity and plant height in F_1 generation while number of seeds per pod and seed yield per plant in F_2 generation. The parent, GC 1 was found to be a good general combiner for the traits like, number of pods per plant and number of pods per cluster in both the generations. The parent, GC 2 found to be good general combiner for 100-seed weight, plant height, days to maturity and days to 50 per cent flowering in both the generations. The parent, GC 4 was found to be good general combiner for days to 50 per cent flowering, days to maturity and 100-seed weight in both the generations. The parent, GC 5 was found to be a good general combiner for number of seeds per pod in F_1 and F_2 generations. The parent, Pant Lobia 2 was found to be a good general combiner for pod length and 100-seed weight in both the generations. It is suggested that population involving these genotypes in a multiple crossing programme may be developed for isolating desirable recombinants. Further, the varieties or lines showing good general combining ability for particular components may be utilized in component breeding for improving the specific trait of interest.

From the estimates of *sca* effects, it was revealed that none of the crosses was consistently superior for all the characters. The crosses displaying high *sca* effects did not always involve parents with high *gca* effects, suggesting that the interallelic interactions were important for the characters. Crosses having high *sca* effects for seed yield did not have high *sca* effects for other yield attributing characters. The crosses exhibiting high heterosis with low inbreeding depression may be exploited for development of high yielding stable lines. The specific combining ability effects for best crosses are presented in Table 3. The results showed that the crosses manifesting high standard heterosis did not always show high *sca* effects for the respective characters. A high *sca* effect denotes undoubtedly a high heterotic response, but this may be due to very poor performance of the parents in comparison with their hybrids. With the same amount of heterotic effects, the *sca* effects may be less, where the mean performance of the parents was higher but this estimate may also be biased. This suggested that the selection of cross combinations based on heterotic response would be more realistic rather than on the basis of *sca* effects.

The cross combinations, which had high *sca* effects in F_1 generation for various characters showed that the cross, GC 4 x Pant Lobia 2 exhibited high *sca* effects for seed yield per plant, number of seeds per pod and number of pods per plant which was followed by the three cross, GC 2 x GC 5, Pusa Phalguni x GC 2 and KM 5 x GC 5, while the cross, GC 1 x GC 5 exhibited high *sca* effects for 100-seed weight and pod length. The cross, GC 1 x Pant Lobia 2 showed high *sca* effects for number of pods per cluster while the cross, Pusa Phalguni x GC 2 recorded high *sca* effects for number of clusters per plant, number of pods per plant and branches per plant. The cross combination, KM 5 x GC 5 showed high *sca* effects for branches per plant, while the cross, GC 4 x Pant Lobia 1 and Pusa Phalguni x Pant Lobia 2 showed high *sca* effects for plant height. The cross combination, Pusa Phalguni x GC 5 exhibited high *sca* effects for days to 50 per cent flowering. The cross, RC 101 x KM 5 and RC 101 x Pant Lobia 1 had high *sca* effects for protein content and harvest index, respectively.

In F_2 generation, the hybrid, GC 4 x GC 5 had high *sca* effects for seed yield per plant. The cross, IT 389561 x GC 5 and GC 1 x GC 4 showed high *sca* effects for days to 50 per cent flowering and days to maturity, respectively. The cross, Pusa Phalguni x GC 4 exhibited high *sca* effects for plant height showed best *per se* performance for plant height. The cross, GC 1 x GC 5 had high *sca* effects for 100 seed weight and seed yield per plant. The cross, Pusa Phalguni x KM 5 showed high *sca* effect for branches per plant and also showed best *per se* performance for days to 50 per cent flowering. While the cross GC 2 x GC 4 had high *sca* effects for number of pods per cluster and second highest for pod length. The cross, GC 5 x

Pant Lobia 1 showed high *sca* effect for pod length while the cross RC 101 x Pusa Phalguni had high *sca* effects for number of seeds per pod and also showed best *per se* performance for seed yield per plant. The cross RC 101 x GC 2 had high *sca* effects and best *per se* performance for protein content while the cross IT 389561 x GC 2 had high *sca* effects for harvest index and best *per se* performance for number of pods per cluster in F_2 generation.

All these crosses involved either good x good, good x average, good x poor, average x poor or poor x poor general combiners. The specific combining ability effects of crosses did not show any specific trend for good general combining ability effects of the parents involved in these combinations. However, in majority of crosses, good x good, good x poor and poor x poor combinations resulted in high *sca* effects.

