Journal of Applied and Natural Science 8 (2): 597 - 603 (2016)

Implications of hybrid vigour, combining ability and *per se* performance in pigeonpea [*Cajanus cajan* (L.) Millsp.]

Yamanura[1]*, S. Muniswamy[1] and Ramesh[2]

[1]Department of Genetics and Plant Breeding, Univesity of Agricultural Sciences, Raichur-584 102 (Karnataka), INDIA
[2]Agricultural Research Station, Kalaburagi-585101 (Karnataka), INDIA
*Corresponding author. E-mail: yaman3181aug8@gmail.com

Received: June 15, 2016; Revised received: January 18, 2016; Accepted: April 11, 2016

Abstract: Three CGMS lines were crossed with 17 testers in a line × tester design during *Kharif* 2013 and sufficient number of hand pollinated seeds was produced. The resultant 51 hybrids along with their 20 parents and standard check variety (Maruti) were evaluated in RBD design with two replications. Combining ability analysis evinced predominance of non-additive gene effects for 7 characters indicating relevance of heterosis breeding for improving yield attributes. The *gca* effects of parents revealed that ICPA-2043, GRG-2009, GRG-2009-2, LAXMI, LRG-41 and JKM-197 were good general combiners for seed yield and it's direct components. The estimates of *sca* effects revealed that 11 experimental hybrids had significant, desirable and positive *sca* effects for seed yield/plant. Among these, three best crosses were selected on the basis of *per se* performance for ascertaining their association with *sca* effects of seed yield per plant and its attributes. The investigation identified the good general combiners (ICPA -2043, GRG-2009, GRG-2009-2, LAXMI, LRG-41 and JKM-197) and promising crosses (ICPA-2043 X GRG-2009-2, ICPA-2047 X GRG-2OO9 and ICPA-2043 X ICPL-288) showing high mean and significant positive *sca* effects involved high × high *gca* effects of parents. These parental combinations may be used in breeding program for exploitation of hybrid vigour.

Keywords: Combining ability, Hybrid vigour, LineX Testers, *per se*, Pigeonpea

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a perennial shrub belong to economically important tribe Phaseoleae and the *subtribe Cajanine*. It is being cultivated as an annual crop in Southern and South Eastern Asia, Eastern Africa, the Caribbean region and South and Central America. It is chiefly grown for its seeds which are consumed either as dry split peas (dhal), providing major source of protein and essential amino acids or as a green vegetable (Saxena *et al.* 2005).
In India, it is one of the very important grain legumes and occupies second position in area and production next to chickpea. It is grown in an area of 3.88 m ha with an annual production of 3.17 m tonnes. In Karnataka, pigeonpea occupies second place in area (6.66 Lakh ha) and ranks second in production (3.66 Lakh tonnes) with a productivity of 555 kg/ha (Sing, 2015).
Most of the economic characters like seed yield, number of pods per plant, days to 50 per cent flowering are mostly governed by polygenes and their inheritance is of complex nature. Therefore, before making attempts for improvement of these characters it is essential to know the nature of gene action controlling these quantitative characters. This information will be helpful to breeders in devising appropriate methods of breeding for crop improvement. A review of literature on quantitative genetics of pigeonpea showed that the presence of significant levels of non additive genetic variation for seed yield which could be profitably exploited through heterosis breeding to increase grain yield (Saxena and Sharma, 1990).
Commercial exploitation of heterosis has been possible in crops like sorghum and cotton either through male sterility systems or through hand pollination. A successful search for easily identifiable and stable genetic male sterility at different institutions in India has paved way for commercial exploitation of hybrid vigour in pigeonpea and six hybrids *viz.,* ICPH 8, COPH 1, COPH 2, PPH 4, AKPH 4104 and AKPH 2022 have been released for commercial cultivation. (Bajpai *et al.,* 2003)
Exploitation of heterosis depends much on general and specific combining ability effects. Combining ability studies are useful in evaluation of the parental lines and their cross combinations, usually this information aids in selection of parents in terms of performance of hybrids and elucidate the nature and magnitude of various types of gene action involved in the expression of quantitative traits (Sony, 2010). Therefore, present study was undertaken to estimate hybrid vigor, combining ability for seed yield and other traits in pigeonpea using three cytoplasmic genic male sterile lines derived from A_4 cytoplasm and 17 diverse testers

ISSN : 0974-9411 (Print), 2231-5209 (Online)

Table 1. Variance due to GCA, SCA ad their proportion for 7 different characters in pigeonpea.

