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Genetic analysis of grain yield in pigeonpea using male sterile lines

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ABSTRACT

A study involving three male sterile lines and seven testers of pigeonpea (*Cajanus cajan (L) Millsp*) showed that gca variance was higher than sca variance for grain yield, pods/plant, seeds/pod, seed size, and days to flower. MS Prabhat (DT) a determinate male sterile line was a good general combiner for dwarfness, earliness and seeds/pod. Among the testers C 11 was found to be the best general combiner for yield.

Information on quantitative genetic parameters provide the necessary rationale for adopting a particular breeding procedure for the improvement of crop plants. Saxena and Sharma (12) in a recent review on this aspect in pigeonpea (L) Millsp.) concluded that both additive as well as non-additive gene actions govern seed yield.

The present investigation, involving three male sterile lines and seven pollen fertile testers was designed to collect information on the general combining ability (gca) of these parents and show the effectiveness of male sterile pigeonpea lines in genetic analysis. Recently, male sterility coupled with natural out-crossing were used to develop world's first commercial pigeonpea hybrid ICPH 8 (11). Information on combining ability of the parents will be useful in identifying desirable parents for producing high yielding pigeonpea hybrids (10).

MATERIALS AND METHODS

Three male sterile lines, MS-3A, MS-4A, and MS-Prabhat (DT), were used as female parents and pollinated by each of seven pollen -fertile lines (C 322, Royes, C 11, ICP 7035, BDN 1, ICP 9150, ICP 9180) chosen for their wide genetic and geographical diversity. The 31 entries, consisting of the ten parents and the 21 F1 hybrids, were grown in RBD replicated four times. Each plot consisted of 4 rows , 4m long with 75 cm inter row and 30 cm intra-row spacing. The experiment was planted on June 25, 1982 on a medium-deep Vertisol at ICRISAT Centre without fertilizers or Rhizobium inoculation . Plant height (cm.), 100-seed weight (g), yield/plant (g), number of primary branches, and number of pods/plant were recorded on ten randomly selected competitive plants in the middle two rows of each plot. Seeds/pod was taken on 10 fully developed healthy matured pods. Days of 50% flowering was recorded on a plot basis. Since the sterile lines segregated for fertility/sterility, only the fertile plants within a plot were selected at random for recording the observations. The combining ability analysis was done using the methods of Kempthorne (5) and Comstock and Robinson (1).

RESULTS AND DISCUSSION

The mean sum of squares attributed to the male and female parents of the hybrids provide a measure of their gca, while the interaction between male and female parents provides a measure of sca . The mean squares for males, females and their interaction were highly significant for plant height, number of primary branches, seeds/pod, and days to 50% flower (Table 1). This indicated that in these crosses the additive as well as non-additive gene effects were important for the inheritance of these traits. For pods/plant, grain yield/plant and 100-seed weight, the mean sum of squares for females and for male x female interaction were not significant. Therefore, one would expect that the performance of these characters in hybrid combinations may adequately be predicted on the basis of gca. This suggests that a superior hybrid may be produced by crossing the two parents having high gca.

The nature of gene action depends on number of factors including population sampled, mating system, experimental design, and environment (3). Genetic analyses (Table1) of the present data set revealed that GCA variance component exceed the value of SCA variance component for most characters. Exceptions were the number of primary branches where SCA variance was greater, and plant height where GCA and SCA variances were similar. Previous reports by Sharma *et al.* (13,14), Dahiya and Brar (2), Saxena *et al.* (9), and Reddy *et al.* (8) also indicated the predominance of additive gene action for most characters in pigeonpea.

Among the lines MS-3A and MS-4A had similar array mean and mean values. With the exception of number of primary branches the GCA effects of these two lines were also similar. Although these two male sterile lines appear similar they were isolated from land races collected in two different states in India (7). MS-Prabhat (DT) was found to be significantly different for almost all the characters and parameters. This early-maturing and short-statured male-sterile line was a good general combiner for dwarfness, earliness, and seeds/pod. GCA for yield and other importnat traits was not significant . MS-3A, which is medium in maturity and adapted to Hyderabad conditions (6), was found to be a good general combiner for plant height and number of primary branches. The means for days to flower of most F_1s involving MS-3A and MS-4A were lower than the late parent and in some cases even lower than the mid-parental value. This indicated that both MS-3A and MS-4A can produce F_1 hybrids flowering in 110-140 days.

Among the testers, C 11 was the best general combiner for primary branches, pods/plant, and yield/plant as indicated by its GCA effects and array means (Table 2). It produced the highest yielding F1 hybrid. ICP 7035, the largest seeded parent was the best combiner for seed size and seeds/pod. ICP 9150 and ICP 9180, both tall and late lines from Kenya, invariably produced tall and late maturing hybrids. ICP 9150 also performed well in hybrid combinations for seeds/pod and 100-seed weight. For earliness and short plant stature, the two West Indian lines C 322 and Royes were found to be good general combiners.

In cases where the number of lines and testers are not equal the precision of estimation is also unequal. For example, in this study where the number of lines is greater than the number of testers, the tester effects are estimated with greater precision than the P 73 line effects, Federer and Sprague (4) stated that the greatest gain in estimating total combining abiltiy is 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 general combining ability (gca) and leaves selection for specific combining ability (SCA) to the more precise tests of single crosses.

From the present study it can be concluded that the C 11 was the best general combiner for yield and important components such as pods/plant, plant height, and number of primary branches. Due to the predominance of additive gene action, lines selected for their superior

Table 1. Sums of squares from analysis of variance for combining ability for six traits in a pigeonpea line X tester cross grown at ICRISAT Centre in the 1982 rainy season.