The best crosses (Table-4), GC 2 x GC 5 had recorded significant *sca* effects in both F_1 and F_2 generations for seed yield per plant followed by IT 389561 x KM 5, IT 389561 x GC 4 and KM 5 x GC 5. The cross, GC 2 x GC 5 was also found to be the best specific combiner for number of pods per cluster, number of pods per plant, number of seeds per pod and harvest index with high *per se* performance for seed yield per plant. These crosses were considered very important to get good transgressive segregants in further generations to make their use in future breeding programme.

The specific combining ability represents dominance and epistatic components of variation which are non fixable in nature. But if crosses showing high *sca* effects involving both good general combiner parents, it shows the additive gene action and could be successfully exploited for varietal improvement and expected to through stable performing transgressive segregants carrying fixable gene effects. In F_1 and F_2 generation, the cross combination, IT 389561 x RC 101 had both high combining parents for branches per plant while the cross combination, RC 101 x Pant Lobia 1 for harvest index in F_1 generation, and the cross combination, IT 389561 x GC 5 for number of pods per cluster in F_2 generation and offer still better possibilities of exploitation of yield through stable segregants in the advance generations and thus need further exploitation in the breeding programme. Similar findings were reported by Patil and Nawale, 2006 and Bhawna Pandey and Singh, 2010.

The specific combining ability represents dominance and epistatic components of variation when it shows high *sca* effects involving one good general combiner parents and one poor, it shows the non-additive gene action. In general in the present study in F_1 generation, the cross combinations *viz.*, Pusa Phalguni x GC 5 (good x poor) for days to 50 per cent flowering, Pusa Phalguni x Pant Lobia 2 (poor x good) for plant height, GC 1 x GC 5 (poor x good) for pod length, GC 4 x Pant Lobia 2 (poor x good) for number of seeds per pod, GC 1 x GC 2 (poor x good) for 100 seed weight and RC 101 x KM 5 and RC 101 x GC 4 (good x poor) for protein content while in F_2 generation, the cross combinations *viz.*, KM 5 x Pant Lobia 2 (good x poor) for days to 50 per cent flowering, GC 5 x Pant Lobia 1 (poor x good) for pod length, GC 2 X GC 5 (poor x good) for number of seeds per pod, GC 1 x GC 5 and GC 1 x GC 4 (poor x good) for 100 seed weight and GC 1 x GC 5 (poor x good) for seed yield per plant, may be expected to for the expression of transgressive and stable performing segregants possessing enhanced yielding ability. These findings are in agreement with the earlier findings of Uma and Kalibowilla (2010) and Chaudhari, *et al.* (2013).

It was further observed that crosses involving poor combiners resulted in high *sca* effects for some of the traits. In F_1 generation, the cross combinations, GC 4 x Pant Lobia 2 for number of pods per plant and seed yield per plant were poor x poor combiners. This may be because of the role of high magnitude of non-additive interactions and under complex gene action. These crosses may be utilized through inter-mating in the segregating generations followed by simultaneous selection for desirable plant type for seed yield and its components. These findings are in agreement with the earlier findings of Uma and Kalubowila, 2010 and Chaudhari, 2013.

High *sca* effects would not necessarily mean a high performance by the hybrid and the estimation of *sca* effects seemed to be superfluous, as no additional information was obtained by doing so. Therefore, it is suggested that the selection of parents for further breeding programme should be based on *gca* effects and due consideration should be given to mean value of the cross combinations while selecting crosses.

In present study, the best performing parent was also found to be best general combiners through their relative ranking were quite different in majority of the characters studied. Further, best general combiners may not always produce best cross combinations for most of the characters. However in few cases, good × good combinations exhibited high *sca* effects. In this situation, it would be better to look for good transgressive segregants in further generations to make their use in future breeding programme.

References

Bhawna, Pandey and Singh, Y.V. 2010. Combining ability for yield over environment in cowpea

[*Vigna unguiculata* (L.) Walp]. *Legume Res.*, **33**(3): 190-195.

Chaudhari, S.B., Naik, M.R., Patil, S.S. and Patel, J.D. 2013. Combining Ability for Pod Yield and Seed Protein in Cowpea [*Vigna unguiculata* (L.) Walp] over Environments. *Trends in Biosci.*, **6**(4): 395-398.

Kempthorne, O. 1957. An introduction to Genetics Statistics. John Wiley and Sons, New York, pp. 176-178.

Nagaraj, K.M., Savithramma, D.L. and Ramesh, S. 2002. Triple test cross analysis in two crosses of vegetable cowpea (*Vigna unguiculata* (L.) Walkp.) *South Indian Hort*., **50**: 98-104.