S. N.	Characters	Variance due to GCA	Variance due to SCA	GCA : SCA proportion
1	Days to 50 per cent flowering	1.18	15.55	1:13.13
2	Days to maturity	1.31	5.50	1:4.19
3	Plant height (cm)	8.30	92.85	1:11.19
4	Number of branches/plant	0.17	1.19	1:6.88
5	Pod bearing length (cm)	3.03	89.34	1:29.47
6	Number of pods/plant	2.58	1269.06	1:492.46
7	Yield per plant(gm)	3.60	312.88	1:86.96

crossed in line x tester design in pigeonpea.

MATERIALS AND METHODS

The parental material comprised of three CGMS lines (ICPA-2043, ICPA-2078 and ICPA-2047) used as a females were crossed with seventeen genotypes *viz.* ICPL-288, ICPL-89004, ICP-6974, ICP-7387, ICP-6972, LRG-41, MARUTI, WRP-1, GRG-2009, JKM-197, GRG-295, TGT-501, PG-12, GRG-2009-2, GRG-2009-3, TS-3 and LAXMI used as a males in line x tester mating design during *Kharif* 2013 and sufficient number of hand pollinated seeds were produced. The resultant 51 hybrids along with their 20 parents and standard check variety (Maruti) were evaluated in a RBD design with two replications. Each genotype was sown in two rows of 4.0 meter length with the spacing of 90cm between rows and 30 cm between plants at Agriculture Research Station, Gulbarga during *kharif* 2014.

Observations on five randomly selected competitive plants were recorded for days to 50% flowering, days to maturity, plant height(cm), number of primary & secondary branches/plant, pod bearing length (cm), number of pods/plant, seed yield/plant (g). Fertile male sibs were used to collect data on male sterile lines. The mean value of five random plants of the above-mentioned characters recorded on parents and hybrids were utilized and variance due to different sources was estimated (Panse and Sukhatme, 1961).

The variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of different cross combinations were worked out using L x T analysis based on the procedure developed by Kempthorne (1957). The GCA variance was more than the SCA variance *i.e.* GCA/SCA variance ratio was more than one indicating predominance of additive variance. The SCA variance was higher than the GCA variance *i.e.* GCA/SCA variance ratio was less than unity, indicating predominance of dominance variance than additive variance. The data was subjected to analysis of variance and combining ability using statistic package WINDOSTAT 8.5 developed by Indostat services, Hyderabad (India).

RESULTS AND DISCUSSION

The results revealed higher magnitude of SCA variance as compared to GCA variance for all the characters indicating the predominance of non-additive gene action. The ratio between GCA and SCA variances were worked out and the proportion was highest for total number of pods per plant (1:492.46) followed by seed yield per plant (1:86.96), pod bearing length (1:29.47), day to 50 per cent flowering (1:13.13), plant height (1:11.19), Number of branches/plant (1:6.88) and days to maturity (1:4.19) and these characters are more likely to be improved through heterosis breeding (Table 1). The above findings are in agreement with the earlier reports of Sunil Kumar *et al.* (2003), Sekhar *et al.* (2004), Sameer Kumar *et al.* (2009), Beekham and Umaharan (2010), Shobha and Balan (2010), Sony Tiwari (2010), Chethana *et al.* (2013) and Meshram *et al.* (2013). They reported the same results for most of

Table 2. ANOVA for combining ability in respect of 7 characters in pigeonpea.

Source of Variation	Degree of freedom	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod bearing length (cm)	No. of pods/ plant	Seed yield/ plant
Females	2	791.18**	544.89**	7105.90**	204.39**	4527.85**	8591.78	4149.21**
Males	16	285.94*	219.15**	1142.43**	17.86	288.20	2667.30	881.14
Females x Males	32	147.92	39.95	443.83**	10.13	261.96**	2902.90**	654.06**
Error	50	116.81	28.95	258.67	7.75	83.28	364.77	28.32

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

Table 3. Per cent contribution of Lines, Testers and Line X Testers to crosses in pigeonpea.

