GENETIC ARCHITECTURE IN COWPEA [*Vigna unguiculata* (L.) WALP.]

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ABSTRACT

The investigation on genetic architecture in cowpea [Vigna unguiculata (L.) Walp.] was undertaken to examine the manifestation of heterosis. Eight diverse lines were crossed in a half diallel fashion and 28 F_1 hybrids were obtained. All the crosses and their parents were sown in randomized block design with three replications at Pulses Research Station, Navsari Agricultural University, Navsari during kharif 2012. A marked degree of heterobeltiosis varied from cross to cross. Nine hybrids expressed significant positive heterosis over better parent. The heterobeltiosis was laid to the range between -40.82 per cent (GC-5 x Pusa Komal) to 70.54 per cent (Subhra x GC-4). The top three heterobeltiotic cross combinations for seed yield per plant were Subhra x GC-4 (70.54 %), GC-3 x Anand Cowpea-1 (62.19%) and GC-502-2 x GC-4 (55.34%). Heterotic response for seed yield per plant was mainly due to high heterotic response observed for number of branches per plant, number of clusters per plant, pod length and number of seeds per pod. From the perusal of data indicated that seven hybrids expressed significant positive heterosis over better parent for seed yield per plant (g). The highest significant positive standard heterosis was recorded by Subhra x GC-4 (70.03%) followed by GC-502-2 x GC-4 (54.88%).

KEY WORDS: Cowpea, heterosis, heterobeltiosis, standard heterosis

INTRODUCTION

Cowpea is known by number of common names *viz*., crowdel pea, black-eyed pea, southern pea and internationally as lobia, coupe or frijole, is well adapted to the tropics. The major cowpea growing countries are Nigeria, Niger, Burkina Faso, Ghana, Kenya, Uganda, Malawi, Tanzania (all countries in Africa) and India, Sri Lanka, Burma, Bangladesh, Philippines, Indonesia, Thailand, etc. Cowpeas are low growing, vigorously bushy or trailing annual herbs. Cowpea is a warm weather and drought resistant crop. In India, it is mainly grown in Rajasthan, Gujarat, Maharashtra, Central India and some regions of Southern India. Cowpea is primarily used in the form of dry seeds, fodders, green pods, green manure and cover crops. Legumes provide the much needed proteins to our predominantly vegetarian population. It represents the second largest family of higher plants, second only to grasses in agricultural importance (Doyle and Luckow, 2003). Cowpea is comparatively a cheap source of quality protein, phosphorus, iron and vitamins and excellent substitute for meat, eggs and other protein rich foods. It is one of the chief pulses in common use in India. Nitrogen - fixing bacteria are present in the root nodules that capable of using free atmospheric nitrogen to produce nitrates on, nitrites, which can be readily used by the plants. Thus it added additional nitrogen in the soil. The overall effect of plant breeding on genetic diversity has been a long standing concern in the evolutionary biology of crop plants (Simmonds, 1962).

Heterosis has contributed significantly towards increased crop production and it has become the basis of multi-billion dollar agro-buisness in the world. The phenomenon of heterosis which manifests itself by greater vitality, rapid growth and development, higher productivity, resistance adaptation and uniformity of F_1 s has been extensively exploited in many self and cross pollinated crops. Cowpea is highly self pollinated crop and the scope for exploitation of hybrid vigour will depend on the direction and magnitude of heterosis and the type of gene action involved. The heterotic response over mid as well as better parents could be informative to identify true heterotic cross combinations. Heterosis for yield and other characters in grain legumes were first reported by Pal (1945). There is a wide range of variability available in the cultivars of cowpea. Therefore, in the present trial crosses between the released varieties were made to study the heterosis.

MATERIALS AND METHODS

The investigation was intended to elicit information on heterosis, heterobeltiosis and standard heterosis in cowpea for thirteen traits. The experiment consisted of thirty six (36) treatments comprising 8 parents and 28 F_1s including check (GC-3) were evaluated in randomized block design with three replications during *Kharif* 2012 at Pulses Research Station, Navsari Agricultural University, Navsari. The selfed seeds of eight diverse parental genotypes of cowpea were used and crossed were made in diallel fashion (excluding reciprocals). The emasculation and pollination was done as per method proposed by Ritchie *et al*. (1975). The spacing between rows was 45 cm and between plants was 10 cm. Border rows on both the sides of experimental plot were grown to avoid the border effect. Total experimental area was 90.72 m^2. The recommended agronomic practices and plant protection measures were adopted for raising a good crop. To record observations, five plants in each treatment in each replication were labelled at random. The thirteen traits were recorded in the field and laboratory and the mean values were subjected to statistical analysis for RBD as per Gomez and Gomez (1984). Mean values for various traits were used for estimation of heterosis. Heterosis expressed as per cent, increase or decrease of F_1 over mid-parent (Heterosis), better parent (Heterobeltiosis) and over standard check (Standard heterosis) was calculated for various characters using the various formulas.

