Electronic Journal of Plant Breeding, 8(1): 72-77 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00010.2

Research Article

Heterosis, inbreeding depression and heritability for yield and yield components in cowpea

A.R. Pathak*, M.R. Naik and H.K. Joshi
Department of Genetics and Plant Breeding, N.M. College of Agriculture, Navsari Agricultural University, Navsari
E-mail: ameepathak10@gmail.com

(Received: 08 May 2016; Revised: 17 March 2017; Accepted: 22 March 2017)

Abstract
A field experiment was undertaken with a view to know the extent of heterosis, inbreeding depression, heritability and genetic advance for yield and yield components in cowpea [*Vigna unguiculata* (L.) Walp.]. Six generations *viz.*, P_1, P_2, F_1, F_2, BC_1 and BC_2 of eight crosses involving sixteen diversified cultivars of cowpea [*Vigna unguiculata* (L.) Walp.] were evaluated for yield and its traits. Significant positive heterosis for seed yield per plant and its related traits followed by significant inbreeding depression indicated major role of non-additive gene actions in the inheritance of seed yield per plant and its attributes. For seed yield per plant top three heterotic crosses were cross II (GC-4 x Pusa komal) followed by cross VIII (Cowpea sabra x Waghai krushi) and cross I (GC-3 x Pusa falguni). High heritability coupled with high genetic advance for cross I (GC-3 x Pusa falguni) and high heritability coupled with moderate genetic advance for cross II (GC-4 x Pusa komal), cross III (GC-5 x Anand cowpea), cross IV (W-203-3 x W-3-1) and cross V (W-502-2 x W-3-2) for seed yield per plant indicated heritability was due to additive gene effects. Involvement of both additive and non-additive gene effects suggested that it would be desirable to follow cyclic method of breeding.

Key words
Cowpea, heterosis, inbreeding depression, heritability, genetic advance

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is diploid with chromosome number 2n=22 and belongs to family *Fabaceae*. It is one of the oldest source of human food in form of green pod as well as dry grain and has most likely been used as a crop. Cowpea an indigenous African annual legume is high in protein (25%) and is having good nutritional qualities. The protein in cowpea seed is rich in the amino acids *viz.*, lysine and tryptophan compared to cereal grains. The heterosis expresses the superiority of F_1 hybrid over its parents in term of yield and other traits. On the other hand, the inbreeding depression reflects on reduction or loss in vigour, fertility and yield as a result of inbreeding. The knowledge of heterosis accompanied by the extent of inbreeding depression in subsequent generations is essential for maximum exploitation of such heterosis by adopting appropriate breeding methodology. In crop improvement, only the genetic component of variation is important since only this component is transmitted to the next generation. Estimates of heritability serves as a useful guide to the breeder. Heritability expresses the relative amount of heritable portion of variation; however its estimate along with genetic advance is more useful in predicting the resultant effect of selecting the best individuals.

Materials and methods

The present investigation was carried out to elicit information on heritability and genetic advance for yield and yield components in cowpea. The experimental material consisting of six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of the following eight single crosses *viz.*, Cross I (GC-3 x Pusa falguni), Cross II (GC-4 x Pusa komal), Cross III (GC-5 x Anand cowpea), Cross IV (W-203-3 x W 3-1), Cross V (W-502-2 x W-3-2), Cross VI (Phule CP-5040 x W 601), Cross VII (CDP-108 x W-4) and Cross VIII (Cowpea Sabra x Waghai Krushi). The F_1 hybrids were generated by above eight single crosses during *Rabi* 2012-13 and Summer 2013. Backcrossing was done in *Rabi* 2013-14 with its respective parents. Selfing of F_1s was done in the same season (*Rabi* 2013-14) to get F_2s. All the six generations were sown at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during *Kharif*-2014 in Compact Family Block Design with three replications. Each replication was divided in eight compact blocks. Each eight crosses consisting of six generations were randomly allotted to the blocks. Six generations were than randomly allotted to each plot within a block. Each plot consisted of one row of parents and F_1s, two rows of the backcrosses and four rows of the F_{2S} of each cross. Inter and intra row spacing was 45 cm and 10 cm, respectively. All the generations were evaluated for extent of heterosis, inbreeding depression, heritability and genetic advance.

