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Genetic variability, heritability and genetic advance studies for yield and its contributing traits in clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.].

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Abstract
Forty diverse clusterbean genotypes were analyzed for genetic variability, heritability and genetic advance for yield and its contributing characters. The genotypes were significantly different for all the characters. High heritability along with high genetic advance (GA) as per cent of mean was recorded for number of branches/plant, biological yield/plant, seed yield/plant, number of clusters/plant and number of pods/plant indicating that these were controlled by additive gene effects and selection would be rewarding for these characters. The PCV estimates were invariably higher than their corresponding GCV values thereby suggesting the role of environmental influence. High estimates of GCV and PCV were observed for number of branches/plant, biological yield/plant, seed yield/plant, number of clusters/plant and number of pods/plant suggesting that selection based on these characters would facilitate successful isolation of desirable genotypes. The genotypes RGC 986, RARI-CB-18-25, HG 2-20, RGC 1017 and RARI-CB-18-20 were found promising having high mean performance for seed yield and other related traits.

Keywords: Variability, heritability, genetic advance and cluster bean

Introduction
Clusterbean is a drought tolerant, self-pollinated, leguminous crop belongs to family *Fabaceae*, commonly known as guar. India is a geographic center of variability for guar (Vavilov, 1951) [14] while Gillet (1958) [4] suggested that tropical Africa as its probable center of origin. It is an arid legume crop, mostly cultivated in the arid and semi-arid areas. Being a short duration crop, it holds immense potential to generate better economic returns to the growers from marginal land holdings with a huge production. Guar is mainly cultivated for food as vegetables, feed, fodder and guar gum. Its tender & young pods are used as vegetables, which also known for cheap source of energy (16 Kcal), protein (3.2 g), carbohydrate (10.8 g), fat (1.4 g), vitamin A (65.3 IU), vitamin C (49 mg), calcium (57 mg) and iron (4.5 mg) for every 100 g of edible portion (Kumar and Singh, 2002). Leaves of guar are eaten to cure night blindness. Like other legumes, guar crop has the feature of formation of root nodules through which nitrogen fixing bacteria fixes about 30-40 kg N/ha. India is the largest producer with an area of 5.6 million hectares with production of 2.7 million tones and productivity 482 kg/ha (Anonymous, 2017) [1]. Rajasthan holds first rank in area and production in India. In Rajasthan, it is cultivated on 3.08 million hectares area with the production of 1.03 million tones and productivity of 334 kg/ha (Anonymous, 2019) [2].
In any crop improvement programme, evaluation of genotype to assess the existing variability is considered as preliminary step. Variability for different traits in the source population is a prerequisite for crop improvement. Heritability is a good index of the transmission of character from parents to their offspring (Falconer, 1981) [3]. Heritability estimates coupled with genetic advance are generally more helpful in predicting the gain under selection rather than heritability estimates alone.

Material and Method
A field experiment was conducted at Research Farm, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif* 2019.

Clusterbean germplasm comprising of 40 genotypes (Table 1) were evaluated in a randomized block design (RBD) with three replications. Each treatment was raised in 4 m long rows with spacing of 45 cm between rows and 30 cm between plants. The observations were recorded on the basis of five randomly selected plants from each replication for ten character *viz.*, plant height, number of branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pod, pod length, 100-seed weight, biological yield per plant, harvest index and seed yield/plant while days to 50% flowering and days to maturity were recorded on plot basis. The genetic variability, heritability and genetic advance were carried out as per standard procedures.

