Forage Res., **37** (4) : pp. 214-220 (2012)

DISSECTION OF GENETIC VARIABILITY AND HERITABILITY ESTIMATES IN CHICKPEA (*CICER ARIETINUM* L.) UNDER LATE SOWN CONDITIONS

PRAMILA YADAV*, DINESH KUMAR TRIPATHI[1], KHALID KAFEEL KHAN AND ASHOK KUMAR YADAV[2]

Department of Botany
Shibli National Post Graduate College
Azamgarh (U. P.), India
*(e-mail : yadavpsc@gmail.com)

SUMMARY

Studies on estimation of heritability (h^2) and genetic advance (GA) were carried out in 45 genotypes of chickpea. High genotypic and phenotypic coefficients of variability were observed for days to 50 per cent flowering, days to maturity, plant height, leaf length, number of leaflets/leaf, leaflet length, width of leaflet, number of primary branches/plant, number of secondary branches/plant, number of pods/plant, pod length, pod width, number of seeds/pod, 100-seed weight, seed yield/plant and biological yield/plant. The differences between genotypic and phenotypic coefficients of variability were very small in all the traits indicating negligible role of environment. In the present study, high heritability coupled with high genetic advance for 100-seed weight, width of leaflet, number of pods/plant and biological yield/plant indicated the presence of a considerable proportion of total variability due to genetic causes particularly the additive gene effects to be important for determining these traits. On the other hand, high h^2 associated with low genetic advance for days to maturity, indicated the influence of dominant and epistemic gene for these traits. Low heritability percentage coupled with low and moderate genetic advancement was observed for days to 50 per cent flowering and indicated that this trait was greatly influenced by environment.

Key words : Genetic variability, heritability, genetic advance, GCV, PCV, chickpea, late sown

Chickpea (*Cicer arietinum* L.) is an important **rabi** pulse crop of rainfed areas of India. Chickpea is one of the world's most important but less-studied leguminous food crop with 740-Mb genome size. Chickpea ranks third among pulses, fifth among grain legumes, and 15th among grain crops of the world (Khan *et al.*, 2011). This crop is highly proteinaceous and seeds are used in various ways for human consumption. Chickpea is valued for its nutritive seeds with high protein content (25.3-28.9%), after de-hulling (Hulse, 1991). It has great importance as food, feed and fodder. Due to the increasing need for legumes, chickpea is no longer considered a subsistence crop. The rising trend in its trade suggests that the crop is grown increasingly for the market (Saxena *et al.*, 1996). Naidu *et al.* (1991) studied 49 lines of mungbean and observed higher magnitude of PCV than GCV in all the mungbean traits. They also recorded higher estimates of heritability in all the traits. High h^2 was associated with high genetic advance for number of branches, clusters, pods per plant, shoot dry weight and grain yield. Aslam *et al.* (1992) reported higher estimates of PCV than GCV in all the characters studied in mungbean. Path analysis indicated that plant height had very high direct effect on yield, followed by 1000-seed weight. The estimates of h^2 varied from 26.20 per cent for yield to 84.10 per cent for days to pod maturity. The phenotypic coefficient of variability (PCV) was greater in magnitude than genotypic coefficient of variability in most of the traits in mungbean (Awan and Malik, 1997). They also reported high heritability (h^2) associated with high genetic advance for plant height, indicating additive gene effect for determination of this trait. The results revealed that additive components of variance were significant for

[1]Department of Botany, Sri Durga Ji Post Graduate College, Chandeshwar, Azamgarh (U. P.), India.
[2]CSIR-Institute of Himalayan Bioresource Technology, Palampur (H. P.), India.

days to flowering, days to first podding and days to first pod maturity. They also observed high heritability estimates for days to flowering, days to first pod maturity and pod maturity percentage. Ali *et al.* (2008) found high broad sense heritability coupled with high genetic advance for plant height and grain yield. The average yield of this crop is generally low, because of drought, susceptibility to disease and low yield potential of varieties. For improvement of this crop, knowledge on variability and heritability of various plant-parameters, along with genetic advance, is needed to decide about the breeding strategy for development of appropriate genotypes.