Source	DF	Days fo 50% flower	Plant Height	Number of Primary branches	Number of pods/ plant	Seeds/pod	100 Seed weight	Grain Yield/ plant
Replications	3	6.5	759.9 **	0.8	11655.2**	0.03	2.3	1119.8 **
Hybrids	20	733.50**	3607.4 **	11.3 **	6137.3**	0.6 **	7.8 **	402.1 **
Male (M)	6	909.4**	5915.7 **	9.8**	15730.5 **	1.7 **	20.6 **	1059.2 **
Female (F)	2	3803.9**	10058.5 **	19.0**	1775.2 **	0.6 **	3.4	116.9
M x F	12	133.8 **	1378.1 **	10.8**	2067.6	0.1 **	2.1	121.0
Error	60	2.8	89.3	2.5	1981.3	0.01	1.5	205.9
GCA	_	111.1	330.5	0.18	334.3	0.05	0.5	23.4
SCA	_	32.7	322.2	2.08	21.6	0.01	0.2	-21.2a
GCA/SCA	_	34:1	1:1	0.09:1	15.5:1	5:1	2.5:1	_

** - Significant at 5% and 1% probability level, respectively

GCA - Estimate of general combining ability variance component.

SCA - Estimate of specific combining ability variance component.

a - Negative ratios are interpreted as zero

Table 2. Mean perfc :mance, array means, and GCA effects for various characters of the parents in line X tester cross grown at ICRISAT Centre, in the 1982 rainy season.

Parents	Origin	Days to 50 % flower			Plant height (cm)			Number of primary branches		
		Mean	Array mean	GCA effect	Mean	Array mean	GCA effect	Mean	Array mean	GCA effect
Female (Male Steriles)										
MS-Prabhat (DT)	Uttar Pradesh India	62	100	-13.5**	92	177	-21.8**	13.7	9.6	-0.6
MS-3A	Andhra Pradesh !ndia	121	121	7.1**	213	209	9.6**	13.3	11.1	0.9**
MS-4A	Maharashtra	117	120	6.4**	216	211	12.2**	9.9	9.9	-0.3
	SE of difference (female)		± 0.4	± 0.5		± 2.1	± 2.53		± 0.34	± 0.42
Male (Normal)										
C 322	West Indies	104	108	-6.0**	126	169	-30.1**	7.4	10.3	0.1
Royes	West Indies	116	111	-3.2**	168	180	-19.6**	6.5	9.6	-0.6
C11	Mahrashtra, India	118	112	-2.5**	203	212	-12.9**	9.3	11.4	1.3*
ICP 7035	Madhya Pradesh, India	127	116	2.2**	204	199	-0.6	7.9	10.2	0.1
BDN 1	India	103	101	-12.6**	213	227	-13.7**	10.0	8.6	-1.6*
ICP 9150	Kenya	157	125	11.5**	219	227	28.1**	8.8	10.8	0.7
ICP 9180	Kenya	160	125	10.5**	222	222	22.9**	9.7	10.3	0.12
	SE of mean	± 1.0	± 0.6	± 0.18	± 5.5	± 3.2	± 1.03	± 0.90	± 0.52	± 0.17
SE of the difference (Males)				± 0.68			± 3.86			± 0.64

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Parents	Origin	Pods/plant			Seeds/pod			100-seed weight			Grain yield/plant (g)		
		Mean	Array mean	GCA effect	Mean	Array mean	GCA effect	Mean	Array mean	GCA effect	Mean	Array mean	GCA effect
Female (Male Steriles)													
MS-Prabhat (DT)	Uttar Pradesh India	210	159	-8.0	3.9	4.6	0.14**	5.7	9.6	-0.89	31.5	46.5	-2.4
MS-3A	Andhra Pradesh India	211	167	-0.1	4.0	4.4	0.01	7.9	10.1	0.14	48.8	50.1	1.3
MS-4A	Maharashtra, India	246	175	8.0	3.8	4.3	-0.14	7.5	10.2	0.25	54.4	49.9	1.1
	SE of difference		± 9.7	± 11.9		± 0.02	± 0.03		± 0.26	± 0.32		± 3.13	±.3.83
Male (Normal)													
C 322	West Indies	205	139	-27.8	5.3	4.8	0.35**	13.2	9.4	0.58	37.5	43.3	-5.5
Royes	West Indies	88	166	-0.9	4.4	4.5	0.04	11.2	9.4	-0.61	44.2	44.2	-4.7
C11	Maharashtra. India	198	240	73.6**	3.8	3.9	-0.49**	10.2	9.2	-0.76	54.4	64.4	15.5**
ICP 7035	Madhya Pradesh, India	76	159	-7.7	4.8	4.6	0.21**	20.1	12.2	2.18**	31.5	59.5	10.7
BDN 1	India	205	171	4.3	3.6	3.9	-0.56**	10.7	8.7	-1.30**	46.1	39.4	-9.4
ICP 9150	Kenya	103	127	-39.9*	5.7	4.7	0.23**	14.4	11.5	1.53**	22.8	43.2	-5.7
ICP 9180	Kenya	115	165	-1.6	5.4	4.7	0.23**	11.4	9.5	-0.45**	30.7	47.9	-1.0
	SE of mean	± 25.7	± 14.8	± 4.86	± 0.06	± 0.03	0.01	± 0.70	± 0.40	± 0.13	± 8.28	± 4.78	1.57
SE of the difference (males)			± 18.17			± 0.04			± 0.49			± 5.86	

GCA should be crossed among themselves and with other known superior genotypes not included in this experiment. Selection in the segregating generations of such crosses may result in superior inbred lines. This line should be tested further for use in commercial hybrid seed production. In view of its high GCA for yield this line should also be converted into a male sterile background for use as a female parent for producing high yielding F_1 hybrids.

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