RESULTS AND DISCUSSION

The analysis of variance for parents, hybrids and parents vs. hybrids compared for different thirteen characters under investigation are presented in Table 1. The mean squares due to genotypes, parents and hybrids were found significant for all the characters, indicated that there is sufficient variability among the genotypes as well as parents and F_1s for the characters under study and thus, there has been a chance for the improvement. The mean squares due to parents and hybrids indicated much variation among them. This indicated the existence of considerable variability contributed by the genetic causes. Parents vs. hybrids comparison indicated that means of hybrids were significantly different from means of parents as a group for all the characters, except for days to maturity, clusters per plant and harvest index, indicating substantial amount of heterosis for most of the characters.

The aim of estimation of heterosis in the present study was to find out the superior combinations of parents giving the high degree of useful heterosis for yield and its contributing characters and for its future use in breeding programme. Fonesca and Patterson (1968) coined the new term "heterobeltiosis" as an improvement of heterozygote in relation to better parent. The estimates of heterosis over mid parent, better parent and standard check for different characters are presented in Table 2.

Eighteen hybrids manifested significant negative heterosis for days to flowering over their respective mid parental value (Table 2). The same crosses also depicted significant negative (desirable) heterosis over their respective better parents. The crosses showing significant heterobeltiosis were Subhra x Pusa Komal (-28.41%), GC-502-2 x Subhra (-22.33%) and GC-502-2 x GC-4 (-22.00%). Twenty five hybrids exhibited significant negative standard heterosis over check. The hybrid GC-5 x Anand Cowpea-1 (-31.09%) was at pinnacle followed by GC-3 x GC-5 (-30.13%) and Subhra Pusa Komal (-28.41%). Pal *et al*. (2007), Aremu and Adewale (2010) and Ushakumari *et al*. (2010) have reported desirable heterosis in cowpea for number of days to 50 per cent flowering.

For days to 80 per cent maturity, five hybrids manifested significant negative relative heterosis (Table 2). The estimates of heterosis over better parent reveled that six crosses depicted significant negative (desirable) heterosis over their respective better parent with a range from -16.38 per cent (GC-5 x Anand Cowpea-1) to 7.77 per cent (GC-5 x GC-502-2). The crosses showing significant heterobeltiosis were GC-5 x Anand Cowpea-1 (-16.38%), GC-3 X GC-4 (-16.00%), Subhra x Pusa komal (-10.95%) and GC-3 x Anand Cowpea-1 (-10.06%). The hybrid GC-5 x Anand Cowpea-1 (-17.43%) was paramount followed by GC-3 x GC-4 (-16.00%) and Subhra x Pusa komal (-11.96%) showed peak standard heterosis. Seven cross combinations, depicted significant standard heterosis in desired direction for this trait. Results were in agreement with the findings of Bhor *et al*. (1997), Bhushana *et al*. (2000) and Mehta (2000).

Negative heterosis is considered as desirable for plant height. Seven hybrids exhibited significant negative heterosis over mid parental value (Table 2). Among twenty eight hybrids, twelve hybrids showed significant negative heterosis over better parent, of which three best hybrids were Anand Cowpea-1 x Pusa Phalguni (-37.90 %), GC-3x Pusa Phalguni (-37.35%) and GC-3 x GC-4 (-27.62%). When hybrid performance was compared with check (GC-3), it was observed that fifteen hybrids demonstrated significant negative heterosis. The hybrids Anand Cowpea-1 x Pusa Komal (-41.54%) and Anand Cowpea-1 x Pusa Phalguni (-40.16%) exhibited significant standard heterosis in desirable direction were the two best hybrids for short stature. Results were in agreement with the findings of Sangwan *et al*. (2000), Patil *et al*. (2005), Patel *et al*. (2009), Ushakumari *et al*. (2010) and Nwosu and Awa (2013).

Out of 28 hybrids, 12 hybrids showed significant positive heterobeltiosis and nine hybrids showed significant negative heterobeltiosis for number of branches per plant (Table 2). Cross combination Subhra x Pusa Phalguni (29.46%) had the highest heterobeltiosis for this trait, which was followed by the crosses GC-3 X Subhra (25.68%) and GC-5 X GC-502-2 (24.32%). In case of standard heterosis, none of hybrids showed positive and significant heterosis over check (GC-3). Its magnitude ranged from -23.76 per cent (Anand Cowpea-1 x Pusa Komal) and (Pusa Phalguni x Pusa Komal) to 2.84 per cent (Subhra x Pusa Phalguni). Present results are in accordance with the results of Sangwan *et al.* (2002), Patil *et al*. (2005), Patel *et al*. (2009) and Aremu and Adewale (2010).