Patil, H.E. and Navale P.A. 2006. Combining ability in cowpea [*Vigna unguiculata* (L.) Walp]. *Legume Res.*, **29**(4): 270-273.

Rangiah, S. 2000. Studies on genetic variability and component analysis in cowpea. *Curr. Res*., **29**:16-17.

Uma, M.S. and Kalubowila, I. 2010. Line x Tester analysis for yield and rust resistance in cowpea [*Vigna unguiculata* (L.) Walp]. *Elect. J. Pl. Breed.*, **1**(3): 254-267.

Table 1. Analysis of variance for combining ability for different characters in cowpea

Effect	Generation	d. f.	Days to 50% flowering	Days to Maturity	Plant height (cm)	Branches per plant	Number of pods per plant	Number of clusters per plant	Number of pods per cluster
			Mean Squares						
GCA	F_1	9	26.675 **	24.777 **	23.451 **	1.516 **	16.084 **	1.443 **	0.107 **
	F_2	9	76.653 **	28.837 **	91.308 **	1.835 **	29.991 **	1.758 **	0.382 **
SCA	F_1	45	16.808 **	7.221 **	58.732 **	0.432 **	9.696 **	1.228 **	0.257 **
	F_2	45	8.063 **	5.291 **	35.619 **	0.193 **	7.547 **	0.855 **	0.183 **
Error	F_1	108	0.849	0.981	0.451	0.029	0.436	0.110	0.029
	F_2	108	0.963	0.916	0.394	0.050	0.688	0.087	0.032
σ^2g	F_1		1.985	1.982	1.916	0.123	1.303	0.111	0.006
	F_2		6.306	2.326	7.576	0.148	2.441	0.139	0.029
σ^2s	F_1		15.958	6.240	58.280	0.403	9.260	1.118	0.227
	F_2		7.094	4.375	35.224	0.143	6.859	0.767	0.151
σ^2g/σ^2s	F_1		0.124	0.317	0.032	0.307	0.964	0.099	0.028
	F_2		0.88	0.531	0.215	1.036	0.356	0.181	0.193

Effect	Generation	d. f.	Pod length	Number of seeds per pod	100-seed weight	Seed yield per plant	Protein content	Harvest index (%)
			Mean Squares					
GCA	F_1	9	3.270 **	2.672 **	3.570 **	5.443 **	0.980 **	7.255 **
	F_2	9	8.035 **	7.615 **	9.652 **	37.496 **	0.706 **	10.073 **
SCA	F_1	45	5.197 **	3.002 **	5.927 **	10.381 **	0.896 **	8.337 **
	F_2	45	1.594 **	1.607 **	2.241 **	4.886 **	1.606 **	7.131 **
Error	F_1	108	0.166	0.139	0.270	0.400	0.130	1.044
	F_2	108	0.797	0.180	0.259	0.272	0.410	3.048
σ^2g	F_1		0.258	0.211	0.275	0.420	0.070	0.517
	F_2		0.653	0.619	0.782	3.101	0.024	0.585
σ^2s	F_1		5.030	2.862	5.657	9.981	0.766	7.293
	F_2		1.397	1.426	1.981	4.613	1.196	4.082
σ^2g/σ^2s	F_1		0.051	0.073	0.048	0.042	0.092	0.070
	F_2		0.467	0.434	0.394	0.672	0.020	0.143

*, ** Significant at 5% and 1% levels, respectively

Table 2. Estimation of general combining ability (*gca*) effects of parents in cowpea