Results and discussion

The analysis of variance for individual characters was carried out in each of the eight crosses for eleven traits *viz.*, days to 50 per cent flowering, plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, days to maturity, 100 seed weight, seed yield per plant, protein content and harvest index (Table 1). The mean sum of squares revealed significant differences among the generations in all the crosses for all traits studied indicating considerable

DOI: 10.5958/0975-928X.2017.00010.2

variability in the experimental material. Significant variation for all the characters under study might be due to more diversity between the parents which resulted in high variability among its generations and less environmental influence for the expression of these traits.

All the crosses showed positive and highly significant relative heterosis, heterobeltiosis and inbreeding depression for seed yield per plant (Table 2) *viz*., GC-3 x Pusa falguni (17.94, 12.59, 18.54 %), GC-4 x Pusa komal (20.23, 15.28, 17.99 %), GC-5 x Anand cowpea (17.88, 12.43, 11.35 %), W-203-3 x W-3-1 (16.62, 11.70, 9.52 %), W-502-2 x W-3-2 (16.20, 11.38, 9.49 %), Phule CP-5040 x W-601 (17.29, 12.13, 16.67 %), CDP-108 x W-4 (17.74, 12.46, 17.13 %) and Cowpea sabra x Waghai krushi (18.35, 12.86, 21.19 %), respectively. In the present investigation heterosis for yield was observed due to heterosis for component characters *viz.*, plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, 100-seed weight, seed yield per plant, protein content and harvest index which resulted in increased yield. So, these characters should be given duly consideration while improving yield.

In general, heterosis followed by presence of inbreeding depression were observed in cross I (GC-3 x Pusa falguni) for plant height, number of branches per plant, seed yield per plant and harvest index; in cross II (GC-4 x Pusa komal) for plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, 100-seed weight, seed yield per plant and harvest index; in cross III (GC-5 x Anand cowpea) for number of branches per plant, pod length, number of seeds per pod, days to maturity and seed yield per plant; in cross IV (W-203-3 x W-3-1) for number of branches per plant, number of pods per plant, pod length, number of seeds per pod, days to maturity, 100-seed weight and seed yield per plant; in cross V (W-502-2 x W-3-2) for plant height, number of branches per plant, days to maturity, 100-seed weight, seed yield per plant and harvest index; in cross VI (Phule CP-5040 x W-601) for number of branches per plant, number of pods per plant, pod length, days to maturity, seed yield per plant and harvest index; in cross VII (CDP-108 x W-4) for number of pods per plant, pod length, number of seeds per pod, 100-seed weight, seed yield per plant, 100-seed weight and harvest index; in cross VIII (Cowpea sabra x Waghai krushi) for days to 50 per cent flowering, plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, days to maturity, seed yield per plant, protein content and harvest index indicated that positive and significant heterosis over mid-parent and better-parent along with positive inbreeding depression may be attributed to major contribution from dominance (*h*) and additive x additive (*i*) gene effects and selection will be effective only in later generations. Significant positive heterosis for seed yield per plant and its related traits followed by significant inbreeding depression indicated major role of non-additive gene actions in the inheritance of seed yield per plant and its attributes. These findings are similar to those of Joseph and Santoshkumar (2000), Pal *et al.* (2003), Lal *et al.* (2007), Patel *et al.* (2009), Aremu and Adewale (2010), Rashwan (2010), Patel *et al.* (2013) and Nautiyal *et al*. (2015).