Source of Variation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod bearing length (cm)	No. of pods/ plant	Seed yield/ plant
Lines	14.53	18.55	30.44	40.13	41.07	11.25	19.15
Testers	42.01	59.69	39.15	28.04	20.91	27.94	32.54
LinesX Testers	43.46	21.76	30.42	31.83	38.02	60.81	48.31

Table 4. General combining ability effects for parents in respect of 7 characters in pigeopea.

Entries	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod bearing length (cm)	No. of pods/ plant	Seed yield/ plant
LINES							
ICPA-2043	-0.75	-1.25	-4.14	2.57 **	1.51	18.25 **	10.45 **
ICPA2078	-4.40 *	-3.23 **	-11.93 **	-2.31 **	-12.22 **	-7.46 *	-11.56 **
ICPA-2047	5.16 **	4.48 **	16.08 **	-0.27	10.71 **	-10.79 **	1.11
CD@5%	5.26	2.62	7.84	1.35	4.44	9.31	2.59
CD@1%	7.02	3.49	10.45	1.8	5.93	12.41	3.45
TESTERS							
ICPL-288	-3.96	-4.87 *	-10.85	-0.22	5.1	30.62 **	9.71 **
ICPL-89004	-6.29	-7.21 **	-8.35	-1.56	1.54	9.68	-1.77
ICP-6974	0.71	-0.21	-9.91	0.61	-2.79	14.9	-11.35 **
ICP-7387	3.04	2.13	-1.13	1.17	-2.62	-15.21	-8.54 **
ICP-6972	-11.63 *	-12.54 **	-28.13 **	-3.83 **	-9.74 *	-34.60 **	-23.33 **
LRG-41	-12.96 **	4.29	5.54	0.94	0.82	16.02 *	8.95 **
MARUTI	1.37	2.29	10.04	-0.11	10.65 **	-15.82 *	-8.95 **
WRP-1	4.21	3.29	11.31	-1.95	17.26 **	-17.49 *	-13.60 **
GRG-2009	3.21	2.29	4.98	0.67	-5.51	-20.54 *	18.60 **
JKM-197	15.21 **	13.13 **	15.37 *	1.55	4.1	44.35 **	4.51 *
GRG-295	3.21	2.29	3.98	3.55 **	-3.68	9.01	3.4
TGT-501	-0.46	-1.37	11.03	0.94	-9.35 *	7.46	-3.71
PG-12	-5.79	-6.71 **	-31.96 **	-1.87	-3.07	-16.93 *	-6.51 **
GRG-2009-2 (209)	-0.46	-2.54	1.87	-0.17	-0.51	7.73	20.11 **
GRG-2009-3 (216)	1.04	-2.04	2.65	-0.95	2.54	-7.27	-7.47 **
TS-3	9.37 *	8.46 **	11.92	-0.5	-7.01	-23.60 **	4.17
LAXMI	0.21	-0.71	11.65	1.72	2.26	11.68	15.79 **
CD@5%	12.54	6.24	18.66	3.23	10.59	22.16	6.17
CD@1%	16.72	8.32	24.88	4.3	14.12	29.55	8.23

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

the important characters including seed yield except plant height indicating these traits are under the influence of non additive gene action.

Analysis of variance for combining ability revealed that mean squares due to females were significant for all most all the characters except number of pods per plant while mean squares due to males were significant for characters *viz.,* days to 50% flowering, days to maturity and plant height (cm). The mean squares due to line x tester interaction were significant for plant height (cm), pod bearing length (cm), number of pods per plant and seed yield/plant (g). Thereby it is sug-

Table 5. Comparison of best crosses on the basis of specific combining ability effects for different characters.