An examination of extent of heterosis revealed that eight hybrids showed significant positive relative heterosis for number of clusters per plant (Table 2). Only three hybrids GC-5 x Subhra (12.96%), GC-3 x Subhra (12.50%) and GC-5 x Pusa Phalguni (11.11%) exhibited significant heterobeltiosis in positive direction for this trait. The range of standard heterosis for check (GC-3) was observed from -28.15 per cent (GC-3 x Subhra) to -5.30 per cent (Subhra x Anand Cowpea-1). None of the crosses showed positive significant heterosis over standard check. Mehta (2000), Shashibhushan and Chaudhari (2000) and Ushakumari *et al*. (2010) supported to the results for number of clusters per plant.

The hybrid performance data pertained that twelve hybrids exhibited significant positive heterosis over mid parent for number of pods per plant (Table 2). With respect to heterobeltiosis, five hybrids exhibited significant positive heterotic effect over their respective better parent. The cross Subhra x Pusa Phalguni (24.74 %) was associated with maximum heterosis over their better parent followed by the crosses Subhra x GC-4 (20.63%) and GC-502-2 x GC-4 (16.36%). None of the cross combinations showed significant and positive standard heterosis for number of pods per plant over check (GC-3). Results are in harmony with the findings of Patil *et al*. (2005), Patel *et al*. (2009), Ushakumari *et al*. (2010), Yadav *et al*. (2010) and Nwosu and Awa (2013).

The data for pod length reveled that sixteen hybrids registered significant positive heterosis over mid parent (Table 2). A perusal of the data presented on heterobeltiosis revealed that ten and fourteen hybrids exhibited significant positive and negative heterosis over better parent, respectively. The estimation of data for economic heterosis over check (GC-3) revealed that only two hybrids Anand Cowpea-1 x Pusa Komal (7.74%) and GC-4 x Pusa Komal (6.77%) showed significant positive heterosis for this trait. Results are supported by Sangwan *et al*. (2000), Savithramma *et al*. (2001), Patil *et al*. (2005), Patel *et al*. (2009) and Ushakumari *et al*. (2010).

The estimates of relative heterosis for number seeds per pod indicated that twenty seven hybrids had significant and positive heterosis, whereas only one hybrid exhibited significant heterosis in negative direction (Table 2). In all crosses, twenty three crosses showed significant positive and only one crosses showed significant negative better parent heterosis. The highest heterobeltiosis to the extent of 36.01 per cent (Anand Cowpea-1 x Pusa Phalguni) was recorded over its superior parental value, followed by the cross GC-5 x GC-502-2 (32.35%), GC-502-2 x Anand Cowpea-1 (30.29%), and Subhra x Anand Cowpea-1 (25.82%). With respect to standard heterosis for check (GC-3), twenty one and two hybrids, respectively showed significant positive and negative heterosis for number of seeds per pod. The number of seeds per pod might be resulted in to increasing yield of pod which resulted in higher seed yield per plant. These results are in agreement with those reported by several earlier workers like Shashibhushan and Chaudhari (2000), Patil *et al*. (2005) and Ushakumari *et al*. (2010).

Fifteen hybrids exhibited significant positive heterosis over mid parent for seed yield per plant (g) (Table 2). Nine hybrids expressed significant positive heterosis over better parent. The heterobeltiosis was laid to the range between -40.82 per cent (GC-5 x Pusa Komal) to 70.54 per cent (Subhra x GC-4). The top three heterobeltiotic cross combinations for seed yield per plant were Subhra x GC-4 (70.54 %), GC-3 x Anand Cowpea-1 (62.19%) and GC-502-2 x GC-4 (55.34%). With respect to standard heterosis, seven hybrids depicted significant positive. The highest significant positive standard heterosis was recorded by Subhra x GC-4 (70.03%) followed by GC-502-2 x GC-4 (54.88%). The heterotic response of F_1 is indicative of genetic diversity among the parents involved (Moll *et al*., 1962). Almost identical results have been reported by Aravindhan and Das, (1996), Ponmariammal and Das (1996), Shashibhushan and Chaudhari (2000), Sangwan *et al*. (2002), Patil *et al*. (2005) Ushakumari *et al*. (2010).

The data revealed that ten hybrids exhibited significant positive heterosis over mid parental value for 100 seed weight (g) and five hybrids expressed significant positive heterosis over better parent (Table 2). The hybrids showing positive heterosis over better parent were Subhra x GC-4 (19.15 %), GC-4 x Pusa Komal (17.93%) and Anand Cowpea-1 x Pusa Komal (17.19%). None of the hybrids demonstrated positive significant heterosis. The hybrids *viz*., Subhra x GC-4 (4.53%), GC-4 x Pusa

Komal (3.47%) and GC-3 x GC-4 (2.67%) were exhibited maximum standard heterosis. Sawant *et al*. (1994), Sangwan *et al*. (1995), Bhor *et al*. (1997), Shashibhushan and Chaudhari (2000) and Patel *et al*. (2009) reported the similar results for 100 seed weight (g).