For seed yield per plant narrow sense and broad sense heritability ranged from 19.15 per cent to 61.59 per cent and 40.19 per cent to 73.31 per cent, respectively (Table 3). For the character seed yield per plant, only one cross GC-5 x Anand cowpea (61.59 %) showed high narrow sense heritability. The values of broad sense heritability were high for five crosses *viz.*, GC-4 x Pusa komal (73.31 %), W-203-3 x W-3-1 (72.63 %), GC-3 x Pusa falguni (71.28 %), GC-5 x Anand cowpea (63.46 %) and W-502-2 x W-3-2 (62.20 %). Genetic advance ranged from 9.25 per cent (GC-4 x Pusa komal) to 27.87 per cent. High heritability coupled with high genetic advance were observed in cross I (GC-3 x Pusa falguni) for all the characters except days to maturity and 100-seed weight; in cross II (GC-4 x Pusa komal) for days to 50 per cent flowering, plant height, pod length, number of seeds per pod and 100-seed weight; in cross III (GC-5 x Anand cowpea) for plant height, pod length, 100-seed weight and protein content; in cross IV (W-203-3 x W-3-1) for plant height, number of branches per plant, number of seeds per pod, 100-seed weight and protein content; in cross V (W-502-2 x W-3-2) for plant height, number of seeds per pod, days to maturity and 100-seed weight; in cross VI (Phule CP-5040 x W-601) for days to 50 per cent flowering, plant height, number of branches per plant, pod length, number of seeds per pod, days to maturity, 100-seed weight and protein content; in cross VII (CDP-108 x W-4) for days to 50 per cent flowering, plant height, number of branches per plant and 100-seed weight indicated that most likely the heritability was due to additive gene effects and selection in early generations may be effective.

Low heritability coupled with high genetic advance were recorded in cross VIII (Cowpea sabra x Waghai krushi) for pod length revealed that the character is governed by additive gene effects and low heritability was due to high environmental effects. Selection may be effective in such case. Low heritability coupled with low genetic advance were recorded in cross VIII (Cowpea sabra x Waghai krushi) for number of pods per plant and protein content indicated that the character was highly influenced by environmental effects and selection would be

DOI: 10.5958/0975-928X.2017.00010.2

ineffective. Moderate heritability coupled with high genetic advance were recorded in cross I (GC-3 x Pusa falguni) for 100-seed weight; in cross III (GC-5 x Anand cowpea) for number of branches per plant and number of seeds per pod; in cross IV (W-203-3 x W-3-1) for pod length; in cross V (W-502-2 x W-3-2) for number of branches per plant and pod length; in cross VII (CDP-108 x W-4) for pod length; in cross VIII (Cowpea sabra x Waghai krushi) for number of branches per plant and number of seeds per pod indicated that heritability was due to additive gene effects and selection may be effective.

High heritability coupled with moderate genetic advance were observed in cross II (GC-4 x Pusa komal) for number of pods per plant, days to maturity, seed yield per plant, protein content and harvest index; in cross III (GC-5 x Anand cowpea) for seed yield per plant and harvest index; in cross IV (W-203-3 x W-3-1) for number of pods per plant, seed yield per plant and harvest index; in cross V (W-502-2 x W-3-2) for days to 50 per cent flowering and harvest index; in cross VI (Phule CP-5040 x W-601) for harvest index; in cross VII (CDP-108 x W-4) for days to maturity and harvest index indicated the presence of additive gene effects and selection may be effective for these traits. These results are similar to the findings of different scientists *viz.*, Umaharan *et al.* (1997), Khaimar *et al.* (2003), Lopes *et al*. (2003), Rehman *et al*. (2009), Aremu and Adewale (2010) and Noubissie *et al*. (2011).

In general, higher magnitude of desirable heterosis, moderate to high heritability coupled with moderate/high expected genetic advance for most of the characters suggested involvement of both additive and non-additive gene effects and it would be desirable to follow cyclic method of breeding involving conventional breeding approach of selection of superior recombinants and their inter-mating for the development of elite homozygous recombinants having high quality and high yielding potentiality.