The presence of genetic variability is of utmost importance for any breeding programme and for that reason the plant breeders have emphasized the evaluation of germplasm for the improvement of crop yield (Virmani *et al.*, 1983; Bakhsh *et al.*, 1992) as well as for utilization in further breeding programmes. Chickpea has high variation for various qualitative and quantitative characters that can help breeders to release better and superior lines and varieties (Dasgupta *et al.*, 1987; Singh, 1997). For maintenance and efficient utilization of germplasm, it is important to investigate the extent of genetic variability and its magnitude for the determination of the success of a breeding programme (Smith *et al.*, 1991). The present experiment was planned to estimate the variability, heritability (broad sense) and genetic advance for various qualitative and quantitative characters in chickpea.

MATERIALS AND METHODS

The present investigation comprised 45 genetically diverse genotypes/varieties of chickpea (*Cicer arietinum* L.) obtained from the Genetics Division, I. A. R. I., New Delhi and Department of Genetics and Plant Breeding, N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U. P.). These genotypes/varieties were : Pant G-186, 486-18, GCP-105, Vishal, BG-256, Udai, ICCV-15676, ICC-11535, Anupam, BG-261, J. B. 315, B. G. 209, BG-391, Green-112, BG-1108, BG-376, BG-2019, BG-1101, BG-390, EC-539009, BG-1107, Pusa-1088, BG-1044, ILC-2002, ICCV-88503, BG-1103, Pusa-372, ICRISAT-3070, KLB-97-5, NDL. 2-96-21, KLB-97-8, IPL-110, KLB-97-7, IPC-2002-36, KLB-97-8, Awarodhi, BG-203, Pusa-256, ICRISAT-3074, BG-1105, BG-1053, ICRISAT-3073, BG-1073, K-850 and H. O. O. 108. The experimental trial was laid out in randomized block design in three replications at the Agricultural Research Farm of S. D. J. Post Graduate College Chandeshwar, Azamgarh, U. P. during 2008-09. Each plot comprised three rows of 3 m length, spaced 30 cm apart with plant to plant spacing of 10 cm. All the necessary requirements of the crop such as irrigation and inter-cultural operations were fulfilled and the crop was maintained properly. Observations were recorded on randomly selected 10 competitive plants in each replication for plant height (cm), leaf length (cm), number of leaflets/leaf, leaflet length (cm), width of leaflet (cm), number of primary branches/plant, number of secondary branches/plant, number of pods/plant, pod length (cm), pod width (cm), number of seeds/pod, 100-seed weight (g), seed yield/ plant (g), biological yield/plant (g), while data on days to 50 per cent flowering and days to maturity were recorded on plot basis. Broad sense heritability (h^2) was calculated, following Burton (1952). The expected genetic advance (GA), with selection intensity (K), was also calculated using the following formula, proposed by Singh and Chaudhary (1985) :

$$GA = K \cdot \sigma_p \cdot h^2$$

Where, GA is genetic advance, σ_p is phenotypic standard deviation of mean performance of population, K (2.06) is the constant standardized selection-differential at 5 per cent and h^2 is broad sense heritability.

RESULTS AND DISCUSSION

Forty-five genotypes of chickpea were studied for 16 quantitative characters to evaluate genetic variability. The genotypes differed significantly for all traits. Mean squares for genotypes as shown in Table 1 were found to be significant for days to 50 per cent flowering, days to maturity, plant height (cm), leaf length (cm), number of leaflets/leaf, leaflet length (cm), width of leaflet (cm), number of primary branches/plant, number of secondary branches/plant, number of pods/ plant, pod length (cm), pod width (cm), number of seeds/ pod, 100-seed weight (g), seed yield/plant (g) and biological yield/plant (g).

