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COMBINING ABILITY STUDIES INVOLVING MALE STERILE LINES IN PIGEONPEA

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ABSTRACT

Combining ability and genetic variance for nine quantitative traits in pigeonpea (*Cajanus cajan* (L.) Millsp.) were estimated through line x tester analysis involving three male-sterile lines, 18 pollinators and 54 F_1 hybrids. The male-sterile lines and pollinators differed for their GCA for almost all the characters. Additive gene effects were predominant for the inheritance of plant height, pods per plant and seed size, whereas non-additive gene effects appeared to be more important for rest of the characters. Among females ms Prabhat (DT) was a good combiner for early maturity, plant height, number of primary branches, seeds per pod, seed size and grain yield. Pollinators such as AL 688 and AF 276 were observed to be high combiners for early maturity, heigher number of pods and higher grain yield. The three top yielding hybrids viz. PMS 1 x AF 276, ms Prabhat (DT) x AL 688 and PMS 1 x AL 201 also exhibited high SCA effects for seed yield and these experimental hybrids involved parents with high GCA effects.

Key Words : *Cajanus cajan*, line x tester, male sterility, pigeonpea

IN addition to the presence of sufficient amount of cross-pollination and heterosis, the discovery of stable genetic male sterility and development of efficient hybrid seed production technology (Verma and Sidhu, 1995) have made commercial production of hybrids practical in pigeonpea. For the development of superior hybrids, it is mandatory for the breeders to isolate desirable genotypes that will contribute favourable genes or combination of genes for yield and other agronomic traits. A line x tester analysis provides useful information about combining ability of parental lines to be used in hybrid programme, besides identifying superior cross combinations. The present study is an attempt to determine the general (GCA) and specific (SCA) combining ability of three genetic male-sterile lines, 18 pollinators and 54 F_1 hybrids for nine quantitative traits.

MATERIALS AND METHODS

The experimental material comprised of three genetic male sterile lines viz. ms Prabhat (DT), IMS-1 and PMS-1 (a variant of line QMS 1 described by Wallis *et al.*, 1981 for anther type. This line has white, translucent, normal shaped anthers in contrast to brown, shrivelled, arrow head shaped ones of original QMS 1), used as females (lines) and 18 diverse genotypes, namely, AL 13, AL 31, AL 101, AL 201, AL 227, AL 230, AL 259, AL 344, AL 587, AL 600, AL 601, AL 688, AF 98, AF 276, ICPL 151, ICPL 83006, ICPL 88001, and H 82-1, differing in plant type, maturity and other traits, used as males (testers). Fifty four crosses along with 21 parental lines, were grown in three randomized complete blocks, at Punjab Agricultural University, Ludhiana during *kharif*, 1993. The fertile sibs in the male-sterile lines were used to represent female lines. Seeds of each entry were grown in single row of 4 meter length at 50x25 cm spacings. The data recorded on five random competitive plants were used for statistical analysis. The combining ability analysis was done following Kampthorne (1957).

RESULTS AND DISCUSSION

Highly significant differences among male-sterile lines as well as pollinators (Table 1) indicated that the females and males, used to develop the crosses under study, differed for GCA for all the characters except number of pods per plant in case of female lines. The non-significant differences for number of pods could obviously be due to the fact that in the course of development of these male-sterile lines, variability for pods per plant may not have been considered. Similarly, the hybrids also differed significantly with respect to SCA for all the traits, as revealed by the significance of interaction between female and male parents.