The estimates of relative heterosis for straw yield indicated that eleven hybrids had significant and positive heterosis and three hybrids exhibited significant heterosis in negative direction (Table 2). With respect to heterobeltiosis, four hybrids exhibited significant positive heterotic effect over their respective better parent. The cross Pusa Phalguni x Pusa Komal (19.71%) was associated with maximum heterosis over their better parent followed by the cross GC-4 x Pusa Komal (16.23%) and GC-5 x Pusa Phalguni (10.11%). When hybrid performance was compared with check (GC-3), only one hybrid GC-4 x Pusa Komal (11.95%) demonstrated significant positive heterosis. Results are in accordance with the results of Sawant *et al*. (1994), Sangwan *et al.* (2002) and Yadav *et al*. (2010).

The estimates of relative heterosis for harvest index indicated that only one hybrid had significant and positive heterosis (Table 2). None of the hybrid showed significant positive heterosis over better parent. With respect to standard heterosis, the minimum and maximum values of standard heterosis for harvest index were -19.82 per cent (GC-3 x Subhra) and 6.96 per cent (GC-4 x Pusa Komal), respectively. It was observed that only numerical increment was observed against check, which might be due to its high energy consumption for biomass rather than economic part. Sawant *et al*. (1994) and Philip (2004) reported the similar results for harvest index.

An examination of the extent of heterosis revealed that twenty two hybrids possessed significant and positive mid-parent heterosis for the protein content (%). The hybrids showing highest heterosis percentage over better parents were Subhra x Pusa Komal (47.01%) followed by GC-4 x Pusa Komal (23.53%). For standard heterosis, five hybrids showed positive and significant heterosis for protein content. Top three ranking hybrids were Subhra x Pusa Phalguni (16.65%), Subhra x Pusa Komal (14.50%) and GC-5 x Anand Cowpea-1 (10.85%). Present results are in harmony with Arvindhan and Das (1996), Shashibhushan and Chaudhari (2000), Savithramma *et al*. (2001) and Patel *et al*. (2009).

CONCLUSION

The top four crosses, Subhra x GC-4, GC-502-2 x GC-4, GC-4 x Pusa Komal and GC-502-2 x Pusa Komal showed significant desirable standard heterosis was different in respect to all most all the characters studied. This conclusion clearly indicated that only a single yield attribute with high heterosis is not sufficient to cause the quantum jump in the seed yield, but it is the combined interaction effects of major yield contributors. The critical study of these top four performing hybrids thus, clearly indicated that as the high heterosis for seed yield coupled with high heterosis for yield attributes suggests that there is a predominance of additive gene action for seed yield per plant heterosis.

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Table 1: Analysis of variance (mean squares) for experimental design for different characters in cowpea

Source of Variation	d.f.	Days to Flowering	Days to Maturity	Plant Height (cm)	Branches per Plant	Clusters Per Plant	Pods Per Plant	Pod Length (cm)
Replication	2	11.37	5.67	38.22	0.15	0.31	3.63	0.20
Genotype	35	53.86**	49.19**	3180.77**	1.50**	1.90**	45.37**	7.50**
Parents	7	40.48**	31.45*	1167.82**	1.79**	3.17**	49.13**	6.70**
Hybrids	27	51.96**	55.61**	3557.02**	1.31**	1.61**	45.65**	7.63**
Parents *vs.* Hybrids	1	198.69**	0.05	7112.79**	4.63**	0.79	11.35*	9.61**
Error	70	4.22	12.12	34.15	0.16	0.23	1.87	0.08
SEm ±	1.19	2.01	3.37	0.23	0.28	0.79	0.16	

Table 1: Contd…

Source of Variation	d.f.	Seeds per Pod	Seed Yield per Plant (g)	100 Seed Weight (g)	Straw Yield (g)	Harvest Index (%)	Protein Content (%)
Replication	2	0.16	23.06	0.09	13.47	24.81	0.09
Genotype	35	6.57**	159.21**	5.66**	119.08**	35.11**	23.87**
Parents	7	1.76**	59.50**	7.865**	179.43**	39.36*	22.58**
Hybrids	27	5.11**	165.76**	5.30**	100.83**	33.75*	20.64**
Parents *vs.* Hybrids	1	79.85**	680.36**	1.38*	189.20**	41.85	120.67**
Error	70	0.10	10.97	0.26	7.28	18.17	0.11
SE±	0.18	1.91	0.29	1.56	2.46	0.19	

****, ** Significant at 5 per cent and 1 per cent levels of probability, respectively.***

Table 2: The estimates of heterosis (%) over mid parent, better parent and standard check for different characters in cowpea