Mean performance of genotypes for different characters are given in Table 2. The general mean of number of days to flowering was 61.52 days, and it

TABLE 1
Analysis of variance for different characters of chickpea

Source of variation	d. f.	Mean sum of squares															
		DF	DM	PH	L.L.	NL/L	Lt.L	WL	NPB	NSB	NP/P	PL	PW	NS/P	100SW	YPP	BY
Replication	2	2.27	12.56	3.22	0.039	0.084	0.003	0.0034**	0.0184	3.85**	20.05*	0.10**	0.0026	0.05*	0.19	1.105	10.82
Treatment	45	15.92**	182.43**	143.60**	0.93**	2.41**	0.08**	0.086**	3.590**	26.59**	276.04**	0.20**	0.052**	0.11**	92.97**	13.901**	359.36
Error	90	3.03	10.81	3.28	0.076	0.039	0.0016	0.0007	0.0675	0.74	4.85	0.018	0.001	0.013	0.35	0.782	13.52

DF : Days to 50% flowering, DM : Days to maturity, PH : Plant height (cm), LL : Leaf length (cm), NL/L : Number of leaflets per leaf, LtL : Leaflet length (cm), WL : Width of leaflet (cm), NPB : Number of primary branches per plant, NSB : Number of secondary branches per plant, NP/P : Number of pods per plant, PL : Pod length, (cm), PW : Pod width (cm) NS/P : Number of seeds per pod, 100 SW : 100-seed weight (g), YPP : Seed yield per plant (g), BY : Biological yield per plant.