Characters	Crosses	SCA effects	GCA effects of Parents and Status			Std. het-erosis	*per se*	Significant SCA effects for other traits
			P1	P2	Status			
Days to 50% flowering	ICPA-2078 X LRG-41	-33.60	-4.40	-12.96	L X L	45.78	61.00	NPP
Days to maturity	ICPA-2043 X LRG-41	-10.91	5.16	-12.90	H X L	8.27	220.50	DM, YLD
Plant height (cm)	ICPA-2047 X ICP-6972	31.26	16.08	-28.13	H X L	8.27	220.50	DM, YLD
	ICPA-2043 X TGT-501	26.13	-4.41	11.03	L X H	-5.91	191.50	DM, YLD
Number of branches per plant	ICPA-2047 X ICP-6972	3.99	-0.27	-3.83	L X L	-23.38	13.66	DM, PHT, YLD
Pod bearing length (cm)	ICPA-2043 X GRG-2OO9	17.83	1.51	-5.10	H X L	21.88	78.00	YLD,
	ICPA-2078 X ICPL-89004	17.66	-12.22	1.54	L X H	11.20	71.17	NB, YLD
	ICPA-2047 X LAXMI	15.29	10.71	2.26	H X H	29.95	83.17	DM, NB, YLD
No. of pods/ plant	ICPA-2043 X LRG-41	75.13	18.25	-34.60	H X L	55.56	240.00	YLD,
	ICPA-2078 X MARUTI	57.85	-7.46	-15.82	L X L	6.96	165.17	YLD,
	ICPA-2078 X GRG-2OO9	57.41	-7.46	-20.54	L X L	-11.43	160.00	NB, YLD
Seed yield/ plant	ICPA-2043 X GRG-2009-2	59.31	10.45	20.11	H X H	95.26	133.75	-
	ICPA-2047 X GRG-2OO9	21.52	1.11	18.60	L X H	24.23	85.10	DM, PHT, NB
	ICPA-2078 X LAXMI	19.86	-11.56	15.79	L X H	-17.72	56.36	NB

DFF= Days to 50 % flowering, DM= Days to maturity, PHT= Plant height (cm), NB = No. of branches, SB= No. of Secondary branches, PBL = Pod bearing length (cm), NPPP= No. of pods/ plant, YPP= Seed yield/ plant.

Table 6. Top three crosses based on *per se* for 7 yield and yield attributing characters in pigeonpea

S. N.	Characters	Crosses	*Per se* performance	Sca effects	GCA status of parents	Std. heterosis
1	Days to 50% flowering	ICPA-2078 X LRG-41	90.00	-33.60	L X L	-14.78
		ICPA-2043 X ICP-6972	98.00	-1.58	L X L	-12.89
		ICPA-2078 X ICP-6972	99.00	3.07	L X L	-12.00
2	Days to maturity	ICPA-2078 X LRG-41	140.00	1.56	L X H	1.90
		ICPA-2043 X ICP-6972	143.00	-1.08	L X L	-9.21
		ICPA-2078 X ICP-6972	144.00	1.89	L X L	-8.57
3	Plant height	ICPA-2047 X LRG-41	237.33	14.43	H X H	16.53
		ICPA-2047 X GRG-2OO9	235.33	12.98	H X H	15.55
		ICPA-2047 X TGT-501	232.67	4.26	H X H	14.24
4	Branches	ICPA-2043 X GRG-295	23.84	3.93	H X H	33.64
		ICPA-2043 X TS-3	20.16	2.09	H X L	13.06
		ICPA-2043 X TGT-501	19.66	2.37	H X L	10.26
5	Pod bearing length	ICPA-2047 X MARUTI	93.83	8.29	H X H	46.61
		ICPA-2047 X WRP-1	93.67	1.51	H X H	46.35
		ICPA-2047 X LAXMI	83.17	15.29	H X H	29.95
6	Number of pods per plant	ICPA-2043 X LRG-41	240.00	75.13	H X H	55.56
		ICPA-2043 X JKM-197	206.17	12.97	H X H	35.06
		ICPA-2043 X ICPL-288	197.83	18.36	H X H	28.05
7	Seed yield per plant (g)	ICPA-2043 X GRG-2009-2	133.75	59.31	H X H	95.26
		ICPA-2047 X GRG-2OO9	85.10	21.52	H X H	24.23
		ICPA-2043 X ICPL-288	79.79	15.74	H X H	16.48

gested that the variation in hybrids in respect of seed yield may be strongly influenced by the lines. The mean squares due to lines were larger in magnitude for most of the important yield attributes than testers indicating greater diversity amongst the lines as compared to testers (Table 2).

The analysis of variance for combining ability showed that the mean squares due to general and specific combining ability effects indicated involvement of both additive and nonadditive gene action. The mean sum of squares due to lines × testers and their interactions were highly significant for seed yield and it's component characters further indicated the importance of *sca* variance, and consequently the non-additive genetic variation in the inheritance of these characters. The trend recorded was in agreement with the findings of Khorgade *et al.* (2000), Sunil Kumar *et al.* (2003) and Sekhar *et al.* (2004). Vaghela *et al.*(2009), Sameer Kumar *et al.* (2009) Bharate *et al.* (2011) for seed yield/plant and other important yield attributes *viz.,* pod bearing length, number of pods per plant and 100 seed weight. Preponderance of non-additive genetic variance has been suggested.