Table 1: Mean performance of clusterbean genotypes for different traits

S. No.	Name of genotypes	Day to 50% Flowering	Plant height (cm)	Number of branches/ plant	Number of clusters/ plant	Number of pods/ plant	Number of seeds/ pod	Pod length (cm)	Day to maturity	100-seed weight (g)	Biological yield/plant (g)	Harvest Index (%)	Seed yield/plant (g)
	RARI-CB-18-01	48.00	102.47	1.47	11.13	35.33	8.60	5.65	112.00	3.89	40.53	25.67	10.37
	RARI-CB-18-02	40.00	81.53	3.87	18.20	41.53	7.33	5.08	98.00	3.17	38.89	27.64	10.65
	RARI-CB-18-03	40.33	89.33	4.47	17.27	47.13	7.60	5.57	99.00	3.18	40.33	29.07	11.65
	RARI-CB-18-04	48.67	125.33	1.87	12.47	30.60	8.80	5.80	118.33	3.24	33.01	25.82	8.45
	RARI-CB-18-05	50.00	126.67	6.00	20.53	51.13	7.27	5.15	119.33	3.59	55.82	26.07	14.50
	RARI-CB-18-06	38.33	122.53	10.07	22.87	59.80	7.93	6.05	108.67	3.77	52.84	31.04	16.32
	RARI-CB-18-07	48.67	125.00	13.20	20.87	62.73	7.67	5.80	121.33	3.62	61.29	26.96	16.42
	RARI-CB-18-08	48.67	124.33	7.93	12.73	34.60	8.20	5.47	117.00	3.45	33.52	25.67	8.53
	RARI-CB-18-09	46.67	136.67	10.93	19.47	59.40	8.53	5.62	115.00	3.16	63.04	27.05	17.06
	RARI-CB-18-10	41.33	112.00	10.07	22.67	56.33	8.53	5.25	112.67	3.21	62.04	25.18	15.57
	RARI-CB-18-11	49.00	126.07	7.00	20.27	53.93	8.73	5.62	120.00	3.74	56.95	27.03	15.36
	RARI-CB-18-12	41.33	103.27	7.67	12.53	35.87	8.93	5.50	114.67	3.63	34.72	27.66	9.60
	RARI-CB-18-13	38.67	107.73	8.20	22.53	57.53	8.87	5.42	119.33	3.09	60.35	25.91	15.57
	RARI-CB-18-14	50.67	129.13	7.67	20.73	44.67	8.00	5.63	124.00	3.58	45.62	26.66	12.16
	RARI-CB-18-15	49.33	129.27	10.67	18.87	41.33	8.93	5.72	121.00	3.75	38.03	29.16	11.09
	RARI-CB-18-16	48.67	133.10	10.33	24.60	55.93	8.07	5.43	121.33	3.72	65.33	24.47	16.00
	RARI-CB-18-17	50.00	126.80	8.53	19.13	41.87	7.93	5.07	119.00	3.08	42.02	26.43	11.09
	RARI-CB-18-18	48.67	122.47	10.07	23.40	58.53	7.53	5.60	124.00	3.22	63.66	25.93	16.32
	RARI-CB-18-19	46.33	125.80	9.07	23.20	61.20	7.80	5.50	122.00	3.80	55.77	31.27	17.41
	RARI-CB-18-20	47.00	122.80	9.73	24.20	76.13	8.80	5.93	122.67	3.32	70.47	25.96	18.16
	RARI-CB-18-21	47.00	110.80	1.40	12.40	63.87	7.67	5.73	110.67	3.77	48.40	26.72	12.80
	RARI-CB-18-22	45.67	93.80	7.33	22.07	35.07	8.47	5.57	109.33	3.32	35.41	25.09	8.89
	RARI-CB-18-23	48.00	86.20	7.87	11.20	57.93	8.00	5.59	111.33	3.23	55.08	28.74	15.78
	RARI-CB-18-24	48.00	92.47	5.00	17.87	48.07	7.73	5.19	110.67	3.82	34.71	31.55	10.88
	RARI-CB-18-25	46.33	95.53	9.00	25.87	65.07	8.27	5.47	120.00	3.66	75.14	26.15	19.51
	RARI-CB-18-26	51.67	115.93	8.67	24.07	57.73	7.60	5.25	121.67	3.76	58.25	26.85	15.36
	RARI-CB-18-27	47.33	114.60	9.33	26.00	56.87	8.40	5.55	120.33	3.75	60.40	27.36	16.44
	RARI-CB-18-28	47.33	111.60	6.60	17.40	50.27	8.00	5.67	121.33	3.27	40.97	30.64	12.48
	RARI-CB-18-29	50.67	106.73	7.73	16.93	44.07	7.47	5.27	118.67	2.99	41.58	26.48	10.88
	RARI-CB-18-30	46.67	115.60	8.73	24.07	55.33	8.53	5.30	123.00	3.73	51.65	31.22	16.00
	RGC 936	46.33	135.47	7.20	21.27	51.47	7.80	5.63	108.67	3.69	52.77	30.11	15.68
	RGC 1003	46.33	130.60	8.07	21.93	59.80	8.73	5.98	121.00	3.86	57.27	29.20	16.64
	RGC 1017	45.00	140.87	8.87	22.33	57.27	8.93	5.73	110.00	3.70	72.93	25.75	18.56
	RGC 1055	44.33	143.60	9.73	11.33	37.27	8.27	5.60	110.00	3.39	35.83	29.43	10.56
	RGC 1031	49.67	138.33	6.80	16.93	43.53	7.73	5.48	119.00	3.66	52.17	25.56	13.34
	RGC 1038	41.67	117.33	5.80	14.20	50.00	7.60	5.53	100.67	3.17	41.92	29.80	12.48
	RGC 1066	44.67	162.40	1.67	13.53	29.07	7.73	5.37	103.00	3.38	32.21	25.23	8.10
	RGC 986	49.33	136.93	7.33	23.00	65.00	8.40	5.95	111.67	3.77	68.87	29.07	19.84
	M 83	40.67	124.80	1.20	14.07	30.53	8.73	7.55	121.33	3.14	39.48	24.98	9.82
	HG-2-20	42.67	113.07	6.67	24.73	62.93	8.20	5.95	106.00	3.90	61.28	31.23	19.06

