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Diallel analysis for combining ability in cowpea (*Vigna unguiculata* (L.) Walp)

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Abstract
The present investigation involving 7 parents and 21 crosses in diallel design in grown in a randomized block design was carried out during 2014-2015 at G.B. Pant University of agriculture and Technology, Pantnagar. Analysis of variance revealed significant mean squares of general and specific combining abilities for all the traits studied. Pant lobia-2, Pant Lobia-3 and Pant Lobia-5 had good GCA for seed yield per hectare. Pant Lobia-1 was best general combiner for number of pods per plant and 100-seed weight whereas; Pant Lobia-2 for number of pods per plant, seed weight per plant, seed yield per hectare. Pant Lobia-3 for seed yield per hectare, seed weight per plant, and days to pod maturity; Pant Lobia-5 for plant height, seed yield per hectare, 100-seed weight, seed weight per plant ; PGCP-59 and PGCP-63 were for plant height; PVCP-20 for green pod weight per plant and pod length.

Keywords: Cowpea, diallel, gca, sca and yield

Introduction
Cowpea has a number of common names including crowder pea, black eyed pea and southern pea (Verdcourt, 1970) [6] and is generally called beans in Nigeria. The most commonly used designs for combining ability studies are line x tester (L x T) and diallel analysis. Combining ability analysis following line x tester given by Kempthorne (1957) [1] and Imric and Bray (1983) [2] is frequently used for testing the performance of lines in hybrid combinations. It is also useful in characterizing the nature and magnitude of gene action involved in controlling the quantitative traits a high genetic advance. Mishra *et al*. (1987) [3] reported that both general and specific combining ability were important for days to 50% flowering and seed yield with G.C.A. more important for days to 50% flowering and SCA more important for seed yield. Narrow sense heritability 52.7% for days to 50% flowering and 27.9% for seed yield were recorded. Analysis of variance revealed significant mean square due to G.C.A. as well as S.C.A. for all the characters. (Patel *et al.*, 2013) [4].
Diallel cross analysis technique has been found one of the best biometrical techniques for the identification of the lines possessing a built-in genetic potential for superior performance in hybrid combinations. Pal *et al.*, (2007) [5]. These analyses also permit the classification of parental lines in terms of their combining ability in hybrids and throw light on genetic architecture of parents and offsprings for different characters, which is very much essential to formulate a sound breeding programme and for the selection of appropriate breeding methods for the genetic improvement in the traits of economic interest. The practical utility of this technique has not been adequately tested for the genetic improvement in green pod yield of cowpea.

Materials and Methods
The 21 F1's were obtained by crossing 7 genotypes in diallel design during 2014-15 grown in a randomized block design with three replications at Breeder Seed Production Center of G. B. Pant University of Agriculture & Technology, Pantnagar. Each genotype was sown in three rows with row to row spacing (45 cm) and plant to plant (20 cm) respectively. The experiment was conducted under irrigated conditions. Recommended crop production and protection practices were followed to raise a good crop. The observations were recorded on five plants from each replication. The general combining ability (GCA) effects of parents and specific combining ability (SCA) effects of hybrids were worked out as suggested by Kempthorne (1957) [1].

Results and Discussion

The relative estimates of variances due to general combining ability effects (GCA) and specific combining ability effects (SCA) for various characters under study are given in Table 1. The variances due to general combining ability and specific combining ability were found to be significant for all the characters. In present study significant and negative GCA effects were considered desirable for days to 1st flowering, plant height and days to pod maturity. The best general combiner for number of pods per plant and 100-seed weight was Pant Lobia-1 whereas, Pant Lobia-2 for number of pods per plant, seed weight per plant and seed yield per hectare. The parent Pant Lobia-3 had good general combining ability for seed yield per hectare, seed weight per plant, and days to pod maturity whereas, Pant Lobia-5 was good general combiner for plant height, seed yield per hectare, 100-seed weight and seed weight per plant whereas, PGCP-59 and PGCP-63 were good general combiners for plant height whereas, PVCP-20 was a good combiner for green pod weight per plant and pod lengths (Table-2.)

Specific combing ability analysis indicated that the cross Pant Lobia- 3 x Pant Lobia-2 was the best cross combination for days to 1st flowering, while and cross PGCP-63 x PVCP-20 showed the highest value for pod length, cross Pant Lobia-3 x Pant Lobia-2 for number of seeds per pod. Cross PVCP-20 x Pant Lobia-5 gave the highest positive SCA effect for green pod weight per plant while cross Pant Lobia-2 x Pant Lobia-1 was the best cross combination for green pod yield per plant, seed weight per plant, and for days to pod maturity, PVCP-20 x Pant Lobia-3 was the best cross combination. Cross Pant Lobia-3 x Pant Lobia-1 was found to be best combination for 100-seed weight and Pant Lobia-5 x Pant Lobia-1 was the best cross combination for plant height. Thus, these crosses could be judged as outstanding crosses for simultaneous improvement of seed yield and one or more component characters (Table-3).