In view of the small number of male-sterile lines used in this study, the variance components due to GCA were computed only for the pollinators. The estimates of variance components due to GCA and SCA have clearly revealed that the inheritance of plant height, pods per plant and seed size was predominantly under the control of additive gene effects. Previous reports by Saxena *et al.*, (1981); Sidhu *et al.*, (1981) and Sidhu *et al.* (1996) for plant height and seed size and by Patel *et al.* (1987) for pods per plant also indicated predominance of additive gene effects. Non-additive gene effects appeared to be more important for the inheritance of days to 50% flowering, days to maturity, number of primary and secondary branches, seeds per pod and grain yield. These results are in agreement with earlier findings of Sidhu *et al.*, (1981); Batta *et al.*, (1986) and Patel *et al.*, (1992) for days to maturity, number of primary branches, seeds per pod and grain yield. However, there are conflicting reports in literature on the nature of gene effects controlling the inheritance of all the characters studied here. The exact cause of such differences is not known, but it could be related to the genetic architecture of the material used, mating system, method of evaluation and the test environment (Saxena *et al.*, 1981).

The estimated GCA effects of females and males (Table 2) revealed that among females, ms Prabhat (DT) appeared to be good general combiner for early maturity, plant height, number of primary branches, seeds per pod, 100-seed weight and grain yield per plant. The same male-sterile line has been reported to be a good general combiners for

Table 1. Analysis of variance for combining ability for nine quantitative traits in pigeonpea.

Source	*d.f*	*Days to 50% flowering*	*Days to maturity*	*Plant height*	*Primary branches per plant*	*Secondary branches per plant*	*Pods per plant*	*Seeds per pod*	*100 seed weight*	*Grain yield*
Replications	2	5.60*	0.70	389.00	23.52**	41.46**	7300.13*	0.04	0.02	687.46**
Hybrids	53	236.31**	116.71**	6107.36**	31.11**	95.98**	17700.27**	0.14**	0.93**	921.71**
Lines	2	944.86**	623.96**	12461.00**	24.02**	87.57**	4237.31	0.47**	0.93**	1089.79**
Testers	17	270.51**	125.85**	14880.64**	46.45**	87.99**	31659.02**	0.12**	2.57**	1324.87**
Line x Tester	34	177.53**	82.30**	1346.97**	23.87**	100.47**	11512.84**	0.13**	0.11**	710.23**
Error	106	1.78	1.44	253.15	2.81	6.91	2018.56	0.02	0.01	55.59
σ^2A	-	20.66	9.68	3007.48	5.02	-2.78[a]	4476.92	0.00	0.54	136.58
σ^2D	-	58.58	26.95	364.61	7.02	31.19	3164.76	0.04	0.03	218.21

*, ** Signiticant at 5% and 1% levels respectively.

σ^2A Estimates of additive genetic variance component.

σ^2D Estimates of non-additive genetic variance component.

a Negative variances are interpreted as zero.

Table 2. Estimates of general combining ability effects for nine quantitative traits in pigeonpea.