References

Aremu, C.O. and Adewale, B.D. 2010. Heterosis and phenolic performance in a selected cross of cowpea [*Vigna unguiculata* (L.) walp] for humid environment performance. *Agric. J*., **5**(5): 292-296.

Joseph, J. and Santoshkumar, A.V. 2000. Genetic analysis of metric traits in green gram (*Vigna radiata* (L.) Wilczek). *International J. Tropic. Agri.*, **18**(2): 133-139.

Khaimar, M.N., Patil, J.V., Deshmukh, R.B. and Kute, N.S. 2003. Genetic variability in mung bean. *Legume Res.*, **26**(1): 69-70.

Lopes, F.C., Gomes, R.F.L. and Filho, F.R.F. 2003. Genetic control of cowpea seed sizes. *Scientia Agricola*, **60**(2): 315-318.

Noubissie, J.B.T., Youmbi, E., Njintang, N.Y., Bell, J.M. and Maina, A.N. 2011. Generation mean analysis of seed sucrose content in cowpea [*Vigna unguiculata* (L.) Walp.]. *Asian J. Agric. Sci.*, **3**(6): 475-480.

Pal, A.K., Singh, B. and Maurya, A.N. 2003. Inbreeding depression in cowpea (*Vigna unguiculata* (L.)Walp.). *J. Applied Hort.*, **5**(2): 105-107.

Patel, S.J., Desai, R.T., Bhakta, R.S., Patel, D.U., Kodappully, V.C. and Mali, S.C. 2009. Heterosis studies in cowpea [*Vigna ungiculata* (L.) Walp]. *Legume Res*., **32**(3): 199-205.

Patel, H., Patel, J.B., Sharma, S.C. and Acharya, S. 2013. Heterosis and inbreeding depression study in cowpea [*Vigna unguiculata* (L.) Walp.]. *An International e-Journal*, **2**(2): 165-172.

Rashwan, A.M.A. 2010. Estimation of some genetic parameters using six populations of two cowpea hybrids. *Asian J. Crop Sci.*, **2**: 261-267.

Rehman, A.U., Ali, M.A., Atta, B.M., Saleem, M., Abbas, A. and Mallahi, A.R. 2009.Genetic studies of yield related traits in mungbean (*Vigna radiata* L. Wilczek). Australian J. *Crop Sci*., **3**(6): 352-360.

Santos, C.A.F., Costa, D.C.C., Silva, R.W. and Boiteux, L.S. 2012. Genetic analysis of total seed protein content in two cowpea crosses. *Crop Sci.*, **52**: 2501-2505.

Umaharan, P., Ariyanayagam, R.P. and Haque, S.O. 1997. Genetic analysis of yield and its components in vegetable cowpea (*Vigna unguiculata* L. Walp). *Euphytica*, **96**: 207–213.

Electronic Journal of Plant Breeding, 8(1): 72-77 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00010.2

Table 1. Analysis of variance of days for yield and yield component in eight crosses of cowpea