TABLE 2
Mean performance of chickpea genotypes for different characters

S.	Genotypes	DF	DM	PH	LL	NL/L	LtL	WL	NPB	NSB	NP/P	PL	PW	NS/P	100SW	YPP	BY
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	Pant-G- 186	61.67	9.67	53.07	3.57	11.87	0.96	0.49	5.93	12.17	38.20	1.37	0.80	1.70	13.40	6.21	39.71
2.	486-18	60.67	103.00	59.33	4.63	12.13	1.14	0.78	4.73	8.77	34.07	1.83	1.14	1.67	25.17	10.24	32.06
3.	GCP-105	63.33	102.33	54.07	4.67	13.40	1.16	0.64	4.73	12.47	30.47	1.77	1.16	1.60	24.43	7.37	36.23
4.	Vishal	60.67	113.33	51.60	4.53	13.60	1.18	0.85	5.87	11.23	39.87	2.10	1.11	1.97	26.10	9.93	36.31
5.	BG-256	62.00	100.33	52.13	3.83	12.13	1.09	0.78	5.30	12.67	54.90	1.67	1.05	1.60	22.30	10.90	36.34
6.	Udai	63.00	119.00	50.20	4.27	13.00	1.00	0.57	5.60	13.07	31.67	1.70	0.96	2.30	15.37	9.94	39.11
7.	ICCV-15676	63.00	125.00	48.93	4.23	11.87	0.99	0.53	4.53	13.07	38.27	1.57	0.96	1.99	12.17	8.25	38.45
8.	ICC-11535	63.00	119.00	40.33	3.73	12.40	0.87	0.48	7.13	13.00	43.07	1.23	0.81	1.83	10.77	8.48	23.10
9.	Anupam	63.33	103.00	44.53	3.97	11.93	1.03	0.57	5.73	10.43	42.00	1.67	1.01	2.00	12.13	10.00	22.21
10.	BG-261	62.67	120.33	47.33	3.67	12.67	0.89	0.45	7.70	18.40	55.93	1.43	0.84	2.07	9.90	8.70	39.42
11.	JB-315	63.00	110.67	53.60	4.23	11.93	1.10	0.64	4.13	11.27	37.00	1.47	0.97	1.73	14.10	8.17	20.34
12.	BG-209	63.00	122.00	44.40	3.73	13.47	0.83	0.53	5.73	9.70	57.80	1.53	0.93	1.97	10.37	10.70	29.12
13.	BG-391	61.67	113.67	45.93	3.80	11.93	1.16	0.54	4.40	9.97	41.87	1.70	0.99	1.80	22.33	9.27	24.01
14.	Green-112	65.00	123.33	52.00	4.20	12.80	1.19	0.76	4.80	9.33	51.33	1.73	1.11	2.07	15.37	11.00	24.23
15.	BG-1108	62.67	120.00	64.07	5.13	12.27	1.34	1.06	4.80	6.83	39.33	2.13	1.27	1.87	28.37	12.59	28.04
16.	BG-376	54.67	106.00	63.73	4.60	11.87	0.94	0.67	4.07	8.37	30.60	1.53	0.88	1.57	16.53	7.30	26.55
17.	BG-2019	61.00	104.33	55.33	4.47	11.93	1.39	0.98	4.70	7.00	25.27	2.00	1.03	1.70	23.83	7.51	18.23
18.	BG-1101	61.00	116.67	63.53	4.30	11.40	1.16	0.83	4.03	10.20	37.60	1.87	1.03	1.77	22.93	10.02	35.03
19.	BG-390	63.33	114.00	52.73	4.50	11.87	1.05	0.68	5.40	7.67	37.00	1.87	1.03	1.53	29.30	13.38	25.23
20.	EC-539009	62.00	101.33	66.73	5.17	13.87	1.14	0.83	3.13	5.13	17.83	1.90	1.07	1.37	21.00	13.33	18.03
21.	BG-1107	60.33	103.33	59.73	4.80	12.60	1.25	0.92	2.67	9.20	16.33	2.17	1.14	1.53	27.10	8.57	24.11
22.	Pusa-1088	62.33	108.67	51.47	5.03	12.43	1.31	0.98	3.83	11.27	30.13	2.33	1.20	1.93	26.90	10.61	43.56
23.	BG-1044	59.67	102.00	45.53	5.30	12.07	1.49	1.20	3.60	7.67	32.33	2.23	1.22	1.57	22.80	7.83	16.22
24.	ILC-2002	63.00	104.00	50.27	4.27	13.00	1.12	0.59	3.33	10.60	38.40	1.47	0.79	1.80	12.80	8.18	30.45
25.	ICCV-88503	57.33	103.00	49.53	3.93	12.33	0.83	0.50	5.47	13.47	61.67	1.50	1.03	1.73	14.93	10.81	45.56
26.	BG-1103	63.00	103.67	53.33	4.27	11.80	1.04	0.73	5.23	10.00	40.47	1.87	1.02	1.70	25.17	10.15	32.23
27.	Pusa-372	63.00	107.33	55.07	5.37	13.13	1.31	0.89	5.13	9.00	42.00	2.13	1.12	1.47	26.63	15.20	22.34
28.	ICRISAT-3070	59.00	105.33	72.67	5.50	11.93	1.41	0.89	4.70	12.80	46.07	2.00	1.20	1.83	20.60	8.13	26.65
29.	KLB-97-5	63.00	108.00	42.87	4.00	12.40	1.01	0.67	4.73	10.83	40.57	1.90	0.86	1.93	16.17	11.82	28.56
30.	NDL-2-96-21	60.33	104.00	56.47	4.10	12.00	1.31	0.66	4.43	11.30	30.73	1.90	1.27	1.90	20.70	9.93	33.34

Contd.