Lines/Testers	*Days to 50% flowering*	*Days to maturity*	*Plant height*	*Primary branches per plant*	*Secondary branches per plant*	*Pods per plant*	*Seeds per pod*	*100 seed weight*	*Grain yield*
Lines									
ms Prabhat (DT)	1.48**	-2.50**	13.53**	0.65**	0.13	6.30	0.06**	0.08**	2.46**
PMS 1	3.24**	3.87**	2.90	0.02	-1.33**	3.83	-0.11**	0.07**	2.72**
IMS 1	-4.72**	-1.37**	-16.43**	-0.68**	1.20**	-10.13*	0.04*	-0.15**	-5.19**
S.E. (±)	0.15	0.12	1.69	0.19	0.28	4.71	0.02	0.01	0.82
Testers									
AL 600	-1.39*	-6.24**	37.05**	1.60**	-5.87**	-28.24*	-0.01	-0.34**	2.93
AL 601	0.06	-1.46**	20.49**	1.38*	2.80**	4.09	0.05	-0.20**	1.04
AF 98	-7.50**	-3.69**	-93.40**	-2.18**	0.24	-74.57**	-0.24**	-0.25**	-15.96**
AF 276	9.61**	-31.00**	30.38**	-0.29	3.80**	53.98**	0.03	-0.20**	19.37**
ICPL 151	-6.39**	1.76**	-45.06**	-3.62**	-2.09**	-89.24**	-0.06	1.88**	-17.07**
ICPL 83006	2.94**	2.87**	-53.73**	-3.07**	-0.65	-34.24*	-0.07	0.10**	-22.30**
H 82-1	13.28**	10.20**	11.60*	-2.40**	-3.98**	-21.69	-0.18**	-0.45**	7.26**
ICPL 88001	-2.17**	0.87*	-69.73**	-2.85**	-3.09**	-78.91**	-0.15**	0.60**	-14.07**
AL 688	-1.72**	-3.91**	2.60	2.27**	-1.31	69.43**	-0.05	-0.42**	18.48**
AL 101	-0.28	-2.91**	10.72*	0.38	0.46	13.87	0.12*	0.13**	-1.30
AL 31	0.72	0.20	37.05**	2.82**	2.02*	36.20*	0.04	-0.09**	4.70*
AL 259	-10.06**	-5.24**	-35.73**	0.49	-2.09**	-66.91**	-0.09	-0.19**	-15.07**
AL 587	0.06	1.09**	20.27**	3.27**	6.13**	5.09	0.09	-0.02	3.26
AL 230	-0.28	-0.80*	19.94**	1.82**	4.35**	116.43**	0.03	0.22**	4.69*
AL 227	-0.61	0.65	18.72**	3.27**	-1.65*	5.09	0.13*	-0.20**	3.37
AL 344	-1.50*	2.43**	19.27**	-0.07	2.69**	-10.91	0.11	0.03	1.59
AL 13	0.50	1.76**	39.05**	-1.40**	-1.54	-0.24	0.16**	-0.12**	8.81**
AL 201	4.72**	2.09**	30.49**	-1.40**	-0.20	100.76**	0.10	-0.39**	10.37**
S.E. (±)	0.43	0.36	4.92	0.54	0.80	13.73	0.06	0.03	2.39

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

earliness and seeds per pod (Omanga *et al.*, 1992; Patel *et al.*, 1992) and for early maturity, plant height, number of primary branches and grain yield (Sidhu *et al.*, 1996). Another female line line, PMS-1 was best combiner for developing late maturing, bold seeded and higher yielding hybrids, whereas IMS-1 possessed desirable genes for early flowering, short plant stature, early maturity and higher number of secondary branches. This is in agreement with an earlier study by Sidhu *et al.*, (1996) with the only exception, where male sterile line PMS 1 has been observed to be a good combiner for earliness.

Among males, AL 688 and AF 276 were found to be high combiners for early flowering, early maturity, higher grain yield and its important component, number of pods per plant. In addition to these characters, AL 688 was also good combiner for higher number of primary branches and medium plant height; whereas AF 276 was a good combiner for tall plant stature. In a previous study, Sidhu *et al.*, (1996) has reported AL 688 as a very good general combiner for developing superior hybrids and it was also the pollinator parent of the first pigeonpea hybrid PPH 4, released for general cultivation in Punjab (Verma *et al.*, 1994). AL 230 was the best combiner for the most important yield component, pods per plant. Similarly, AL 201 was a good combiner for developing late maturing, tall growing hybrids having higher number of pods and grain yield per plant. Other good combiners for grain yield were AL 13, H 82-1 and AL 31, whereas AF 98, AL 600, AL 601, AL 259, AL 101 and AL 230 were good combiners for early maturity. Pollinators such as ICPL 151, ICPL 88001, AL 230, ICPL 83006 and AL 31 were observed to be good general combiners for bold seed size. AF 98 followed by ICPL 88001, ICPL 83006, ICPL 151 and AL 259 were good combiners for developing short stature, wereas AL 344 appeared to be good combiner for the production of tall and late maturing hybrids.

In the present investigation, the estimation of tester effects is more precise as compared to the line effects, because number of testers used was large than number of lines, as also reported earlier by Omanga *et al.*, (1992). The greater gain in estimating total combining ability is, however, expected when more than one tester is used, while the specific combining ability effects are, in part at least, averaged out. This ensures a more precise measure of GCA and leaves selection for SCA to the more precise tests of single crosses (Fedrer and Sprague, 1947).