Source	d.f.	Mean sum of square										
		Days to 50 per cent flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Days to maturity	100 seed weight	Seed yield per plant	Protein content (%)	Harvest index
Cross I (GC-3 x Pusa falguni)												
Replication	2	15.16	30.65	2.03	5.42	0.54	0.83	14.02	0.41	352.98	1.29	3.51
Generation	5	12.60*	45.28*	11.23**	24.41*	1.01*	5.83**	20.76*	1.04*	3743.44*	2.11**	19.59*
Error	10	3.77	11.26	1.74	6.10	0.25	0.87	3.81	0.20	802.04	0.34	4.14
Cross II (GC-4 x Pusa komal)												
Replication	2	10.19	52.85	4.19	6.41	6.92	4.20	10.50	0.50	257.18	1.70	3.82
Generation	5	11.79*	235.31*	21.36**	52.19**	16.34**	17.15**	25.64**	5.32**	3805.22**	4.83**	25.61*
Error	10	2.55	47.26	2.09	7.99	1.73	1.38	3.01	0.64	605.39	0.44	4.82
Cross III (GC-5 x Anand cowpea)												
Replication	2	10.95	29.31	3.07	11.40	2.93	6.59	45.03	0.41	275.95	1.54	3.35
Generation	5	32.91**	42.28*	3.71*	63.04*	38.57**	24.15**	313.38**	6.25**	3677.93**	3.56**	33.21**
Error	10	2.60	10.57	0.89	15.76	2.58	2.47	11.26	0.79	626.94	0.40	5.11
Cross IV (W-203-3 x W-3-1)												
Replication	2	9.11	2.45	0.27	8.73	2.42	2.90	38.69	0.75	185.17	0.60	1.88
Generation	5	13.89**	86.73*	8.46**	54.66*	27.96**	16.69**	768.88**	7.21**	1997.25*	3.48**	15.89*
Error	10	2.28	21.57	0.48	10.99	2.04	0.93	9.94	0.64	559.63	0.17	3.34
Cross V (W-502-2 x W-3-2)												
Replication	2	3.91	18.26	7.94	10.76	0.78	1.66	31.69	0.91	184.05	0.93	1.87
Generation	5	56.06**	50.68*	12.69*	38.21*	2.09*	3.78**	279.01**	33.77**	1922.94*	1.64**	28.73**
Error	10	1.00	15.17	2.37	9.45	0.44	0.50	7.92	0.48	563.97	0.24	3.16
Cross VI (Phule CP-5040 x W-601)												
Replication	2	2.73	7.25	4.19	8.88	1.07	0.96	36.73	0.27	315.36	0.64	4.23
Generation	5	80.17**	706.37**	6.48*	46.29*	4.93**	1.86*	338.08**	2.50*	3113.40*	3.07**	22.39*
Error	10	0.71	28.20	1.28	13.86	0.69	0.35	8.57	0.56	760.86	0.18	5.79
Cross VII (CDP-108 x W-4)												
Replication	2	2.02	14.19	1.19	7.08	1.25	3.01	16.50	0.61	325.66	0.13	3.59
Generation	5	101.73**	606.88**	2.17**	54.27**	7.16**	5.18*	110.34**	3.84**	3291.95*	73.15**	17.75*
Error	10	0.54	41.56	0.37	9.60	0.86	1.27	3.79	0.33	759.21	0.44	4.48
Cross VIII (Cowpea Sabra x Waghai Krushi)												
Replication	2	1.26	113.77	4.73	16.58	2.87	2.09	42.73	0.46	415.07	3.12	3.91
Generation	5	17.43**	208.00*	12.55**	78.48*	50.61**	22.95**	441.45**	2.21**	4848.85*	25.02**	19.56*
Error	10	1.57	52.72	1.55	19.60	2.98	0.56	10.68	0.26	891.73	0.82	5.40

*, **significant at 5 and 1 per cent level, respectively

Electronic Journal of Plant Breeding, 8(1): 72-77 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00010.2

Table 2. Estimates of relative heterosis (RH %), heterobeltiosis (HB %) and inbreeding depression (ID %) for days to 50 per cent flowering, plant height (cm), number of branches per plant, number of pods per plant, pod length (cm) and number of seeds per pod in eight crosses of cowpea