Table 2 contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
31.	KLB-97-8	63.00	103.67	58.00	4.50	14.07	1.04	0.63	5.53	10.40	56.40	1.80	1.05	1.70	16.73	9.53	25.43
32.	IPL-110	61.67	105.33	51.00	5.70	15.27	1.21	0.63	5.20	12.37	39.00	2.10	1.14	1.67	23.87	14.81	26.45
33.	KLB-97-7	60.33	104.67	48.53	4.63	11.07	1.32	0.82	3.90	5.80	32.67	1.50	0.99	1.80	17.37	5.73	18.56
34.	IPC-2002-36	63.00	106.67	51.93	4.20	12.60	1.33	0.92	7.00	14.00	44.13	2.13	1.31	1.90	19.67	10.63	33.12
35.	KLB-97	62.33	101.67	51.27	4.20	13.80	1.04	0.60	6.80	12.20	44.67	1.83	1.13	1.67	16.20	8.45	26.34
36.	Awarodhi	63.00	112.33	38.13	4.20	12.73	0.96	0.55	6.07	10.20	44.20	1.57	0.84	2.03	17.03	9.37	41.23
37.	BG-203	62.67	119.67	46.73	3.50	12.13	0.96	0.53	5.40	20.67	50.20	1.63	0.96	1.93	9.33	10.57	56.57
38.	Pusa-256	62.67	117.67	54.67	4.07	12.20	1.09	0.91	4.70	12.87	44.60	1.90	1.06	1.73	24.87	15.51	47.01
39.	ICRISAT-3074	54.67	118.33	52.00	4.73	10.80	1.19	0.69	3.80	5.23	44.93	1.97	1.05	1.77	17.83	8.96	19.88
40.	BG-1105	62.33	102.00	64.47	4.13	12.13	1.13	0.75	4.60	8.63	46.33	1.90	1.14	1.83	18.63	10.80	32.34
41.	BG-1053	61.33	115.67	50.80	4.77	12.73	1.13	0.74	4.40	11.67	39.33	2.23	1.21	1.70	25.53	9.42	45.32
42.	ICRISAT-3073	54.67	113.00	54.80	5.10	11.20	1.31	0.72	4.40	8.80	37.07	1.83	0.98	1.90	16.17	10.01	21.89
43.	BG-1073	60.67	107.33	55.30	5.27	11.27	1.36	0.72	4.83	8.20	37.07	2.07	1.20	1.83	16.87	8.50	35.56
44.	K-850	61.67	121.67	56.27	5.27	14.33	1.28	0.85	3.03	10.20	45.60	2.07	1.27	1.60	25.40	11.37	33.43
45.	H. O. O-108	63.00	94.33	55.13	4.07	12.67	1.43	0.82	6.60	13.07	52.80	1.90	1.17	1.40	22.93	10.07	42.21
	Mean	61.53	107.56	53.10	4.45	12.47	1.14	0.72	94.46	10.69	40.48	1.82	1.06	1.78	19.51	9.96	31.11
	C. D.	2.83	5.34	2.94	0.45	0.32	0.06	0.04	0.42	1.40	3.58	0.22	0.05	0.18	0.95	1.44	3.01

Character details are given in Table 1.

ranged from 54.67 days (ICRISAT 3074) to 65 days (Green-112. Whereas mean value of number of days to maturity was 109.00 days and it ranged from 94.33 days (H.O.O-108) to 125 days (ICCV-15676). Plant height mean was 46.47 cm, and it ranged from 32.2 cm (ICC-11535) to 62.67 cm (ICRISAT-3070). Leaf length ranged from 3.50 cm (BG-203) to 5.70 cm (IPL-110). Number of leaflets per leaf ranged from 10.80 (ICRISAT-3074) to 15.27 (IPL-110). The mean of 100-seed weight was 19.51 g and ranged from 9.33 g (BG-203) to 29.30 (BG-390). Seed yield per plant ranged from 5.28 g (KLB-97-7) to 16.68 g (Pusa-372) with mean of 9.95 g. The total biological yield per plant ranged from 16.22 g (BG-1044) to 56.57 g (BG-203) with a mean of 31.11 g.

Days to 50 per cent flowering showed moderate estimate of heritability (58.6%). This indicated that total variability was due to genetic causes as well as due to environment. Days to maturity, plant height (cm), number of leaflets/leaf, leaflet length (cm), width of leaflet (cm), number of primary branches/plant, number of secondary branches/plant, number of pods/plant, pod width (cm), 100-seed weight (g) seed yield/ plant (g) and biological yield/plant (g), seed yield/plant exhibited high estimate of heritability (84.1, 93.5, 92.5, 94.5, 97.6, 94.6, 92.0, 94.9, 94.3, 98.9, 84.8 and 89.0%), which indicated that a proportion of the total variability were due to genetic causes. The differences between genotypic and phenotypic coefficient of variability was very small (Table 3) indicating negligible role of environment. Heritability estimates for plant height, leaflet length, number of primary branches/plant, number of pods/plant and pod width were high (93.5, 94.5, 94.6, 94.9 and 94.3%), indicating the success of selection for their traits. Leaf length exhibited moderately high estimate of heritability (78.8%), which indicated that a reasonable proportion of the total variability was due to genetic causes. The differences between genotypic and phenotypic coefficient of variability showed the environmental influence. The results are in agreement with those of Jahagirdar *et al.* (1994) who found high estimate of heritability for this character. Heritability estimate for number of leaflets/leaf was high (92.5%), indicating the success of selection for this trait. The differences between genotypic and phenotypic coefficient of variability were very small indicating negligible role environment. The results are in accordance with the findings of Iqbal *et al.* (1994).