Hybrids	Days to Flowering			Days to Maturity			Plant Height (cm)			Branches per Plant		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
GC-3 x GC-5	-9.33**	-10.67**	-20.73**	-4.86	-6.53	-6.53	36.34**	25.80**	25.80**	14.86**	14.86**	-9.57**
GC-3 x GC-502-2	-10.43**	-13.80**	-17.27 **	-4.72	-7.87*	-7.87*	107.05**	76.94**	76.94**	19.73**	18.92**	-6.38
GC-3 x Subhra	-11.12**	-16.12**	-16.12**	-4.38	-4.93	-4.93	87.81**	54.70**	54.70**	25.96**	25.68**	-1.06
GC-3 x GC-4	-15.51**	-21.27**	-30.13**	-10.34**	-16.00**	-16.00**	-20.87**	-27.62**	-27.62**	-6.18	-10.93**	-21.99**
GC-3 x Anand Cowpea-1	-14.34**	-14.92**	-24.50**	-9.49 **	-10.06**	-10.06**	-10.81**	-12.43**	-12.43**	-1.98	-12.41**	-12.41**
GC-3 x Pusa Phalguni	-11.56**	-13.72**	-19.51**	-6.30 *	7.24*	-7.24*	-18.19**	-37.35**	-37.35**	9.42*	8.93*	-13.48**
GC-3 x Pusa Komal	-2.00	-3.10	-12.03**	1.95	0.00	0.00	3.96	-17.83**	-17.83**	-7.50*	-13.95**	-21.28**
GC-5 x GC-502-2	1.05	-4.13	-8.00*	9.53 **	7.77*	4.00	-0.62	-8.63	-22.75**	25.17**	24.32**	-2.13
GC-5 x Subhra	-6.91 *	-13.37**	-13.37**	-1.72	-2.90	-4.00	27.59**	12.64*	-4.77	9.26*	9.01*	-14.18**
GC-5 x GC-4	8.10*	2.15	-12.03**	0.72	-4.05	-7.40*	33.68**	32.41**	11.94**	15.57**	9.72*	-3.90
GC-5 x Anand Cowpea-1	-20.63**	-21.27**	-31.09**	-15.42**	-16.38*	-17.43**	5.65	-11.44*	-14.67**	3.97	-7.09*	-7.09*
GC-5 x Pusa Phalguni	6.13	2.06	-4.80	4.39	3.61	1.52	-3.43	-21.35**	-33.51**	9.42*	8.93*	-13.48**
GC-5 x Pusa Komal	5.10	2.40	-7.04 *	2.62	2.44	-1.14	19.09**	0.45	-15.08**	3.75	-3.49	-11.70**
GC-502-2 x Subhra	-20.73**	-22 33**	-22.33**	1.66	-1.15	-2.27	37.70**	31.69**	-6.61	17.73**	17.19**	-8.16*
GC-502-2 x GC-4	-13.27**	-22.00**	-25.14**	6.83	3.38	-3.45	33.87**	24.17**	2.97	12.45**	6.07	-7.09*
GC-502-2 x Anand Cowpea-1	-3.00	-7.27*	-11.00**	0.50	-2.22	-3.45	36.69**	18.64**	14.32**	-6.59	-17.02**	-17.02**
GC-502-2 x Pusa Phalguni	-12.37**	-13.60**	-17.08**	-0.90	-3.22	-5.18	92.49**	68.39**	19.41**	19.19**	17.86**	-6.38
GC-502-2 x Pusa Komal	-7.30 *	-9.80**	-13.44**	7.95*	6.39	2.32	-15.17**	-22.85**	-45.29**	5.66	-2.33	-10.64**
Subhra x GC-4	-11.55**	-21.88**	-21.88**	4.73	-1.36	-2.48	87.62**	67.03**	38.52**	-0.85	-6.07	-17.73**
Subhra x Anand Cowpea-1	5.36	-1.22	-1.22	4.20	4.13	2.95	16.43**	-2.68	-6.23	-6.96*	-17.02**	-17.02**
Subhra x Pusa Phalguni	-10.63**	-13.63**	-13.63**	4.00	3.53	2.36	75.94**	60.21**	3.71**	30.34**	29.46**	2.84
Subhra x Pusa Komal	-24.95**	-28.41**	-28.41**	-9.72**	-10.95*	-11.96**	84.01**	74.56**	13.00**	8.98	1.16	-7.45*
GC-4 x Anand Cowpea-1	11.15**	4.24	-8.77**	7.69*	1.49	0.21	-6.34	-12.86**	-16.04**	0.57	-5.67	-5.67
GC-4 x Pusa Phalguni	5.95	-3.50	-9.98 **	6.77*	0.99	-1.05	-10.81*	-26.82**	-39.31**	18.05**	12.55**	-1.42
GC-4 x Pusa Komal	-9.06**	16.14**	-23.86 **	2.64	-2.06	-5.81	0.54	-14.52**	-29.11**	1.39	-0.87	-9.22**
A. Cowpea-1 x Pusa Phalguni	5.31	2.06	-4.80	3.17	2.77	1.47	-19.95**	-37.90**	-40.16**	1.98	-8.51*	-8.51*
A. Cowpea-1 x Pusa Komal	-11.52**	-13.11**	-21.11**	-3.69	-4.95	-6.15	-24.29**	-39.32**	-41.54**	-20.37**	-23.76**	-23.76**
Pusa Phalguni x Pusa Komal	-12.34**	-13.51**	-19.32**	2.32	1.38	-0.67	20.44**	15.34*	-33.01**	-10.79**	-16.67**	-23.76**
SEm ±	1.45	1.68	1.68	2.46	2.84	2.84	4.13	4.77	4.77	0.28	0.33	0.33
CD at 5%	2.90	3.35	3.35	4.91	5.67	5.67	8.24	9.52	9.52	0.56	0.65	0.65
CD at 1%	3.85	4.44	4.44	6.52	7.53	7.53	10.94	12.63	12.63	0.75	0.86	0.86