Out of 54 crosses, only 17 crosses exhibited significant positive SCA effects for seed yield. The SCA analysis of these 17 crosses (Table 3) further indicated that none of these experimental hybrids combined high SCA effects for all the characters studied. However, it was interesting to note that three highest yielding experimental hybrids, namely, PMS 1 x AF 276 (106.7 g plant $^{-1}$), ms Prabhat DT x AL 688 (89.3 g plant $^{-1}$) and PMS 1 x AL 201 (81.3 g plant $^{-1}$), were also ranked first, fifth and seventh, respectively, on the basis of their SCA for seed yield. As discussed earlier in the text, one of these three promising hybrids, viz. ms Prabhat DT x AL 688 (PPH 4) has already been released for general cultivation. The experimental hybrids, PMS 1 x AF 276 also top ranked on the basis of its SCA for number of pods per plant. The performance of this hybrid, in comparison with the standard hybrid/cultivar, needs to be evaluated in large scale multilocation trials.

The results further indicated that the above mentioned three top yielding crosses are combinations of high general combiners. Both the parents involved contribute favourable genes and a part of the interactions involved will be of additive x additive type and a portion of heterosis would be fixable. High combining genotypes are expected to produce

Table 3. Estimates of desirable and significant specific combining ability effects for grain yield and other quantitative traits in pigeonpea.

S.No.	*Cross*	*SCA for*	*Mean*	*GCA status*	*Other characters* having higher SCA*
1	PMS 1 x AF 276	31.39	1	HxH	5,6,8
2	IMS 1 x ICPL 88001	21.74	26	LxL	3,7
3	ms PRABHAT (DT) x AL 227	19.98	4	HxM	2,3,5,6
4	IMS 1 x ICPL 83006	19.63	37	LxL	2,3,4,5,7,8
5	ms PRABHAT (DT) x AL 688	15.20	2	HxH	2,4,6,7
6	IMS 1 x AL 600	15.07	11	LxM	2
7	PMS 1 x AL 201	15.06	3	HxH	2,3,7
8	IMS 1 x ICPL 151	13.41	38	LxL	2,3,7
9	PMS 1 x AF 98	13.39	29	HxL	2,5
10	IMS 1 x AL 230	12.41	13	LxH	4,5,6,8
11	ms PRABHAT (DT) x AL 601	10.65	9	HxM	2,5,6
12	ms PRABHAT (DT) x AL 31	10.65	7	HxH	2,4,8
13	PMS 1 x AL 259	9.83	30	HxL	6,7
14	IMS 1 x AL 344	8.41	23	LxM	5,6,7
15	IMS 1 x H 82-1	8.07	14	LxH	-
16	ms PRABHAT (DT) x AL 230	7.43	8	HxH	2,7
17	ms PRABHAT (DT) x AL 13	7.20	5	HxH	5,6

*1- days to flowering, 2 - days to maturity, 3 - plant height, 4 - primary branches per plant, 5 - secondary branches per plant, 6 - pods per plant, 7 - seeds per pod, 8 - seed size
H, high; L, low; M - medium.

hybrids with high *per se* performance (Bains *et al.*, 1972) as has been observed in this study. Table 3 also revealed that the crosses involving low x high combiners, viz. PMS-1 x AF 98, IMS 1 x AL 230 and IMS 1 x H 82-1 also recorded desirable SCA effects and exhibited good *per se* performance. These crosses seem to involve recessive x dominance type interactions and the heterosis resulting in such crosses will not be fixable. Such type of crosses may be used for identifying superior transgressive segregants. Singh *et al.*, (1993) also reported the potential of such high x low crosses in providing useful transgressive segregants in pigeonpea. In general, all the high combining crosses involved either both or one parent with high GCA, whereas majority of the poor performing crosses resulted from low x low combinations.

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