Parents	Number of pods per cluster		Pod length		Number of seeds per pod		Branches per plant		Number of pods per plant		Number of clusters per plant	
	F_1	F_2	F_1	F_1	F_2	F_1	F_1	F_2	F_1	F_2	F_1	F_2
IT 389561	0.08	0.32**	-0.32**	-0.03	0.90**	0.65**	0.67**	0.45**	2.77**	2.26**	0.83**	0.04
RC 101	0.07	-0.04	-0.96**	-0.10	0.17	0.66**	0.59**	0.40**	0.84**	0.91**	0.14	0.39**
Pusa Phalguni	0.01	-0.06	0.61**	-0.26*	0.01	0.63**	-0.04	0.38**	-0.60**	-0.23	-0.28**	0.04
KM 5	-0.21**	-0.09	0.20	-0.48**	-0.32**	0.33**	-0.10*	0.12	-0.92**	-0.35	0.14	0.06
GC 1	0.09*	0.32**	-0.41**	0.60**	0.60**	-0.01	-0.05	-0.51**	0.56**	0.84**	0.05	-0.32**
GC 2	0.06	-0.11*	0.61**	-1.44**	0.15	-1.22**	-0.13**	0.03	0.00	-0.92**	-0.16	0.02
GC 4	-0.07	-0.01	-0.42**	-0.21	-0.54**	0.59**	-0.01**	0.25**	-0.75**	1.64**	-0.10	0.61**
GC 5	-0.07	0.00	0.45**	-0.52**	0.21*	0.50**	-0.26	-0.10	-0.85**	0.69**	-0.19*	0.24**
Pant Lobia 1	-0.02	-0.21**	-0.08	1.30**	0.23*	-0.98**	-0.23**	-0.48**	-0.13	-2.31**	0.02	-0.41**
Pant Lobia 2	0.06	-0.12*	0.32**	1.14**	0.52**	-1.15**	-0.44**	-0.54**	-0.92**	-2.52**	-0.45**	-0.68**
S. E. (gi) ±	0.047	0.049	0.111	0.121	0.102	0.116	0.046	0.061	0.180	0.227	0.091	0.081
S. E. (gi - gj) ±	0.070	0.073	0.166	0.181	0.152	0.173	0.069	0.091	0.269	0.338	0.135	0.120

Parents	Number of pods per cluster		Pod length		Number of seeds per pod		100-seed weight		Seed yield per plant		Protein content		Harvest index (%)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
IT 389561	0.08	0.32**	-0.32**	-0.03	0.90**	0.65**	-0.52**	-0.47**	1.08**	0.52**	0.39**	0.22	0.05	0.77
RC 101	0.07	-0.04	-0.96**	-0.10	0.17	0.66**	-0.92**	-0.58**	0.89**	0.59**	0.27**	-0.21	1.03**	0.01
Pusa Phalguni	0.01	-0.06	0.61**	-0.26*	0.01	0.63**	-0.21	-0.47**	0.08	1.53**	-0.33**	-0.31	0.58*	-0.56
KM 5	-0.21**	-0.09	0.20	-0.48**	-0.32**	0.33**	-0.22	-1.15**	0.12	0.29*	-0.28**	0.31	-0.96**	0.94
GC 1	0.09*	0.32**	-0.41**	0.60**	0.60**	-0.01	-0.29*	-1.24**	0.36*	-2.22**	-0.01	-0.11	-0.54	-0.73
GC 2	0.06	-0.11*	0.61**	-1.44**	0.15	-1.22**	0.38**	0.56**	0.10	1.40**	0.24*	0.15	0.47	0.59
GC 4	-0.07	-0.01	-0.42**	-0.21	-0.54**	0.59**	0.45**	1.06**	-0.36*	1.79**	-0.36**	0.29	-1.23**	0.85
GC 5	-0.07	0.00	0.45**	-0.52**	0.21*	0.50**	0.22	0.35*	-0.69**	1.24**	0.21*	-0.02	-0.08	0.74
Pant Lobia 1	-0.02	-0.21**	-0.08	1.30**	0.23*	-0.98**	0.11	1.27**	-0.66**	-2.81**	-0.24*	0.02	0.96**	-1.55**
Pant Lobia 2	0.06	-0.12*	0.32**	1.14**	0.52**	-1.15**	0.99**	0.68**	-0.93**	-2.34**	0.11	-0.33	-0.29	-1.07*
S. E. (gi) ±	0.047	0.049	0.111	0.121	0.102	0.116	0.142	0.139	0.173	0.143	0.098	0.175	0.279	0.478
S. E. (gi - gj) ±	0.070	0.073	0.166	0.181	0.152	0.173	0.212	0.207	0.258	0.213	0.147	0.261	0.417	0.712

*, ** Significant at 5% and 1% levels, respectively

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Table 3. Best parents for *per se* and GCA, best cross combinations for *per se* and SCA with maximum heterobeltiosis and standard heterosis for various characters in cowpea