Table 2: Contd…..

Hybrids	Number of Clusters per Plant			Number of Pod per Plant			Pod Length (cm)			Number of Seeds per Pod		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
GC-3 x GC-5	15.95**	8.47	-10.93**	17.91**	8.22	-20.00**	-11.90**	-16.52**	-27.66**	4.76*	0.29	-6.32**
GC-3 x GC-502-2	4.92	-1.07	-8.28*	8.94	-0.28	-11.27**	-2.61	-8.84**	-20.70**	26.35**	25.34**	7.09**
GC-3 x Subhra	-12.32**	12.50*	-28.15**	-11.53*	-11.99*	-34.94**	0.22	-8.04**	-20.31**	33.93**	24.18**	24.18**
GC-3 x GC-4	5.14	-0.36	-8.61*	1.96	-6.06	-17.59**	1.90	-4.24**	-17.02**	8.57**	1.98	-0.82
GC-3 x Anand Cowpea-1	1.09	-7.95*	-7.95*	23.44**	7.34	7.34	-3.87**	-5.80**	-18.38**	22.58**	17.35**	9.62**
GC-3 x Pusa Phalguni	6.90	0.00	-17.88**	6.22	-2.05	-27.59**	-6.99**	-9.38**	-21.47**	-8.93**	15.24**	-15.93**
GC-3 x Pusa Komal	-0.39	-4.44	-14.57**	-19.74**	-30.16**	-30.25**	0.31	-6.38**	-6.38**	11.28**	3.31	3.02
GC-5 x GC-502-2	3.23	-8.57*	-15.23**	-2.27	-17.21**	-26.33**	13.96**	12.97**	-12.38**	39.32**	32.35**	23.63**
GC-5 x Subhra	20.52**	12.96**	-7.62	12.57*	3.81	-24.05**	9.13**	5.49**	-18.18**	18.75**	14.84**	14.84**
GC-5 x GC-4	13.18**	0.72	-7.62	-2.46	-16.88**	-27.09**	11.70**	10.72**	-14.12**	10.95**	8.76**	5.77**
GC-5 x Anand Cowpea-1	-15.83**	-27.81**	-27.81**	-13.93**	-30.38**	-30.38**	-5.66**	-8.84**	-24.18**	8.24**	8.24**	1.10
GC-5 x Pusa Phalguni	11.11*	11.11*	-20.53**	5.20	4.67	-34.68**	1.94	0.94	-18.57**	16.12**	12.74**	11.81**
GC-5 x Pusa Komal	-9.47*	-18.52**	-27.15**	-33.28**	-46.01**	-46.08**	4.79**	-6.96**	-6.96**	15.50**	11.85**	11.54**
GC-502-2 x Subhra	7.73*	1.43	-5.96	23.03**	12.09	-0.25	10.39**	7.61**	-17.99**	12.54**	3.57	3.57
GC-502-2 x GC-4	1.26	0.71	-6.62	17.19**	16.36**	3.54	19.04**	19.04**	-9.28**	30.01**	22.03**	18.68**
GC-502-2 x Anand Cowpea-1	-5.84	-9.27*	-9.27*	1.14	-4.43	-4.43	18.45**	13.49**	-5.61**	37.15**	30.29**	21.70**
GC-502-2 x Pusa Phalguni	12.50**	-0.36	-7.62	-5.02	-19.20**	-28.10**	3.30*	-0.47	-18.18**	19.04**	9.97**	9.07**
GC-502-2 x Pusa Komal	2.55	0.71	-6.62	9.65*	3.68	3.54	6.04**	6.58**	-6.58**	18.98**	9.64**	9.34**
Subhra x GC-4	4.96	-0.72	-8.94*	31.55**	20.63**	5.82	18.20**	15.23**	-12.19**	13.85**	12.09**	12.09**
Subhra x Anand Cowpea-1	4.19	-5.30	-5.30	14.62**	-0.76	-0.76	6.19**	0.70	-17.41**	30.11**	25.82**	25.82**
Subhra x Pusa Phalguni	13.61**	6.48	-12.91**	34.64**	24.74**	-8.73*	-8.66**	-14.12**	-29.40**	11.17**	10.71**	10.71**
Subhra x Pusa Komal	7.54	2.96	-7.95*	13.53**	-1.65	-1.77	8.84**	6.19**	-6.19**	17.47**	17.31**	17.31**
GC-4 x Anand Cowpea-1	-10.54**	-14.24**	-14.24**	-19.89**	-24.81**	-24.81**	4.61**	0.23	-16.63**	7.20**	5.08*	2.20
GC-4 x Pusa Phalguni	4.67	-6.86	-14.57**	31.37**	12.41*	-1.39	-9.16**	-12.47**	-28.05**	6.57**	5.54*	4.67*
GC-4 x Pusa Komal	1.65	0.36	-7.95*	-2.53	-8.49*	-8.61*	21.19**	6.77**	6.77**	19.39**	17.91**	17.58**
A. Cowpea-1 x Pusa Phalguni	-2.32	-16.23**	-16.23**	-2.73	-21.01**	-21.01**	12.75**	12.09**	-6.77**	40.00**	36.01**	34.89**
A. Cowpea-1 x Pusa Komal	-23.08**	-27.15**	-27.15**	-30.59**	-30.63**	-30.63**	17.63**	7.74**	7.74**	28.59**	24.52**	24.18**
Pusa Phalguni x Pusa Komal	16.46**	4.81	-6.29	12.01**	-9.00*	-9.11*	2.12	-6.96**	-6.96**	10.22**	9.92**	9.62**
SEm $\pm$	0.34	0.39	0.39	0.97	1.12	1.12	0.20	0.23	0.23	0.23	0.26	0.26
CD at 5%	0.68	0.78	0.78	1.93	2.22	2.22	0.40	0.46	0.46	0.45	0.52	0.52
CD at 1%	0.90	1.04	1.04	2.56	2.95	2.95	0.53	0.61	0.61	0.60	0.69	0.69