Estimates (%)	Days to 50 per cent flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Days to maturity	100-seed weight (g)	Seed yield per plant (g)	Protein content (%)	Harvest index (%)
Cross I (GC-3 x Pusa Falguni)											
RH %	7.19**	14.13**	28.55*	2.88	10.03	49.99**	8.50**	17.30	17.94**	5.77	13.42**
HB %	5.53**	19.89**	25.25**	12.91**	14.79**	35.99**	6.87**	19.72**	12.59**	10.37**	5.71*
ID %	3.59	12.88**	31.94	-3.20	7.58	-7.10	3.27	11.77	18.54**	5.06	11.89
Cross II (GC-4 x Pusa Komal)											
RH %	-0.12	8.06*	36.69**	17.40**	31.09**	29.70**	-1.71	68.30**	20.23**	6.21	17.79**
HB %	-4.85**	17.61**	79.03**	15.36	38.61**	26.02**	2.12	75.63**	15.28**	11.22**	8.34**
ID %	-2.09	12.14**	26.62	10.56	20.00	40.31*	-11.31	33.99	17.99**	10.57	8.86
Cross III (GC-5 x Anand Cowpea)											
RH %	-9.53**	7.79**	46.13**	25.31**	32.85**	19.39*	1.24	58.98**	17.88**	6.05	16.69**
HB %	-2.43	11.35**	31.69**	22.91**	26.37**	15.94**	-6.94	67.82**	12.43**	10.92**	6.61*
ID %	-5.29	17.80**	27.26	11.90*	49.68**	41.66*	18.67	13.01	11.35**	8.60	10.54
Cross IV (W-203-3 x W-3-1)											
RH %	-0.11	23.78**	-7.78	24.44**	31.78**	47.21**	-0.08	28.78	16.62**	4.53	10.98*
HB %	4.78**	23.06**	-12.68**	22.84**	25.48**	44.10**	-16.85**	67.34**	11.70**	8.00**	3.87
ID %	-4.43	-8.42	24.24	12.02*	46.71**	43.15*	26.07**	40.07	9.52**	-10.69	0.71
Cross V (W-502-2 x W-3-2)											
RH %	-0.04	18.83**	38.89**	3.16	22.83*	-2.53	0.04	70.07**	16.20**	5.45	26.16**
HB %	3.57*	27.79**	22.21**	15.30**	17.99**	-4.67	-14.63**	95.98**	11.38**	9.55**	20.01**
ID %	-22.06**	13.56*	39.01	1.64	20.19	-8.35	12.35*	47.31	9.49**	-1.80	17.79
Cross VI (Phule CP-5040 x W-601)											
RH %	-0.01	-3.17	54.33**	20.97**	25.83**	24.91*	0.17	30.28	17.29**	4.63	15.08**
HB %	3.08	-3.02	37.36**	18.94**	20.51**	22.44**	-14.59**	34.48**	12.13**	8.19**	6.29*
ID %	-29.35**	-74.07**	31.21	6.60	29.51	12.78	15.54**	4.24	16.67**	-9.40	11.25
Cross VII (CDP-108 x W-4)											
RH %	0.01	-2.08	28.50	22.34**	27.10**	9.71	0.39	20.93*	17.74**	53.56**	13.03**
HB %	2.65	-1.75	18.96	20.73**	21.57**	6.68	-12.57**	23.94**	12.46**	63.25**	5.39
ID %	-35.62**	-64.68**	-16.96	10.27	33.34	25.88	-3.24	25.70	17.13**	41.03**	10.13
Cross VIII (Cowpea Sabra x Waghai Krushi)											
RH %	7.67**	13.85**	57.62**	20.63**	33.72**	68.55**	3.22	22.95*	18.35**	8.61**	12.53**
HB %	9.51**	19.26**	39.73**	18.70**	27.10**	64.49**	8.01**	26.17**	12.86**	15.80**	5.60*
ID %	7.13	15.09**	42.21	20.24**	51.40**	48.98**	26.84**	19.33	21.19**	22.17	13.75

*, **significant at 5 and 1 per cent level, respectively

Electronic Journal of Plant Breeding, 8(1): 72-77 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00010.2

Table 3. Estimates of heritability and genetic advance for yield and yield component in eight crosses of cowpea