Characters	GCA		SCA	
	F_1	F_2	F_1	F_2
Days to 50% flowering	GC 2	Pusa Phalguni	Pusa Phalguni x GC 5	IT 389561 x GC 5
	GC 4	GC 4	GC 5 x Pant Lobia 1	KM 5 x Pant Lobia 2
Days to maturity	GC 4	GC 2	KM 5 x Pant Lobia 2	GC 1 x GC 4
	GC 2	Pusa Phalguni	GC 2 x GC 5	RC 101 x Pant Lobia 1
Plant height (cm)	GC 4	GC 2	GC 4 x Pant Lobia 1	Pusa Phalguni x GC 4
	Pant Lobia 2	GC 5	Pusa Phalguni x Pant Lobia 2	KM 5 x GC 2
Branches per plant	IT 389561	IT 389561	KM 5 x GC 5	Pusa Phalguni x KM 5
	RC 101	RC 101	Pusa Phalguni x GC 2	IT 389561 x RC 101
Number of pods per plant	IT 389561	IT 389561	GC 4 x Pant Lobia 2	KM 5 x GC 5
	RC 101	GC 4	Pusa Phalguni x GC 2	IT 389561 x GC 2
Number of clusters per plant	IT 389561	GC 4	Pusa Phalguni x GC 2	KM 5 x GC 5
	KM 5	GC 5	RC 101 x Pant Lobia 1	GC 1 x GC 2
Number of pods per cluster	GC 1	IT 389561	GC 1 x Pant Lobia 2	GC 2 x GC 4
	IT 389561	GC 1	RC 101 x GC 4	IT 389561 x GC 1
Pod length	Pusa Phalguni	Pant Lobia 1	GC 1 x GC 5	GC 5 x Pant Lobia 1
	GC 2	Pant Lobia 2	Pant Lobia 1 x Pant Lobia 2	GC 2 x GC 4
Number of seeds per pod	IT 389561	RC 101	Pusa Phalguni x Pant Lobia 2	RC 101 x Pusa Phalguni
	GC 1	IT 389561	GC 4 x Pant Lobia 2	GC 2 x GC 5
100 seed weight (%)	Pant Lobia 2	Pant Lobia 1	GC 1 x GC 5	GC 1 x GC 5
	GC 4	GC 4	GC 1 x GC 2	GC 1 x GC 4
Seed yield per plant (g)	IT 389561	GC 4	GC 4 x Pant Lobia 2	P7 x GC 5
	RC 101	Pusa Phalguni	GC 2 x GC 5	GC 1 x GC 5
Protein content (%)	IT 389561	KM 5	RC 101 x KM 5	RC 101 x GC 2
	RC 101	GC 4	RC 101 x GC 4	Pusa Phalguni x GC 4
Harvest index (%)	RC 101	KM 5	RC 101 x Pant Lobia 1	IT 389561 x GC 2
	Pant Lobia 1	GC 4	GC 2 x GC 5	KM 5 x GC 5

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Table 4. Specific combining ability effects of hybrids for different characters in cowpea

Best cross combinations	Seed yield per plant		Days to 50% flowering		Days to maturity		Plant height (cm)		Branches per plant		Number of pods per plant		Number of clusters per plant	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
IT 389561 x KM 5	3.25**	1.33**	1.44	-3.89**	2.71**	3.33**	-0.61	2.68**	0.49**	0.52**	3.94**	-2.57**	-0.19	-0.43
IT 389561 x GC 4	3.26**	4.04**	2.50**	-1.91	0.18	-0.41	-0.61	-1.09	0.28	-0.12	3.28**	-0.71	-0.07	-0.56*
KM 5 x GC 5	2.15**	1.54**	-0.03	0.55	-1.42	-0.74	3.45**	-2.88**	1.52**	-0.36	-0.91	4.48**	-0.52	1.59**
GC 2 x GC 5	5.12**	2.77**	-0.44	-1.16	-4.45	0.08	-1.03	-6.53**	-0.41*	-0.18	4.43**	2.23*	-0.54	0.03

Best cross combinations	Number of pods per cluster		Pod length		Number of seeds per pod		100-seed weight		Protein content		Harvest index (%)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
IT 389561 x KM 5	0.57**	-0.24	0.15	-0.07	0.24	1.31**	-1.21**	-1.29**	-1.23**	0.61	-0.33	-1.68**
IT 389561 x GC 4	0.45	0.13	-2.26**	-0.67	-3.00**	0.02	1.19*	-0.04	0.48	-3.05**	0.15	-2.17**
KM 5 x GC 5	0.05	0.03	-1.51**	-1.10**	1.29**	1.06*	-5.18**	1.78**	1.19**	-0.32	4.58**	3.40**
GC 2 x GC 5	0.93**	0.32**	-0.72*	1.42**	1.82**	1.79**	1.79**	-1.34**	-0.17	0.18	6.23**	1.58**

*, ** Significant at 5% and 1% levels, respectively