Per cent contribution of line, testers and line x testers to the crosses (Table 3) revealed that a greater contribution of testers was observed for days to 50% flowering, days to maturity, plant height, number of pods per plant and seed yield/plant. Whereas, the contribution of lines to the performance of crosses was found significant for pod bearing length and number of branches per plant indicating the significant contribution of paternal parents. The contribution of lines and testers were found equally important for the development of the yield and its attributing characters. This showed that average general combiner could results in high heterotic performance and could be effectively used in heterosis breeding programmes. Similar results were also reported by Pandey and Singh (2002) and Yamanura *et al.* (2014).

The nature and magnitude of combining ability effects help in identifying superior parents and their utilization in breeding programme. Character-wise estimation of *gca* effects of lines and testers is presented in table 4. The *gca* effects of parents revealed that ICPA-2043, GRG-2009, GRG-2009-2, LAXMI, LRG-41 and JKM-197 were good general combiners for seed yield and it's direct components (Table 4). The line ICPA-2078 and testers ICP-6972 and ICPL-89004 were good general combiners for days to 50 % flowering and days to maturity, line ICPA-2047 and testers JKM-197 and TS-3 for plant height, line ICPA-2043 and testers GRG-295 and LAXMI for number of branches/plant, line ICPA-2047 and testers WRP-1 and MARUTI for Pod bearing length, line ICPA-2043 and testers JKM-197, ICPL-288 and LRG-41 for number of pods/plant.

The top three crosses exhibiting high specific combing ability effects along with their *Per se* performance, standard heterosis and gca status of the parents indicated that the cross combinations ICPA-2043 X GRG-2009-2, ICPA-2047 X GRG-2OO9 and ICPA-2078 X LAXMI were good specific combiners for seed yield per plant. These parental combinations are being used for exploitation of hybrid vigour. The cross combination ICPA-2078 X LRG-41and ICPA-2043 X LRG-41were good specific combiners for days to 50% flowering and maturity as they were showing highly significant negative *sca* effect this is very much suitable in dry land (rainfed) condition because it has advantage of escaping terminal moisture stress. The crosses ICPA-2047 X ICP-6972 and ICPA-2043 X TGT-501for plant height, ICPA-2047 X ICP-6972 for number of branches, ICPA-2043 X GRG-2009, ICPA-

Table 7. *Per se* performce of hybrids and parents in respect of 7 characters in Pigeopea.