Number of secondary branches/plant showed high heritability (92.0%) with small differences between genotypic and phenotypic coefficient of variability and should be selected for constituting desirable genotypes of chickpea. Pod length exhibited moderately high estimate of heritability (77.2%), which indicated that a reasonable proportion of the total variability was due to genetic causes. The differences between genotypic and phenotypic coefficient of variability showed the environment influence. Number of seeds/pod exhibited moderately high estimate of heritability (71.2%), indicating the success of selection for this trait. The differences between genotypic and phenotypic coefficient of variability were very small indicating negligible role of environment. A high estimate of broad sense heritability for 100-seed weight and width of leaflet content reflected that selection could be effective for improving the trait. Smaller differences between genotypic and phenotypic coefficient of variability indicated that major proportion of phenotypic variance was due to genetic differences. From the foregoing results, it may be concluded that the characters with high heritability i. e. 100-seed weight and width of leaflet content with small differences between genotypic and phenotypic coefficient of variability should be selected

TABLE 3

Estimates of genetic parameters for quantitative traits in chickpea

Genetic parameters	Characters															
	DF	DM	PH	LL	NL/L	LtL	WL	NPB	NSB	NP/P	PL	PW	NS/P	100SW	YPP	BY
σ^2g	4.295	57.21	46.79	0.283	0.816	0.027	0.028	1.174	8.614	90.393	0.061	0.016	0.031	30.873	4.373	115.28
GCV	3.37	6.9	12.88	11.96	7.09	14.51	23.3	21.95	27.45	23.48	13.67	12.29	10.03	28.48	21	34.51
σ^2p	7.326	68.0	50.06	0.358	0.855	0.029	0.029	1.241	9.358	95.247	0.08	0.017	0.044	31.218	5.15	128.78
PCV	4.4	7.53	13.32	13.47	7.38	14.92	23.59	22.57	28.61	24.11	15.55	12.65	11.89	28.63	22.8	36.47
h^2_{bs}	58.6	84.1	93.5	78.8	92.5	94.5	97.6	94.6	92	94.9	77.2	94.3	71.2	98.9	84.8	89.0
GA	5.31	13.04	25.65	21.81	14.04	28.86	46.91	43.93	54.28	47.25	24.72	24.55	17.51	58.32	39.93	66.87

Characters details are given in Table 1.

for constituting desirable genotypes of chickpea. Heritability estimate for yield/plant was high (84.8%), indicating the success of selection for this trait. The differences between genotypic and phenotypic coefficient of variability were very small indicating negligible role of environment. The results are in accordance with the findings of Iqbal *et al.* (1994). Ali *et al.* (2008) observed high broad-sense heritability for plant height (97.4%) and grain yield (97.3%).

Only heritability itself does not provide the clue for genetic gain resulting from the best selected individuals. Burton (1952) suggested that h^2, in combination with genetic advance (GA), was more reliable in predicting the effect of selection. The estimates of genetic advance ranged from 5.31 for days to 50 per cent flowering to 66.87 for biological yield per plant (Table 3). In the present study, high heritability coupled with high genetic advance for 100-seed weight, width of leaflet, number of pods/plant and biological yield per plant indicated additive gene effects to be important for determining these traits. On the other hand, high h^2 was associated with low genetic advance for days to maturity, indicating the influence of dominant and epistemic gene for these traits. Low heritability percentage coupled with low and moderate genetic advancement was observed for days to 50 per cent flowering and indicated that this trait was greatly influenced by environment as also observed by Noor *et al.* (2003) and Arshad *et al.* (2004). These results are supported by the findings of Miah and Bhadra (1989), Aslam *et al.* (1992) and Yaqoob *et al.* (2010).

