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Combining ability studies in cowpea

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Abstract
Combining ability was studied in 6 x 6 diallel set (excluding reciprocals) of cowpea for pod yield and its eleven component characters. Both gca and sca variances were highly significant. The higher magnitude of gca variance compared to sca variance indicated preponderance of additive gene effects for the inheritance of all the characters studied. Parents, Chikhali Local and Kashi Kanchan were identified as good general combiners for pod yield and its contributing traits. Majority of their crosses had also manifested significant and desirable sca effects for pod yield per plant. Out of fifteen crosses, six hybrids displayed significant and desirable sca effects for pod yield per plant. Of these Chikahli Local x Pusa Phalguni, Gadchiroli 4 x GADCP 3 and Chikhali Local x Pusa Komal had exhibited high positive sca effects for the trait. An analysis of crosses revealed majority of the superior crosses were involved high x low and in few cases high x high or low x low general combiners.

Keywords: Cowpea, combining ability, diallel cross

Introduction
In a crop improvement programme, the success rests upon isolation of valuable gene combinations as determined in the form of lines with high combining ability. The lines which produce good progenies on crossing are most desired by a plant breeder. The knowledge of gene action and combining ability not only helps in identifying the best combiners which may be hybridized either to exploit heterosis or to accumulate fixable genes through selection but also helps in understanding the inheritance of quantitative characters, so as to choose the proper selection method to be followed in future breeding programmes. There are only few reports available on these aspects of cowpea. The present investigation was, therefore, undertaken to study the combining ability effects and variance using 6 x 6 diallel (excluding reciprocals) in cowpea.

Material and method
The experimental material consisted of six diverse genotypes viz., Chikhali Local, Gadchiroli 4, GADCP 3, Pusa Komal, Pusa Phalguni and Kashi Kanchan crossed in half diallel fashion to secure fifteen F_1 s (for studying combining ability). The crosses along with their respective parents were sown in randomized block design replicated thrice at the Main garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during kharif 2012 and summer 2013. Data were recorded on plant height, days to 50% flowering, days to first pod picking, pod length, peduncle per plant, pods per peduncle, pods per plant, seeds per pod, 100 seed weight and pod yield per plant.
The statistical analysis was performed for analysis of variance as per the methodology suggested by Fisher (1918) [1] and analysis for gca and sca effects by model 1 (fixed effect model) and method 2 (parents and one set of crosses excluding reciprocals) as described by Griffing's (1956) [2].

Results and Discussion
The analysis of variance for combining ability for different characters (Table 1) revealed highly significant gca and sca for all the characters, these suggested the role of both additive and non-additive genetic components in the expression of all the characters. However, higher magnitude of gca variances over sca variances for all the traits indicated that the additive component of genetic variance was predominantly involved in the expression of yield and its attributing characters. Similar results were reported by and Patil and Navale (2006) [9],

Uma and Kalubowila (2010) [11] and Patel *et al*. (2013) [7]. It is evident from these observations that breeding for high yielding varieties in cowpea may become more effective if additive gene effects are more appropriately exploited along with non additive gene effects. In cowpea it could be achieved by the use of good general combining parents in hybridization and selecting desirable segregants from the segregating generations by adopting progeny selection technique meant for exploiting additive genetic variance. Adoption of progeny selection technique for exploiting additive genetic variance in cowpea was also suggested by Ushakumari *et al*. (2005) and Moninuala *et al.* (2013) [6].

Estimate of gca effects for parents (Table 2) indicated that, Chikhali Local was the good combiner for major yield attributing characters like plant height, pod length, pod diameter, seeds per pod, 100 seed weight and pod yield per plant. Parent Kashi Kanchan was found to be good general combiner for plant height, days to first pod picking with negative significant gca effect which is preferred, pod length, pod diameter, peduncle per plant, pods per plant, seeds per pod and pod yield per plant. The parent Pusa Phalguni was good general combiners for plant plant height, days to 50 % flowering, days to first pod picking, peduncle per plant, pods per peduncle, pods per plant and pod yield per plant. It was also generally observed for most of the characters that parents exhibiting high mean performance had high gca effects. A close relationship between the mean performance and gca effects was also reported by Hazra *et al*. (1996) [3], Kwaye *et al.* (2008) [7], Patel *et al.* (2010) [8] in cowpea.

Specific combining ability effects is the index to determine the usefulness of particular cross in the exploitation of heterosis. The significant sca effect observed in different crosses for different characters (Table 3) had the combination of high x high, high x low, low x high and low x low combining parents. It is important to note that among the crosses showing significant sca in desirable direction in respect to all the traits either involved or did not involved one or both the parents as good general combiners for the concerned trait. This indicated that non- additive type of gene action, which are not fixable were involved in these crosses.