Table 2: Contd…..

Hybrids	Seed Yield per Plant (g)			100 Seeds Weight (g)			Straw Yield (g)			Harvest Index (%)			Protein Content (%)		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
GC-3 x GC-5	3.16	-0.32	-24.49*	-16.74**	-22.40	-22.40**	-7.19	-12.25*	-24.24**	9.89	0.71	0.71	14.94**	8.82**	1.97
GC-3 x GC-502-2	34.42**	16.76	11.88	-4.44	-8.24	-13.87**	-10.25*	-16.38**	-16.38**	-5.99	-12.64	-15.24*	27.45**	12.18**	5.12**
GC-3 x Subhra	27.68*	20.81	-4.35	5.23	2.47	-11.47**	-6.16	-6.99	-18.27**	-8.15	-12.16	-19.82**	6.43**	-0.28	6.56**
GC-3 x GC-4	32.56**	13.25	12.91	17.92**	17.02	2.67	-1.39	-6.50	-9.94*	0.80	-4.87	-10.72	-8.91**	-16.12**	-21.40**
GC-3 x Anand Cowpea-1	78.87**	62.19**	40.86**	13.31**	2.47	-11.47**	-5.20	-8.20	-15.39**	-4.96	-8.46	-17.68*	6.32**	4.31**	1.57
GC-3 x Pusa Phalguni	-8.60	-23.80*	-46.16**	-5.45	-19.75	-30.67**	-20.73**	-38.02**	-46.49**	12.39	4.38	1.41	4.70**	1.40	1.40
GC-3 x Pusa Komal	-10.51	-23.64*	-23.64*	-0.49	-6.48	-19.20**	12.10	0.24	-13.46**	9.89	7.65	-10.33	11.67**	-0.14	-6.43**
GC-5 x GC-502-2	14.82	2.80	-1.50	-15.82**	-18.40	-18.40**	12.45**	-0.53	-0.53	1.83	0.32	0.32	25.54**	16.19**	-2.72*
GC-5 x Subhra	10.82	8.43	-14.16	-18.18**	-25.60	-25.60**	15.84**	8.61	-4.55	-4.50	-8.66	-8.66	18.07**	16.77**	-2.23*
GC-5 x GC-4	6.61	-6.19	-6.47	3.41	-9.33	-9.33**	1.00	-9.13	-12.52**	-10.82	-13.56*	-13.56*	19.69**	16.22**	-2.69*
GC-5 x Anand Cowpea-1	-4.56	-10.66	-22.41*	1.41	-16.27	-16.27**	-2.43	-10.50*	-17.51**	0.40	-4.65	-4.65	22.42**	13.84**	10.85**
GC-5 x Pusa Phalguni	26.78	2.85	-22.09*	1.16	-18.93	-18.93**	34.88**	10.11	-15.31**	-4.59	-5.95	-5.95	1.61	-6.65**	-6.65**
GC-5 x Pusa Komal	-32.65**	-40.82**	-40.82**	13.03**	-23.47	-23.47**	-15.93**	-19.10**	-32.71**	-1.40	-11.30	-11.30	14.30**	7.59**	-9.92**
GC-502-2 x Subhra	43.31**	30.85**	25.39*	2.53	-3.98	-9.87**	8.39*	1.81	1.81	5.44	2.32	-0.73	1.30	-5.27**	-22.43**
GC-502-2 x GC-4	58.43**	55.34**	54.88**	1.32	-4.55	-10.40**	5.63	3.68	3.68	3.97	2.27	-0.77	8.30**	3.08*	-18.70**