S.N.	Entries	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod bearing length (cm)	No. of pods/ plant	Seed yield/ plant
1	ICPA-2043 X ICPL-288	110	155	200.33	18.17	73.50	198**	79.79**
2	ICPA-2043 X ICPL-89004	103	148*	179.50	12.84	56.50	153	38.09
3	ICPA-2043 X ICP-6974	111	156	198.67	16.67	73.33	190*	32.58
4	ICPA-2043 X ICP-7387	115	160	202.00	16.17	55.83	98	42.81
5	ICPA-2043 X ICP-6972	98	143**	152.50	8.00	56.00	82	16.41
6	ICPA-2043 X LRG-41	105	150	196.00	18.00	68.17	240**	72.52**
7	ICPA-2043 X MARUTI	113	161	202.00	14.83	69.50	96	41.15
8	ICPA-2043 X WRP-1	116	162	195.00	12.83	77.50	87	31.07
9	ICPA-2043 X GRG-2009	111	156	187.33	17.51	78.00	91	62.44**
10	ICPA-2043 X JKM-197	127	175	205.67	16.83	65.83	206**	63.36**
11	ICPA-2043 X GRG-295	112	157	202.67	23.84**	54.67	184	74.98**
12	ICPA-2043 X TGT-501	111	156	208.33	19.66	62.17	155	50.46
13	ICPA-2043 X PG-12	104	149	191.50	14.83	59.67	123	52.31
14	ICPA-2043 X GRG-2009-2	111	156	217.33	16.00	64.83	144	133.75**
15	ICPA-2043 X GRG-2009-3	111	156	195.50	15.66	64.67	148	41.77
16	ICPA-2043 X LAXMI	122	167	217.33	16.00	64.83	144	32.33
17	ICPA-2043 X TS-3	114	159	200.00	20.16*	71.67	190*	57.84
18	ICPA-2078 X ICPL-288	103	148	174.33	9.16	62.67	115	23.15
19	ICPA-2078 X ICPL-89004	107	152	190.17	11.00	71.17	126	37.58
20	ICPA-2078 X ICP-6974	106	151	159.50	13.00	40.00	127	29.76
21	ICPA-2078 X ICP-7387	111	156	174.00	11.01	53.33	102	16.22
22	ICPA-2078 X ICP-6972	99	144*	146.50	8.17	48.83	102	18.15
23	ICPA-2078 X LRG-41	90	140**	187.17	13.33	48.83	103	42.73
24	ICPA-2078 X MARUTI	115	161	205.00	12.66	61.17	165	28.52
25	ICPA-2078 X WRP-1	113	156	210.33	9.84	73.17	120	29.10
26	ICPA-2078 X GRG-2009	112	157	196.17	11.51	21.50	160	39.89
27	ICPA-2078 X JKM-197	127	169	217.33	16.00	64.83	144	25.48
28	ICPA-2078 X GRG-295	113	158	195.83	14.16	61.33	122	30.46
29	ICPA-2078 X TGT-501	112	157	196.00	10.33	25.00	121	27.78
30	ICPA-2078 X PG-12	103	148*	155.00	8.67	47.17	103	23.19
31	ICPA-2078 X GRG-2009-2	112	152	192.83	12.34	64.67	187	35.42
32	ICPA-2078 X GRG-2009-3	113	148*	197.17	13.34	58.50	121	28.10
33	ICPA-2078 X LAXMI	112	157	198.83	10.16	23.50	111	56.36
34	ICPA-2078 X TS-3	112	157	223.00	10.33	57.67	65	57.59
35	ICPA-2047 X ICPL-288	111	156	196.67	13.33	71.67	171	57.85
36	ICPA-2047 X ICPL-89004	108	153	209.17	12.84	69.50	143	50.67
37	ICPA-2047 X ICP-6974	122	167	216.00	13.50	70.83	119	35.25
38	ICPA-2047 X ICP-7387	120	165	224.50	17.67	75.50	146	46.98
39	ICPA-2047 X ICP-6972	104	149	220.50	13.66	58.50	104	27.09
40	ICPA-2047 X LRG-41	131	176	237.33*	12.83	78.00	97	43.24
41	ICPA-2047 X MARUTI	112	159	227.00	13.50	93.83**	83	35.11
42	ICPA-2047 X WRP-1	121	166	232.50*	12.84	93.67**	133	30.68
43	ICPA-2047 X GRG-2009	123	168	235.33*	14.33	76.50	79	85.10**
44	ICPA-2047 X JKM-197	128	169	227.00	13.17	74.17	174	56.33**
45	ICPA-2047 X GRG-295	121	166	217.33	14.00	65.50	113	36.39
46	ICPA-2047 X TGT-501	112	157	232.67*	14.16	77.33	138	42.27
47	ICPA-2047 X PG-12	112	157	161.50	12.22	76.50	116	36.63
48	ICPA-2047 X GRG-2009-2	112	159	199.33	12.50	61.50	84	22.79
49	ICPA-2047 X GRG-2009-3	116	164	219.17	9.50	77.00	101	39.35
50	ICPA-2047 X LAXMI	130	175	223.50	13.67	83.17*	66	55.48*
51	ICPA-2047 X TS-3	111	156	215.83	16.00	70.00	171	63.59**
52	ICPA-2043	99	137**	173.50	18.67	30.84	96	23.92
53	ICPA2078	92	135**	117.17	9.01	11.92	56	12.25
54	ICPA-2047	111	167	213.83	20.67*	38.83	116	26.34
55	ICPL-288	122	167	175.00	14.16	63.33	162	70.49**
56	ICPL-89004	112	157	164.50	11.34	55.50	135	22.91
57	ICP-6974	113	158	160.50	13.34	47.67	149	41.50
58	ICP-7387	126	159	166.83	13.84	42.17	102	24.34
59	ICP-6972	105	150	137.33	8.66	41.17	107	15.00

Contd.…

Contd.