ACKNOWLEDGEMENT

We are thankful to Dr. Ganesh Prasad, Ex. Head Department of Genetics and Plant Breeding. Sri Durga Ji Post Graduate College, Chandeshwar, Azamgarh, U. P. and Principal Dr. D. P. Dwivedi for providing the scientific suggestion and experimental field, respectively. We are also thankful to Dr. Sandeep Saxena from Pantnagar University for the data analysis and tabulation of the record.

REFERENCES

Ali, M. A., N. N. Nawab, G. Rasool, and M. Saleem, 2008 : *J. Agric. Soc. Sci.* **4** : 177-179.

Arshad, M., A. S. Qureshi, A. Shaukat, A. Bakhsh, and A. Ghafoor, 2004 : *Pak. J. Bot.,* **36** : 779-785.

Aslam M., N. A. Khan, M. S. Mirza, and A. R. Khan, 1992 : *Pak. J. Agric. Res.*, **13** : 20-25.

Awan, M. Y., and A. J. Malik, 1997 : *Pak. J. Agric. Enggs. Vet. Sci.*, **11** : 86-91.

Bakhsh, A., A. Ghafoor, and B. A. Malik, 1992 : *Pak. J. Agic. Res.*, **12** : 245-251.

Burton, G. W, 1952 : *Proc. 6th Intl. Grassland Cong.,* **1** : 277-283.

Dasgupta, T., M. O. Islam, P. Gayen, and K. K. Sarkak, 1987 : *Exp. Genet.*, **3** : 15-21.

Hulse, J. H. 1991 : In : *Uses of Tropical Legumes.* Proc. Consultants' Meeting, 27-30 March 1989, ICRISAT Center, India.

Iqbal, J., M. Saleem, A. A. Khan, and M. Anwar, 1994 : *J. Anim. Pl. Sci.*, **4** : 35-36.

Jahagirdar, J. E., R. A. Patia, and P. R. Khere, 1994 : *Indian J. Pulses Res.*, **7** : 179-180

Khan, R., Farhatullah, and H. Khan, 2011 : *Sarhad J. Agric.,* **27** : 67.

Miah, N. N., and S. K Bhadra, 1989 : *Bangladesh J. Agric.,* **19** : 72-75.

Naidu, N. N, A. S. Naryana, and A. Anatsayana, 1991 : *Indian J. Pulses Res.,* **4** : 19-22.

Noor, F., M. Ashaf, and A. Ghafoor, 2003 : *Pak. J. Biol. Sci.,* **6**: 551-555.

Saxena, N. P., M. C. Saxena, C. Johansen, S. M. Virmani, and H. Harris, 1996 : In : *Adaptation of Chickpea in the West Asia and North Africa Region.,* Saxena, N. P., M. C. Saxena, C. Johansen, S. M. Virmani, and H. Harris (eds.). ICARDA, Aleppo, Syria. pp. 257-263.

Singh, K. B. 1997 : In : *The Chickpea*, Saxena, M. C. and K. B. Singh (eds.). CAB Intl., UK.

Singh, R. K., and B. D. Chaudhary, 1985 : *Biometrical Methods in Quantitative Genetic Analysis.* Kalyani Pub., Ludhiana, New Delhi, India.

Smith, S. E., K. B. Singh, and R. S. Malhotra, 1991 : *Crop Sci.*, **31** : 1150-1163.

Virmani, S. S., K. B. Singh, K. Singh, and R. S. Malhotra, 1983 : *Indian J. Genet.,* **43** : 54-58.

Yaqoob, M., A. B., N. Khan, M. A. Zahid, and L. H. Akhtar, 2010 : *Sci. Technol. & Dev.* **29** : 10-13.