GC-502-2 x Anand Cowpea-1	30.43**	24.33*	19.13	6.84	-18.75	-23.73**	3.90	-0.17	-0.17	8.02	4.07	0.97	19.14**	3.17**	0.46
GC-502-2 x Pusa Phalguni	23.17	8.11	-11.95	9.69*	-9.94	-15.47**	23.33**	-8.32	-8.32	0.41	0.34	-2.52	14.18**	-2.23*	-2.23*
GC-502-2 x Pusa Komal	56.42**	53.15**	53.15**	18.05**	6.82	0.27	3.04	-5.62	-5.62	9.74	0.06	-2.92	7.79**	5.88**	-21.77**
Subhra x GC-4	90.11**	70.54**	70.03**	23.27**	19.15	4.53	-0.44	-4.81	-8.31	10.66	9.14	2.43	12.46**	10.38**	-9.61**
Subhra x Anand Cowpea-1	36.08**	30.02*	12.91	8.61*	-15.31	-30.67**	6.14	3.67	-4.45	0.97	0.22	-8.52	10.13**	1.37	-1.29
Subhra x Pusa Phalguni	28.46	2.49	-18.86	18.70**	-25.08	-38.67**	20.55**	-6.34	-17.70**	5.47	2.29	-0.63	28.27**	16.65**	16.65**
Subhra x Pusa Komal	47.38**	32.03**	32.03**	6.42	2.61	-16.00**	8.68	5.77	-7.05	4.09	-2.40	-10.91	47.01**	39.82**	14.50**
GC-4 x Anand Cowpea-1	-5.99	-12.05	-12.31	7.61*	-3.34	-15.20**	1.37	-0.82	-4.46	0.60	-1.51	-7.56	10.25**	-0.23	-2.85**
GC-4 x Pusa Phalguni	59.54**	17.49	17.15	13.51**	-4.26	-16.00**	42.44**	7.21	3.26	3.75	1.99	-0.92	3.70**	-18.87**	-13.87**
GC-4 x Pusa Komal	53.86**	58.64**	53.64**	26.38**	17.93**	3.47	24.74**	16.23**	11.95*	23.11**	13.96	6.96	27.59**	23.56**	-2.55*
A. Cowpea-1 x Pusa Phalguni	48.62**	14.65	-0.43	6.97	-0.33	-30.40**	41.46**	8.88	-0.39	2.07	-1.73	-4.53	-17.53**	-18.61**	-18.61**
A. Cowpea-1 x Pusa Komal	11.86	4.50	4.50	22.12**	17.19**	-10.93**	11.90*	6.45	-1.89	10.84	4.67	-5.87	0.61	-12.60**	-14.90**
Pusa Phalguni x Pusa Komal	54.06**	13.36	13.36	23.68**	10.88*	-15.73**	51.09**	19.74**	-0.40	8.14	-1.46	-4.27	12.29**	-2.38*	-2.38*
SEm ±	2.34	2.70	2.70	0.36	0.41	0.41	1.91	2.20	2.20	3.01	3.48	3.48	0.23	0.27	0.27
CD at 5%	4.67	5.39	5.39	0.71	0.82	0.82	3.80	4.39	4.39	6.01	6.94	6.94	0.47	0.54	0.54
CD at 1%	6.20	7.16	7.16	0.95	1.10	1.10	5.05	5.83	5.83	7.98	9.22	9.22	0.62	0.72	0.72

, ** Significant at 5 per cent and 1 per cent levels of probability, respectively.

[MS received: October 11, 2016] ***[MS accepted: November 27, 2016]***