Table 1: Analysis of variance for gca and sca effects

Source of variation	d.f.	Mean square										
		Days to 1st flowering	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Green pod weight per plant (g)	Green pod yield per plant (g/plant)	Days to pod maturity	Seed weight per plant (g)	100-Seed weight (g)	Plant height (cm)	Seed yield per hectare (q/ha)
GCA	6	11.039**	36.721**	77.747**	11.463**	78.641**	24757.483**	18.301**	19.843**	13.137**	118.942**	36.721**
SCA	21	4.718**	22.721**	1.58**	3.397**	14.763**	20766.591**	5.823**	10.367**	4.746**	15.162**	22.794**
Error	54	0.297	0.281	0.017	0.033	0.0895	0.131	0.1852	0.0427	0.608	0.608	0.09

** Significant at 1% probability level
* Significant at 5% probability level

Table 2: Estimation of general combining ability effects of parents

Name of parents	Mean square										
	Days to 1st flowering	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Green pod weight per Plant (g)	Green pod yield per plant (g/plant)	Days to pod maturity	Seed weight per plant (g)	100-Seed weight (g)	Plant height (cm)	Seed yield (q/ha)
Pant Lobia-1	-0.41*	1.91**	-1.20**	-2.00**	-2.06**	35.03	0.57**	-0.85**	1.39**	1.67**	-0.80**
Pant Lobia-2	2.10**	3.03**	-0.22**	1.05**	-0.14**	96.87**	1.57**	0.59**	-0.30**	1.22**	1.03**
Pant Lobia-3	-0.20*	-2.09**	-0.81**	0.75**	-076**	-69.62**	-1.79**	1.13**	-0.35**	0.187**	1.84**
Pant Lobia-5	-0.91**	0.53**	-0.29**	1.24**	-0.31**	29.83**	-1.95**	2.21**	1.74**	-1.86**	3.05**
PGCP-59	-0.87**	-0.34**	-1.92**	-0.49**	-1.34**	-15.81**	0.14	-1.56**	-0.14	-1.36**	-1.93**
PGCP-63	-0.60**	-0.45**	-2.03**	-0.42**	-1.88**	-25.04**	0.20*	-1.85**	-1.82**	-1.04**	-1.50**
PVCP-20	0.90**	-2.58**	6.47**	-0.13*	6.49**	-27.06**	1.54**	0.34**	-0.52**	-6.11**	-1.72**
SEM± (gi)	0.41	0.13	0.1	0.14	0.23	0.27	0.32	0.16	0.19	0.59	0.23

** Significant at 1% probability level
* Significant at 5% probability level

Table 3: Table showing general combiner and specific combining ability cross combinations

S. No.	Characters	General combiner	Specific cross combination
1	Days to 1st flowering	Pant lobia-1, Pant Lobia-3, Pant lobia-5 PGCP-59 and PGCP-63	Pant Lobia-3 x Pant Lobia-2, Pant Lobia-5 x Pant Lobia-2, PVCP-20 x Pant Lobia-1, PGCP-59 x Pant Lobia-2
2	Number of pods per plant	Pant Lobia-1, Pant Lobia-2, Pant Lobia-3, and Pant lobia-5	Pant Lobia-2 x Pant Lobia-1, PGCP-59 x Pant Lobia-5, Pant Lobia-5 x Pant Lobia-2, PVCP-20 x Pant Lobia-3
3	Pod length (cm)	PVCP-20	Pant Lobia-3 x Pant Lobia-1, Pant Lobia-5 x Pant Lobia-2, PVCP-20 x PGCP-63, PVCP-20 x Pant Lobia-1
4	Number of seeds per pods	Pant Lobia-2, Pant Lobia-3, and Pant lobia-5	Pant Lobia-3 x Pant Lobia-2, Pant Lobia-3 x Pant Lobia-1, PGCP-59 x Pant Lobia-5, PGCP-63 x Pant Lobia-5
5	Green pod weight per plant (g)	Pant lobia-5	PVCP-20 x Pant Lobia-5, PGCP-59 x Pant Lobia-5, PGCP-63 x PGCP-59, Pant Lobia-5 x Pant Lobia-2
6	Green pod yield per plant (g/plant)	Pant Lobia-2 and Pant lobia-5	Pant Lobia-2 x Pant Lobia-1, PGCP-63 x PGCP-59, Pant Lobia-5 x Pant Lobia-2, PVCP-20 x Pant Lobia-2
7	Days to pod maturity	Pant Lobia-3 and Pant lobia-5	PVCP-20 x Pant Lobia-3, Pant Lobia-5 x Pant Lobia-2, PGCP-59 x Pant Lobia-2
8	Seed weight per plant (g)	Pant Lobia-2, Pant lobia-5 Pant lobia-3 and PVCP-20	Pant Lobia-2 x Pant Lobia-1, PVCP-20 x PGCP-59, PVCP-20 x PGCP-63, Pant Lobia-5 x Pant Lobia-2,

9	100-Seed weight (g)	Pant Lobia-1 and Pant lobia-5	Pant Lobia-3 x Pant Lobia-1, Pant Lobia-3 x Pant Lobia-2, Pant Lobia-5 x Pant Lobia-2, PGCP-59 x Pant Lobia-3
10	Plant height (cm)	Pant lobia-5,PGCP-59, PGCP-63 and PVCP-20,	PGCP-59 x Pant Lobia-1, PVCP-20 x PGCP-59, PGCP-63 x Pant Lobia-3
11	Seed yield per hectare (q/ha)	Pant lobia-2, Pant Lobia-3 and Pant lobia-5	Pant Lobia-2 x Pant Lobia-1, PGCP-63 x Pant Lobia-5, PVCP-20 x Pant Lobia-2, Pant Lobia-3 x Pant Lobia-1

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