Estimates (%)	Days to 50 per cent flowering	Plant height (cm)	Number of branches per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Days to maturity	100-seed weight (g)	Seed yield per plant (g)	Protein content (%)	Harvest index (%)
Cross I (GC-3 x Pusa falguni)											
Heritability (NS) %	60.78	69.58	39.84	29.59	32.40	6.60	28.38	22.47	48.08	41.27	34.85
Heritability (BS) %	81.87	96.39	79.86	86.39	82.37	73.46	38.79	52.40	71.28	77.20	83.42
Genetic advance %	33.51	33.34	68.93	24.41	64.32	32.01	8.00	37.56	27.87	23.00	29.18
Cross II (GC-4 x Pusa komal)											
Heritability (NS) %	50.82	30.85	46.12	30.23	48.42	46.94	34.54	66.92	50.99	56.50	57.66
Heritability (BS) %	85.96	85.78	59.41	60.06	65.35	64.95	70.37	70.45	73.31	60.96	64.59
Genetic advance %	29.46	25.46	84.99	13.15	51.02	69.69	13.73	92.58	19.07	17.88	13.97
Cross III (GC-5 x Anand cowpea)											
Heritability (NS) %	19.08	66.44	34.81	25.89	42.91	37.27	29.42	47.79	61.59	69.95	60.58
Heritability (BS) %	57.72	73.95	45.21	32.65	69.11	49.79	34.52	83.07	63.46	75.76	76.27
Genetic advance %	15.38	23.84	53.48	6.99	53.71	46.22	9.35	77.47	18.21	22.35	16.03
Cross IV (W-203-3 x W-3-1)											
Heritability (NS) %	4.36	83.36	27.96	43.76	17.50	35.78	4.79	63.31	46.61	53.13	62.05
Heritability (BS) %	37.46	96.95	69.60	63.07	46.97	64.71	55.67	80.26	72.63	70.49	77.94
Genetic advance %	8.91	38.91	21.10	13.70	34.26	40.36	13.70	48.75	18.45	21.45	16.31
Cross V (W-502-2 x W-3-2)											
Heritability (NS) %	44.54	29.84	19.83	32.00	7.65	16.89	48.33	41.50	29.46	47.92	32.32
Heritability (BS) %	71.88	63.00	40.60	37.80	51.17	73.29	75.05	74.06	62.20	55.02	67.15
Genetic advance %	17.34	20.23	40.60	8.86	24.92	79.88	26.91	52.46	14.34	17.03	11.60
Cross VI (Phule CP-5040 x W-601)											
Heritability (NS) %	82.34	45.73	13.86	31.90	53.22	87.65	93.73	85.69	22.03	88.92	64.09
Heritability (BS) %	84.99	89.86	86.06	44.47	70.72	91.04	95.83	92.15	53.53	90.94	85.96
Genetic advance %	20.09	43.39	74.65	9.69	34.56	40.89	28.16	82.78	12.46	27.43	17.43
Cross VII (CDP-108 x W-4)											
Heritability (NS) %	69.87	41.55	74.10	45.49	47.06	11.37	72.08	69.31	22.92	19.24	86.21
Heritability (BS) %	86.43	90.28	83.02	53.98	49.09	38.68	74.79	76.57	40.19	58.70	89.56
Genetic advance %	20.12	43.38	81.66	11.15	23.62	15.21	19.18	43.06	9.25	13.35	18.32
Cross VIII (Cowpea Sabra x Waghai Krushi)											
Heritability (NS) %	46.84	52.76	22.98	20.48	21.53	55.34	21.32	8.36	19.15	7.49	37.98
Heritability (BS) %	56.24	52.85	54.98	26.77	23.42	57.59	48.11	20.45	51.31	15.38	44.01
Genetic advance %	11.86	18.85	85.75	7.71	22.54	66.89	13.78	16.16	12.04	5.02	8.20