60	LRG-41	122	167	198.83	18.66	44.17	218**	44.02
61	MARUTI	113	150	203.67	17.84	64.00	155	41.23
62	WRP-1	114	153	197.67	10.67	74.83	148	38.92
63	GRG-2009	123	168	214.17	18.84	72.50	167	51.09
64	JKM-197	123	168	205.33	19.50	66.67	184	54.75*
65	GRG-295	121	166	193.83	20.50*	53.33	137	57.27**
66	TGT-501	109	154	200.83	14.83	69.17	208	54.72*
67	PG-12	105	150	166.00	14.50	61.50	168	56.05*
68	GRG-2009-2	107	148	207.00	16.00	68.17	206**	77.22**
69	GRG-2009-3	108	151	210.67	14.50	66.67	145	40.44
70	TS-3	113	158	201.83	19.66*	57.67	195*	76.06**
71	LAXMI	122	167	205.83	13.00	66.33	140	51.66
Geeral mean		112	157	196.91	14.24	61.54	136	43.92
CD @ 5%		18.22	10.13	34.63	5.35	18.73	46.69	9.79
CD @1%		24.21	13.46	46.01	7.11	24.89	62.02	13.01

2078 X ICPL-89004 and ICPA-2047 X LAXMI for pod bearing length, ICPA-2043 X LRG-41, ICPA-2078 X MARUTI and ICPA-2078 X GRG-2OO9 for number of pods per plant were found to be useful. The estimates of *sca* effects revealed that 11 experimental hybrids had significant, desirable and positive *sca* effects for seed yield/plant. Among these, three best crosses were selected on the basis of *per se* performance for ascertaining their association with *sca* effects of seed yield per plant and its attributes (Table 5).

Out of three crosses showing high mean and significant positive *sca* effects for seed yield along with their *per se* performance as well as *gca* effects of parents and their significant response to other characters are presented in table 6. The crosses ICPA-2043 X GRG-2009-2, ICPA-2047 X GRG-2009 and ICPA-2043 X ICPL-288 showing high mean and significant positive *sca* effects involved high × high *gca* effects of parents. These results were also in conformity with those of Baskaran and Muthiah (2007), Meshram *et al.* (2013) and Chethana *et al.* (2013). Better performance of hybrids involving high x low or low x low general combiners indicated dominance x dominance (epitasis) type of gene action. The crosses showing high *sca* effects involving one good general combiner indicated additive x dominance type gene interaction which exhibit the high heterotic performance for yield and yield related traits.

The mean *per se* performance is an important parameter to be considered in selection of promising genotypes as they directly influence on other parameters like GCA, SCA and also on magnitude of heterosis in crosses. The mean *per se* performance of parents and crosses obtained in the present study were given in the table 7. Seed yield per plant is the effect of the component characters related to it. The potentiality of line to be used as a parent in hybridization, or in a cross to be used as a commercial hybrid may be judged by comparing the *per se* performance of the parents, the F_1 value and the combining ability effects.

The results suggested that the crosses having high mean performance, positive *sca* effects for seed yield and their significant response to other related traits had necessarily involved both or at least one parent as good combiner which could be commercially exploited for heterosis by taking advantage of high degree of natural out crossing in pigeonpea.

Conclusion

From the present study, the genotypes *viz.,* ICPA-2043, GRG-2009, GRG-2009-2, LAXMI, LRG-41 and JKM-197 were identified as good general combiners and ICPA-2043 X GRG-2009-2, ICPA-2047 X GRG-2OO9 and ICPA-2043 X ICPL-288 as promising crosses having high mean and significant positive *sca* effects involving high × high *gca* effects of parents. These parental combinations may be used in breeding program for exploitation of hybrid vigour.

ACKNOWLEDGEMENTS

Sincere thanks to National Food Security Mission, New Delhi and International Crop Research Institute for Semi-arid and Tropics, Hyderabad for having provided seed materials and financial support under the project entitled “Taking pigeonpea projects to the door steps of the farmers”.

REFERENCES

Bajpai, G.C., Jogendra Singh, Tewari, S.K. (2003). Pigeonpea hybrids - A review. *Agric. Reviews,* 24(1) 1-15.

Baskaran, K. and Muthiah, A.R. (2007). Combining ability studies in pigeonpea. *Legume Research.* 30: 67-69.