Results and Discussion

The analysis of variance revealed that genotypes under study differed significantly for all the characters (Table 2). The data on general mean, range, the phenotypic (PV) and genotypic (GV) variance, phenotypic (PCV) and genotypic (GCV) coefficients of variation, broad sense heritability (h2), genetic advance (GA) and genetic advance over mean (GAM) are presented in Table 3. PCV were higher than GCV for all the characters. This indicated the positive effect of environment in enhancing differences among genotypes at phenotypic level. High values of phenotypic and genotypic coefficient of variations were showed by number of branches/plant, number of clusters/plant, number of pods/plant, biological yield/plant and seeds yield per plant. These characters pointed out the presence of relatively high amount of genetic variability suggesting good scope for improvement by creating variability either by hybridization or mutation followed by selection. Moderate GCV and PCV was recorded for plant height while pod length and harvest index showed moderate PCV but low GCV which suggests that improvement in these characters might be gained up to reasonable extent. The low GCV and PCV values were found for days to 50% flowering, number of seeds/pod, days to maturity and 100-seed weight.

The heritability estimates in general were high (>70%) for days to 50% flowering, plant height, number of branches/plant, number of pods/plant, number of clusters/plant, seed yield/plant, biological yield/plant and days to maturity. According to Panse and Sukhatme (1957) [10] such characters are governed pre-dominantly by additive gene action and could be improved through individual plant selection programme due to their high heritability values. These findings are in consonance with those of Kumar and Ram (2015) [7], Patil *et al.* (2016) [11], Santhosha *et al.* (2017) [13], Rishitha *et al.* (2019) [12] and Kgasudi *et al.* (2019) [6].

The genetic advance (GA) is important in estimating the amount of progress that can be achieved by selecting for the particular trait. The expected genetic advance manifested as percentage of mean varied from 4.79 to 77.71. High genetic

advance were noticed for number of branches/plant, seed yield/plant, number of clusters/plant, biological yield/plant and number of pods/plant.

Heritability estimate generally affected by the type of genetic material, size of sample, sampling method, method of calculation and effect of linkage etc. Thus heritability values coupled with genetic advance would be more reliable and useful in predicting the gain under selection than heritability estimates alone. In the present study the traits like number of branches/plant, seed yield/plant, number of pods/plant, number of clusters/plant, biological yield/plant and plant height recorded high heritability accompanied with high genetic advance over mean indicated that genotypic variation in the material for these characters may possibly be due to high additive genetic variance, which show the possibility for high selection efficacy. These results are in conformity with the earlier findings of Muthuselvi and Shanthi (2013) [9], