

HYBRID VIGOUR FOR POD YIELD AND SEED PROTEIN CONTENT IN COWPEA [*Vigna unguiculata* (L.) WALP]

*KATARIYA, H. M.; PARMAR, V. L.; AHIR, S. D.;
SOLANKI, H. V. AND MAGHERA, Y. V.

DEPARTMENT OF GENETICS & PLANT BREEDING
N.M. COLLEGE OF AGRICULTURE,
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI 396 450, GUJARAT, INDIA

*Email: katariyahitesh52@gmail.com

ABSTRACT

The present study on hybrid vigour for seed yield, its components and protein content was carried out in a set of 21 F₁ hybrids of cowpea obtained from a diallel mating design involving seven elite parental lines at Navsari Agricultural University, Navsari during Kharif 2013. All hybrids exhibited significant variation among them and parents vs. hybrids significant for days to 50% flowering, plant height, seed yield per plant and protein content. The degree of heterosis varied from cross to cross for all the characters. None of the hybrid showed heterosis for all the studied characters. The economic heterosis was ranged from -45.67 to 4.15 per cent for seed yield per plant. The highest standard heterosis was recorded by cross GC 4 x Waghai local (12.45%) followed by W 3-2 x W 5 (10.38%), CDP 108 x CDP 11 (8.30%), Phule CP-5040 x W 5 (6.23%) and Waghi Local x W 5 (4.15%). Heterosis for plant height, branches per plant, pods per plant and pod length are the major yield increasing attributes of the top most hybrids.

KEY WORDS: Cowpea, diallel, hybrid vigour, seed yield

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important vegetable crop, native of West Africa (Vavilov, 1951), but Steele (1976) suggested Ethiopia as the primary and Africa as the secondary centre of diversity. It is a diploid species with somatic chromosome number 2n=22 (Darlington and Wylie, 1955). Among all the pulses, cowpea locally known as *lobiya*, *chowla* (*chowli*), *southern pea* or *black eye pea*, is an annual legume that is adopted to warm condition and cultivated in the tropics and sub-tropics for dry grains, green edible pods for vegetable as well

as fodder. Cowpea fits well in a variety of cropping system and is grown as cover crop, mixed crop, catch crop and green manure crop. Being a pulse crop it is capable of restoring soil fertility and therefore, remains an integral part of subsistence and sustainable production system. It is chiefly important source of protein and varies from 20 – 25 per cent that is double of the protein in most cereals (Stanton, 1966).

In different parts of the country, still local strains of cowpea are commercially grown by farmers, which results into very low yield. Poor performance of local varieties is due to

genetic impurities. No doubt, there are few improved varieties of cowpea available in our country and are exploited commercially. However, more emphasis should be given to further genetic improvement, through extensive research. The phenomenon of heterosis has been a powerful in the evolution of plants and it has been exploited extensively in crop production which is the greatest practical achievement of the science of genetics and plant breeding. Exploitation of hybrid vigour has been recognized as an important tool for making genetic improvement of yield and its attributing characters in cowpea by several earlier workers Sharma *et al.* (2010), Meena *et al.* (2010) and Chaudhari *et al.* (2013). Therefore, present study was undertaken to assess the extent of exploitation of heterosis in 7×7 diallel crosses without reciprocals in cowpea.

MATERIALS AND METHODS

An experiment was conducted during *Kharif* 2013 at the Pulses Research Station, Navsari Agricultural University, Navsari. The experimental materials comprised of seven elite lines namely GC 4, W 3-2, CDP 108, Phule Cp-5040, CDP 11, Waghai Local and W 5 were crossed in all possible combinations excluding reciprocals to obtain 21 hybrids. The emasculation and pollination was done as per method proposed by Ritchie *et al.* (1975). At the same time, all the seven lines were selfed, so as to get sufficient seeds for experiment. The complete set of 21 F_1 s and seven parents were grown in randomized block design (RBD) with three replications. The spacing kept 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. The recommended agronomic practices and plant protection measures were adopted

for raising a good crop. Observations were recorded on important characters, viz. days to 50 per cent flowering (days), plant height (cm), number of branches per plant, number of pods per plant, pod length (cm), number of seeds per pod, seed yield per plant (g), harvest index (%) and protein content (%). Heterotic effects were expressed as percentage increase or decrease over better parent (Hayes *et al.*, 1955) and standard variety (GC 4) (Fonseca and Patterson, 1968).

RESULTS AND DISCUSSION

From the analysis of variance (Table 1), it was observed that the mean square due to parents was significant for plant height, pod length, seed per pod, seed yield per plant, harvest index and protein content, which implying variability existed between them. Sharma *et al.* (2010) reported that heterosis did not always occur in crosses between widely divergent parents, but also observed in closely related parents. All hybrids generated showed significant variability between them. The significant variation observed between parents and hybrids for days to 50% flowering, plant height, seed yield per plant and protein content. These results are more or less observed by Pal *et al.* (2007), Meena *et al.* (2010), Chaudhari *et al.* (2013).

The primary objective of heterosis breeding is to achieve a quantum jump in yield of crop plants. Heterosis over standard parent for nine characters is presented in Table 2. The results indicated that the phenomenon of heterosis was of a general occurrence for almost all the characters under study. Several workers reported substantial heterosis for various agronomic characters. This result is in accordance with Ushakumari *et al.* (2010) and Yadav *et al.* (2010).

Days to 50% flowering

The estimates of heterosis for days to 50 % flowering revealed that heterosis ranged from 39.73 per cent (CDP 11 x W 5) to 10.29 per cent (GC 4 x CDP 11). Among the twenty one crosses, none of the cross exhibited negative heterosis for this trait. The results were supported by the findings of Mehta (2000), Pal *et al.* (2007), Ushakumari *et al.* (2010).

Plant height (cm)

With regards to heterobeltiosis for plant height, it varied from -31.01 per cent (Phule CP-5040 x Waghi Local) to -2.30 per cent (GC 4 x W 3-2). All hybrids were dwarf over the standard variety GC 4. The present findings were in close association with the results reported by Patel *et al.* (2009), Ushakumari *et al.* (2010) and Sharma *et al.* (2010).

Branches per plant

Five crosses had the positive heterosis in desired direction. The range of standard heterosis was from -25.74 per cent (CDP 108 x W 5) to 7.00 per cent (GC 4 x Waghi Local). The highest significant heterosis over GC 4 was recorded by cross GC 4 x Waghi Local (7.00%) followed by W 3-2 x W 5 (5.83%) and CDP 108 x CDP 11 (4.67%). These results were in confirmation with the results reported by Patel *et al.* (2009), Chuadhari *et al.* (2013) and Kadam *et al.* (2013).

Number of pods per plant

Out of twenty one crosses, GC 4 x Waghi Local (5.82%) followed by W 3-2 x W 5 (4.85%) and CDP 108 x CDP 11 (3.88%), Phule CP-5040 x W 5 (2.91) and Waghi Local x W 5 (1.94) exhibited positive heterotic effects over standard variety. The results were in agreement with the findings of Ushakumari *et al.* (2010), Chuadhari *et al.* (2013) and Kadam *et al.* (2013).

Pod length (cm)

With regards to heterosis for pod length, it varied from -23.31 per cent

(CDP 108 x W 5) to 6.33 per cent (GC 4 x CDP 11). With respect to heterosis, sixteen hybrids recorded negative heterotic effects and five hybrids were positive. The present findings were in close association with the results reported by Patel *et al.* (2005), Patel *et al.* (2009) and Ushakumari *et al.* (2010).

Number of seeds per pod

Seeds per pod is an important component which considerably contributes towards higher seed yield. In case of number of seeds per pod, only four crosses showed heterosis over standard variety in desired direction. The cross W 3-2 x CDP 108 (6.25%) exhibited highest economic heterosis. The results reported by Patel *et al.* (2005), Patel *et al.* (2009) and Ushakumari *et al.* (2010).

Seed yield per plant

For this economically important trait, heterosis over better parent varied from -45.67 per cent (CDP 108 x W 5) to 12.45 per cent (GC 4 x Waghi Local). Under present study, sixteen crosses showed significant heterobeltiosis. Out of sixteen, five crosses exhibited positive heterosis. The highest economic heterosis was recorded in hybrid GC 4 x Waghi Local (12.45%) followed by W 3-2 x W 5 (10.38%), CDP 108 x CDP 11 (8.30%), Phule CP-5040 x W 5 (6.23%) and Waghi Local x W-5 (4.15%). Similarly, The results were in agreement with the findings of Ushakumari *et al.* (2010), Kajale and Ravindrababu (2012), Chaudhari *et al.* (2013) and Kadam *et al.* (2013).

Harvest index

Heterotic effects for harvest index varied from -24.83 per cent (CDP 108 x W 5) to 27.00 per cent (CDP 11 x Waghi Local). With respect to heterosis, fourteen hybrids showed positive heterotic effects, of which seven hybrids showed significant

positive heterosis and five hybrids expressed significant negative standard heterosis for this trait. Positive heterosis for this trait was reported by Chuadhari *et al.* (2013) and Kadam *et al.* (2013)

Protein content

For protein content, five crosses showed positive standard heterosis. The cross GC 4 x Waghi Local (4.63%) was top in heterosis percentage. The range of heterobeltiosis for protein content varied from -17.00 per cent (CDP 108 x W 5) to 4.63 per cent (GC 4 x Waghi Local). These results were in confirmation with Mote *et al.* (2006) and Patel *et al.* (2009).

As observed in the present study, the degree of heterosis varied from cross to cross for all the characters. The heterotic response of F₁ is indicative of genetic diversity among the parents involved (Moll *et al.*, 1962). The results were in agreement with the findings of Patil *et al.* (2005), Chaudhari *et al.* (2013) and Yadav *et al.* (2010). Considerably high heterosis in the certain crosses and low in the others revealed that nature of gene effects varied with the genetic architecture of the parents. It also observed that none of the hybrid exhibited standard heterosis for all studied characters.

In the present investigation, heterosis was ranged from -45.67 to 4.15 per cent in standard heterosis for seed yield per plant. The highest standard heterosis was recorded by cross GC 4 x Waghai local (12.45%) and followed by W 3-2 x W 5 (10.38%), CDP 108 x CDP 11 (8.30%), Phule CP-5040 x W 5 (6.23%) and Waghi Local x W 5 (4.15%) (Table 3). Almost identical results have been reported by Patil *et al.* (2005) Ushakumari *et al.* (2010), Kajale and Ravindarbabu (2012) and

Kadam *et al.* (2013). The above top five crosses showed desirable standard heterosis was different in respect to almost 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. In others words, it is called as combinational heterosis. The critical study of these top performing hybrids, thus, clearly indicated that as the high heterosis for seed yield coupled with high heterosis for yield attributes suggested that there is a predominance of additive gene action for seed yield per plant heterosis. Heterosis for seed yield associated with heterosis for yield components were observed by Patel *et al.* (2009), Yadav *et al.* (2010), Kajale and Ravindarbabu (2012) and Patel *et al.* (2013). The heterosis for seed yield in these crosses was only due to manifested of heterosis to components traits viz., plant height, branches per plant, pods per plant and pod length. These hybrids could be recommended for commercial cultivation after verifying yield parameters on bigger plots in respective environments. These crosses may also be used to develop new pools population or base populations to extract new pure lines with good combination of characters.

CONCLUSION

From the above results and discussion, it can be concluded that GC 4 x Waghai local (12.45%) followed by W 3-2 x W 5 (10.38%), CDP 108 x CDP 11 (8.30%), Phule CP-5040 x W 5 (6.23%) and Waghi Local x W 5 (4.15%) were the most standard heterotic hybrid combinations and can be exploited further yield improvement in cowpea.

REFERENCES

- Chaudhari, S. B.; Naik, M. R.; Patil, S. S. and Patel, J. D. (2013). Heterosis in cowpea for seed yield and its attributes over different environment. *Trends Biosci.*, **6**(4): 464-466.
- Darlington, C. D. and Wylie, A. P. (1955). Chromosome Atlas of flowering plants, George Allen and Unwin, London, pp. 132-134.
- Fonseca, S. and Patterson, F. L. (1968). Hybrid vigour in seven parental diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Sci.*, **8**(1): 85-88.
- Hayes, H. K.; Immer, F. R. and Smith, D. C. (1955). Methods of Plant Breeding 2nd Edn., McGraw Hill Book Co., Inc., New York. pp. 52-65.
- Kadam, Y. R.; Patel, A. I.; Patel, J. M.; Chudhari, P. P. and More S. J. (2013). Heterosis study in vegetable cowpea [*Vigna unguiculata* (L.) Walp]. *Crops Res.*, **45**(1, 2 & 3): 202-205.
- Kajale, D. B. and Ravindarbabu (2012). Heterosis studies in cowpea [*Vigna unguiculata* (L.) Walp]. *GAU Res. J.*, **37**(1): 7-9.
- Meena, R.; Pithia, M. S.; Savaliya, J. J. and Pansuriya, A. G. (2010). Heterosis in vegetable cowpea [*Vigna unguiculata* (L.) Walp]. *Crop improv.*, **36**(1): 1-5.
- Mehta, D. R. (2000). Comparison of observed and expected heterosis and inbreeding depression in four cowpea crosses. *Indian J. Agri. Res.*, **34**(2): 97-101.
- Moll, R. H.; Salhuana, W. S. and Robinson, H. F. (1962). Heterosis and genetic diversity in variety crosses of maize. *Crop Sci.*, **2**: 197-198.
- Mote, M. S.; Bendale, V. W.; Bhawe, S. G.; Jadhav, B. B. and Sawant, S. S. (2006). Heterosis and combining ability studies for seed yield in cowpea [*Vigna unguiculata* (L.) Walp]. *J. Maharashtra Agril. Univ.*, **31**(2): 159-162.
- Pal, A. K.; Kumar, S. and Maurya, A. N. (2007). Genetic study for earliness in cowpea [*Vigna unguiculata* (L.) Walp]. *Indian J. Hort.*, **64**(1): 63-66.
- Patel, Hiral; Patel, J. B.; Sharma, S. C. and Acharya, S. (2013). Heterosis and inbreeding depression study in cowpea. [*Vigna unguiculata* (L.) Walp]. *AGRES - An International e - Journal*, **2**: 165-172.
- Patel, S. J.; Desai, R. T.; Bhakta, R. S.; Patel, D. U.; Kodappully, V. C. and Mali, S. C. (2009). Heterosis study in cowpea [*Vigna unguiculata* (L.) Walp]. *Legume Res.*, **32**(3): 199-202.
- Patil, H. E.; Navale, P. A. and Reddy, N. B. R. (2005). Heterosis and combining ability analysis in cowpea [*Vigna unguiculata* (L.) Walp]. *J. Maharashtra Agril. Univ.*, **30**(1): 88-90.
- Ritchie, R. H.; Tung, C. J.; Anderson, V. E. and Ashley, J. C. (1975). Electron slowing-down spectra in solids. *Radiat Res.*, **64**: 181-204.
- Sharma, D.; Mehta, N.; Trivedi, J. and Gupta, C. R. (2010). Heterosis combining ability and genetic divergence in cowpea [*Vigna Unguiculata* (L.) Walp]. *Veg. Sci.*, **37**(2): 156-159.
- Stanton, W. R. (1966). Grain legumes in Africa. Food and agricultural organization of the United Nations, Rome, Italy, pp. 210-213.

- Steele, W. M. (1976). Cowpeas, [*Vigna unguiculata* (L.) Walp]. In: Evolution of crop plants, [Eds. R. J. Summerfield and A. H. Bunting], HMSO, London, pp. 183-185.
- Ushakumari, R.; Vairam, N.; Anandakumar, C. R. and Malini, N. (2010). Studies on hybrid vigour and combining ability for seed yield and contributing characters in cowpea [*Vigna unguiculata* (L.) Walp]. *Electronic J. Plant Breed.*,1(4): 940-947.
- Vavilov, N. I. (1951). The origin, variation, immunity and plant breeding of cultivated plants, Ronald Press Corporation, New York, pp. 256-257.
- Yadav, K. S.; Yadav, H. S. and Dixit, H. (2010). Heterosis and inbreeding depression in cowpea. *Int. J. Agri. Sci.*, 2: 537-540.

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

Source of Variation	d.f.	Days to 50 % Flowering	Plant Height (cm)	Branches Per Plant	Number of Pods Per Plant	Pod Length (cm)	Seeds Per Pod	Seed Yield Per Plant (g)	Harvest Index (%)	Protein Content (%)
Replication	2	45.98	146.38	2.66	14.74	7.63	6.79	53.11	0.02	1.29
Genotype	27	64.73**	319.63**	2.62**	12.48**	5.97*	6.62**	183.02**	211.37**	6.43**
Parents	6	4.50	400.27**	1.01	4.81	6.30*	5.11*	70.61**	58.48*	2.48**
Hybrids	20	36.66*	201.70**	3.16**	15.02**	7.18**	7.20**	220.27**	264.47**	7.74**
Parents vs Hybrids	1	987.54**	2194.44**	1.61	7.67	3.68	16.0	112.48*	66.70	3.95**
Error	54	17.36	55.32	1.01	5.56	2.88	2.55	20.11	19.87	0.49

Table 2: Estimates of per cent heterosis over better parent (BP) and standard check (SC) for different character of cowpea.

Sr. No.	Crosses	Days to 50% Flowering		Plant Height (cm)		Branches Per plant		Number of Pods Per Plant		Pod Length (cm)	
		BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
1	GC 4 × W 3-2	8.46	13.24	-2.30	-2.30	-23.37**	-23.37**	-19.42*	-19.42*	-21.19*	-21.19*
2	GC 4 × CDP 108	15.28	22.07*	-17.23**	-17.23**	-16.41	-16.41	-13.59	-13.59	-14.84	-14.84
3	GC 4 × Phule CP-5040	14.3	17.66	-16.08**	-16.08**	-3.5	-3.5	-2.91	-2.91	-3.18	-3.18
4	GC 4 × CDP 11	2.74	10.29	-12.64*	-12.64*	-22.21*	-22.21*	-18.45*	-18.45*	-20.13*	-20.13*
5	GC 4 × Waghi Local	14.89	25.02**	-14.93*	-14.93*	7.00	7.00	5.82	5.82	6.33	6.33
6	GC 4 × W 5	26.11**	27.95**	-8.04	-8.04	-10.54	-10.54	-8.74	-8.74	-9.55	-9.55
7	W 3-2 × CDP 108	8.33	14.70	-19.26**	-22.97**	-10.21	-17.57*	-8.32	-14.56	-9.15	-15.9
8	W 3-2 × Phule CP-5040	25.37**	30.90**	-15.47*	-18.38**	-2.43	-4.7	-1.98	-3.88	-2.15	-4.25
9	W 3-2 × CDP 11	10.97	19.13*	-4.93	-11.49	-14.02	-21.07*	-11.46	-17.48*	-12.59	-19.09*
10	W 3-2 × Waghi Local	21.65**	32.37**	-7.4	-13.78*	-23.69**	-24.58**	-19.61*	-20.39*	-21.40*	-22.25*
11	W 3-2 × W 5	31.01**	36.79**	-20.92**	-21.82**	15.29	5.83	12.50	4.85	13.74	5.29
12	CDP 108 × Phule CP-5040	9.72	16.18	-17.84**	-20.68**	-9.59	-11.7	-7.93	-9.71	-8.66	-10.62
13	CDP 108 × CDP 11	12.33	20.59*	-15.65*	-19.53**	21.81*	4.67	17.58	3.88	19.39	4.2
14	CDP 108 × Waghi Local	13.54	23.55*	-20.47**	-24.12**	-11.84	-12.87	-9.81	-10.68	-10.69	-11.66
15	CDP 108 × W 5	19.46*	26.49**	-25.56**	-26.42**	-18.06	-25.74**	-14.74	-21.36**	-16.21	-23.31*
16	Phule CP-5040 × CDP 11	20.56*	29.43**	-26.17**	-28.71**	-3.62	-5.87	-2.98	-4.86	-3.25	-5.33
17	Phule CP-5040 × Waghi Local	27.06**	38.26**	-28.55**	-31.01**	-17.78*	-18.74*	-14.7	-15.53	-16.03	-16.94
18	Phule CP-5040 × W 5	31.45**	35.31**	-8.13	-9.19	5.97	3.5	4.95	2.91	5.40	3.14
19	CDP 11 × Waghi Local	2.72	11.77	-19.74**	-25.27**	-18.96*	-19.91*	-15.7	-16.51*	-17.13	-18.03*
20	CDP 11 × W 5	30.15**	39.73**	-26.73**	-27.57**	2.61	-7.00	2.12	-5.82	2.3	-6.37
21	Waghi Local × W 5	21.65**	32.37**	-29.05**	-29.87**	3.51	2.3	2.94	1.94	3.22	2.10
S.E.+		3.40	3.40	6.07	6.07	0.81	0.81	1.92	1.92	1.38	1.38
CD at 5%		6.82	6.82	12.17	12.17	1.64	1.64	3.86	3.86	2.78	2.78
CD at 1%		9.08	9.08	16.21	16.21	2.18	2.18	5.14	5.14	3.70	3.70

*, ** significant at 5% and 1% levels of probability, respectively.

Table 2: Contd....

Table 2: Contd....

Sr. No.	Crosses	Number of Seeds Per Pod		Seed Yield Per Plant (g)		Harvest Index (%)		Protein Content(%)	
		BP	SC	BP	SC	BP	SC	BP	SC
1	GC 4 × W 3-2	3.76	3.76	-41.52**	-41.52**	3.76	3.76	-41.52**	-41.52**
2	GC 4 × CDP 108	-9.98	-9.98	-29.06**	-29.06**	-9.98	-9.98	-29.06**	-29.06**
3	GC 4 × Phule CP-5040	-18.58*	-12.48	-6.23	-6.23	-18.58*	-12.48	-6.23	-6.23
4	GC 4 × CDP 11	-14.98	-14.98	-39.44**	-39.44**	-14.98	-14.98	-39.44**	-39.44**
5	GC 4 × Waghi Local	-7.49	-7.49	12.45	12.45	-7.49	-7.49	12.45	12.45
6	GC 4 × W 5	-27.45**	-27.45**	-18.68*	-18.68*	-27.45**	-27.45**	-18.68*	-18.68*
7	W 3-2 × CDP 108	8.97	6.25	-19.43*	-31.14**	8.97	6.25	-19.43*	-31.14**
8	W 3-2 × Phule CP-5040	-10.44	-3.73	-4.33	-8.3	-10.44	-3.73	-4.33	-8.3
9	W 3-2 × CDP 11	1.29	-1.24	-26.72**	-37.36**	1.29	-1.24	-26.72**	-37.36**
10	W 3-2 × Waghi Local	-15.36	-17.47	-42.40**	-43.59**	-15.36	-17.47	-42.40**	-43.59**
11	W 3-2 × W 5	-17.92	-19.97*	29.14**	10.38	-17.92	-19.97*	29.14**	10.38
12	CDP 108 × Phule CP-5040	-29.01**	-23.70*	-17.33*	-20.76*	-29.01**	-23.70*	-17.33*	-20.76*
13	CDP 108 × CDP 11	-19.14	-26.19**	44.23**	8.30	-19.14	-26.19**	44.23**	8.30
14	CDP 108 × Waghi Local	12.32	2.52	-21.20*	-22.83**	12.32	2.52	-21.20*	-22.83**
15	CDP 108 × W 5	-13.31	-18.71*	-34.85**	-45.67**	-13.31	-18.71*	-34.85**	-45.67**
16	Phule CP-5040 × CDP 11	-26.69**	-21.20*	-6.5	-10.38	-26.69**	-21.20*	-6.5	-10.38
17	Phule CP-5040 × Waghi Local	-30.16**	-24.93**	-31.80**	-33.21**	-30.16**	-24.93**	-31.80**	-33.21**
18	Phule CP-5040 × W 5	-27.86**	-22.46*	10.83	6.23	-27.86**	-22.46*	10.83	6.23
19	CDP 11 × Waghi Local	18.26	4.99	-33.92**	-35.29**	18.26	4.99	-33.92**	-35.29**
20	CDP 11 × W 5	-10.65	-16.21	4.98	-12.45	-10.65	-16.21	4.98	-12.45
21	Waghi Local × W 5	1.34	-4.97	6.36	4.15	1.34	-4.97	6.36	4.15
S.E.+		3.40	1.30	1.30	3.66	3.66	1.30	1.30	3.66
CD at 5%		6.82	2.61	2.61	7.34	7.34	2.61	2.61	7.34
CD at 1%		9.08	3.48	3.48	9.77	9.77	3.48	3.48	9.77

*,** significant at 5% and 1% levels of probability, respectively.

Table 3: Comparison of top four promising crosses for seed yield per plant on the basis of standard heterosis and desirable heterotic effect for other characters.

Sr. No.	Hybrids	Standard Heterosis for Seed Yield (%)	Desirable Heterotic Effect for Other Characters
1.	GC 4 x Waghai local	12.45	Plant height, branches per plant, pods per plant , pod length, protein content, harvest index
2.	W 3-2 x W 5	10.38	Plant height, branches per plant, pods per plant , pod length, seed yield, protein content, harvest index
3.	CDP 108 x CDP 11	8.3	Plant height, branches per plant, pods per plant, pod length, protein content.
4.	Phule CP-5040 × W 5	6.23	Plant height, branches per plant, pods per plant, protein content.
5.	Waghai local x W 5	4.15	Plant height, branches per plant, pods per plant, pod length, seed yield, protein content.

[MS received: November 06, 2015]

[MS accepted: December 18, 2015]