Out of fifteen crosses studied, the six F_1 Crosses viz., Chikhali Local x Gadchiroli 4, Chikhali Local x Pusa Komal, Chikali Local x Pusa Phalguni, Gadchiroli 4 x GADCP 3, Gadchiroli 4 x Pusa Phalguni and GADCP 3 x Pusa Komal exhibited significant positive sca effect for pod yield plant. Out of these crosses besides pod yield per plant, the cross Chikhali Local x Gadchiroli 4 also exhibited significant sca effect for plant height, pods per peduncle, pods per plant. Similarly, Chikhali Local x Pusa Komal besides pod yield also recorded significant positive sca effects for pod length, peduncle per plant, pods per peduncle, pods per plant and 100 seed weight, Chikhali Local x Pusa Phalguni for days to first pod picking, pod length, peduncle per plant, pods per peduncle, pods per plant, seeds per pod and 100 seed weight, Gadchiroli 4 x GADCP 3 for plant height, days to first pod picking, pods per peduncle, pods per plant, seeds per pod, Gadchiroli 4 x Pusa Phalguni for pod length, peduncle per plant, pods per peduncle, pods per plant, seeds per pod, 100 seed weight and GADCP 3 X Pusa Komal for days to first pod picking, pod length, pod diameter, pods per peduncle, pods per plant, seeds per pod. On the basis of sca effect these five crosses Chikhali Local x Pusa Phalguni, Chikhali Local x Gadchiroli 4, Chikhali Local x Pusa Komal, Gadchiroli 4 x Pusa Phalguni and Gadchiroli 4 x GADCP 3 were identified as superior crosses, similar type of results were also reported by Kwaye *et al*. (2008) [4], Uma and Kalubowila (2010) [11], Patel *et al.* (2013) [7].

It is clear from the results that in majority of the crosses good sca effects were observed. Most of the crosses included high x low, high x high, low x low and high x low type of general combiners. The desirable cross combination with average x average type of general combiners were also obtained, which may be due to complimentary gene effects. The low x low type of general combiners, which may be due to complimentary gene effects. The crosses involving parents with good gca effects can be exploited effectively by conventional breeding procedure like pedigree method. However, the crosses involving one good combiner and other average or low combiner could produce desirable transgressive segregants if additive genetic system was operative in good combining parents and epistatic effects also act in the same direction. Similar results were also reported by Patel *et al*. (2013) [7], Sawant (1995) [10], Hazra *et al*. (1996) [3] and Manivannan and Sekar (2005) [5].

Table 1: Analysis of variance for combining ability

Source of Variations	d.f.	Mean Sum of Squares					
		Plant Height (cm)	Days to 50 percent flowering	Days to first pod picking	Pod length (cm)	Pod diameter (cm)	Peduncle per plant
GCA	5	70.589 **	16.727 **	61.951 **	35.889 **	0.012 **	4.404 **
SCA	15	10.525 **	2.622 **	4.812 **	8.088 **	0.003 **	1.717 **
Error	40	0.044	1.038	0.010	0.059	0.00014	0.008

Source of Variations	d.f.	Mean Sum Squares				
		Pods per peduncle	Pods per plant	Seeds per pod	100 seed weight (g)	Pod yield per plant (g)
GCA	5	0.176 **	142.226**	4.154 **	2.006 **	8815.630 **
SCA	15	0.103 **	31.971 **	0.616 **	0.599 **	4180.289 **
Error	40	0.001	0.281	0.001	0.00012	12.988

* Significant at 5 percent
** Significant at 1 percent

Table 2: General combining ability estimates of parents

Sr. No.	Parents	Plant Height (cm)	Days to 50 percent flowering	Days to first pod picking	Pod length (cm)	Pod diameter (cm)	Peduncle per plant
1.	Chikhali Local	1.294**	1.714**	3.678**	1.788**	0.017**	-0.159**
2.	Gadchiroli 4	-0.451**	1.210**	2.205**	0.969**	0.005	0.549**
3.	GADCP 3	-5.821**	0.385	0.359**	1.225**	0.012**	-1.051**
4.	Pusa Komal	1.522**	-2.287**	-4.270**	-2.170**	-0.022**	-0.558**
5.	Pusa Phalguni	1.551**	-0.786*	-1.089**	-3.191**	-0.062**	0.975**
6.	Kashi Kanchan	1.906**	-0.237	-0.883**	1.379**	0.050**	0.245**
	S.E.(gi)	0.068	0.329	0.033	0.079	0.004	0.029
	S.E. (gi-gj)	0.105	0.329	0.051	0.122	0.006	0.044

Sr. No.	Parents	Pods per peduncle	Pods per plant	Seeds per pod	100 seed weight (g)	Pod yield per plant (g)
1.	Chikhali Local	-0.088**	-1.824**	0.761**	0.436**	41.706**
2.	Gadchiroli 4	-0.067**	0.085	0.369**	0.286**	-2.398*
3.	GADCP 3	-0.147**	-5.323**	0.266**	0.257**	-51.657**
4.	Pusa Komal	0.034**	-1.082**	-0.379**	0.021**	-21.741**
5.	Pusa Phalguni	0.274**	7.455**	-1.267**	-0.956**	12.433**
6.	Kashi Kanchan	-0.007	0.688**	0.250**	-0.044**	21.656**
	S.E.(gi)	0.009	0.171	0.012	0.003	1.163
	S.E. (gi-gj)	0.015	0.265	0.018	0.005	1.802