Beekham, A.P. and Umaharan. (2010). Inheritance and combining ability studies of pod physical and biochemical quality traits in vegetable pigeonpea. *Euphytica.* 176:36-47.

Bharate, B.S., Wadikar, P.B. and Ghodke, M.K. (2011). Studies on combining ability for yield and its components in pigeonpea. *Journal of Food Legumes.* 24(2): 148-149.

Chethana, C.K., Dharmaraj, P.S., Lokesha, R., Girisha, G., Muniswamy, S, Yamanura, Niranjana kumar and Vinayaka, D.H.(2013). Genetic analysis for quantitative traits in pigeonpea (*Cajanus Cajan* L. Millsp.). *Journal of Food Legumes.* 25(1): 1-18.

Kempthorne, O. (1957). *An Introduction to Genetic Statistics.* John Wiley and Sons Inc., New York; Chapman and Hall, London. .545.

Khorgade, P.W., Wankhade, R.R. and Wanjari, K.B. (2000). Combining ability analysis in pigeonpea using male sterile lines. *Indian Journal Agricultural Research.* 34: 112-116.

Meshram, M.P., Patil, A.N. and Abhilasha, K. (2013). Combining Ability Analysis in Medium Duration CGMS Based Hybrid Pigeonpea (*Cajanus cajan* (L.) Millsp.,). *Journal of Food Legumes.* 26(3 & 4): 29-33.

Pandey, N. and Singh, N.B. (2002). Hybrid vigour and combining ability in long duration pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids involving male sterile lines. *Indian J. Genet. and Pl. Breed.* 62(3): 221-225.

Panse, V.G. and Sukhatme, P.V. (1961). *Statistical Methods for Agricultural Workers*, ICAR Publication, New Delhi. P. 359.

Kumar, S., C.V. Sreelaxmi, C.H. and Kishore Verma, P. (2009). Studies on Combining ability and heterosis in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Legume Research.* 32(2): 92-97.

Saxena, K.B. and Sharma, D. (1990). Pigeonpea Breeding. The pigeonpea (Eds. Nene, Y.I., Hall, S.D. and Sheila,V. K.,). 375-399.

Saxena, K.B., Kumar, R.V., Dalvi, V.A., Mallikarjuna, N., Gowda, C.L.L., Singh, B.B., Tikka, S.B.S., Wanjari, K.B., Pandet, L.B., Paralkar, L.M., Patel, M.K., Shiying, B. and Xuxiao, Z. (2005). Hybrid breeding in grain legumes -a success story of pigeonpea. Khairwal MC, Jain HK (eds) *Proceedings of the international food legumes research conference*. New Delhi, India.

Sekhar, M.R., Singh, S.P., Mehra, R.B. and Govil, J.N. (2004). Combining ability and heterosis in early maturing pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids. *Indian Journal of Genetics and Plant Breeding.* 64 (3): 212 – 216

Shobha, D. and Balan, A. (2010). Combining Ability in CMS/GMS Based Pigeonpea *(Cajanus cajan (L.)* Millsp.,) Hybrids. *Madras Agricultural Journal*. 97 (1-3): 25-28.

Sing, I.P. (2015). Project Coordinator's Report- *Kharif* Pulses. All Indian Coordinated Resaerch Project on Pigeonpea, Indian Institute of Pulses Research, Kanpur, India. P. 18 & 24

Tiwari, S. (2010). Estimation of heterosis, combining ability and genetic components for yield and yield attributes in Pigeonpea (*Cajanus cajan* L.). *MSc (Agri) Thesis* submitted to UAS, Raichur

Kumar, S., Lohithaswa, H.C., Dharmaraj, P.S. (2003). Combining ability analysis for grain yield, protein content and other quantitative traits in pigeonpea. *J. Maharashtra Agric. Univ.* 28(2): 141-144.

Vaghela, K.O., Desai, R.T., Nizama, J.R., Patel, J.D. and Sharma, V. (2009). Combining ability analysis in pigeonpea. *Legume Research.* 32 (4): 274-277.

Yamanura, Lokesha, R., Dharmaraj, P.S., Muniswamy, S. and Diwan, J.R. (2014). Estimation of Heterosis, Combining ability and Gene action in Pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Elect. J. of Plant. Breed.,* 5(2): 173-178.