* Significant at 5 percent
** Significant at 1 percent

Table 3: Specific combining ability estimates of crosses

Sr. No.	Crosses	Plant Height (cm)	Days to 50 percent flowering	Days to first pod picking	Pod length (cm)	Pod diameter (cm)	Peduncle per plant
1.	Chikhali Local x Gadchiroli 4	1.488**	3.337**	0.025	-0.824**	0.019	-1.012**
2.	Chikhali Local x GADCP 3	5.128**	1.382	-0.290**	-0.519**	0.017	-0.672**
3.	Chikhali Local x Pusa Komal	-1.315**	-1.756	1.705**	2.221**	-0.024*	0.364**
4.	Chikhali Local x Pusa Phalguni	-1.804**	-1.347	-1.176**	2.917**	0.023	0.702**
5.	Chikhali Local x Kashi Kanchan	-1.234**	-0.101	0.843**	-0.628**	-0.036**	0.387**
6.	Gadchiroli 4 x GADCP 3	3.224**	1.916*	-1.612**	-0.311	-0.006	-0.661**
7.	Gadchiroli 4 x Pusa Komal	-2.499**	-1.522	-2.892**	2.449**	-0.017	-0.274**
8.	Gadchiroli 4 x Pusa Phalguni	-1.213**	-0.998	0.517**	2.650**	0.018	0.694**
9.	Gadchiroli 4 x Kashi Kanchan	-0.898**	-1.547	1.206**	-0.385	-0.044**	0.124
10.	GADCP 3 x Pusa Komal	-4.414**	0.048	-0.987**	1.444**	0.041**	-0.159*
11	GADCP 3 x Pusa Phalguni	-3.378**	0.822	0.713**	2.330**	0.046**	-1.251**
12	GADCP 3 x Kashi Kanchan	-4.638**	0.278	1.567**	-1.840**	-0.051**	-2.876**
13	Pusa Komal x Pusa Phalguni	1.334**	-0.471	-2.428**	-0.330	0.056**	-1.199**
14.	Pusa Komal x Kashi Kanchan	-1.511**	-0.160	-3.494**	-4.340**	-0.037**	-0.489**
15.	Pusa Phalguni x Kashi Kanchan	-0.120	0.109	-2.510**	-4.508**	-0.102**	1.088**
	S.E. (Sij)	0.186	0.903	0.090	0.216	0.011	0.079
	S.E. (Sij-Sik)	0.277	1.348	0.134	0.323	0.016	0.117
	S.E. (Sij-Skl)	0.257	1.248	0.124	0.299	0.015	0.109

Sr. No.	Crosses	Pods per peduncle	Pods per plant	Seeds per pod	100 seed weight (g)	Pod yield per plant (g)
1.	Chikhali Local x Gadchiroli 4	0.414**	4.171**	-0.167**	-0.226**	46.089**
2.	Chikhali Local x GADCP 3	-0.086**	-2.661**	0.721**	-0.202**	-3.414
3.	Chikhali Local x Pusa Komal	0.173**	3.827**	-0.039	0.039**	51.505**
4.	Chikhali Local x Pusa Phalguni	0.178**	4.912**	0.913**	1.006**	96.548**
5.	Chikhali Local x Kashi Kanchan	-0.021	0.327	-0.119**	0.114**	-0.605
6.	Gadchiroli 4 x GADCP 3	0.582**	7.791**	0.253**	-0.247**	56.442**
7.	Gadchiroli 4 x Pusa Komal	-0.194**	-3.527**	-0.067*	-0.016	-20.802**
8.	Gadchiroli 4 x Pusa Phalguni	0.096**	3.968**	1.035**	0.971**	47.400**
9.	Gadchiroli 4 x Kashi Kanchan	-0.463**	-7.841**	0.298**	0.059**	-78.482**
10.	GADCP 3 x Pusa Komal	0.392**	5.797**	0.271**	-0.015	31.673**
11	GADCP 3 x Pusa Phalguni	-0.003	-3.775**	-0.097**	0.959**	-11.239**
12	GADCP 3 x Kashi Kanchan	-0.183**	-9.548**	-0.809**	0.043**	-92.302**
13	Pusa Komal x Pusa Phalguni	0.001	-3.625**	0.203**	0.718**	-7.655*
14.	Pusa Komal x Kashi Kanchan	0.237**	2.366**	-1.029**	-0.196**	-20.208**
15.	Pusa Phalguni x Kashi Kanchan	0.155**	5.887**	-1.226**	-1.839**	-37.118**
	S.E. (Sij)	0.026	0.469	0.033	0.010	3.194
	S.E. (Sij-Sik)	0.039	0.701	0.049	0.014	4.767
	S.E. (Sij-Skl)	0.036	0.649	0.045	0.013	4.414

* Significant at 5 percent
** Significant at 1 percent

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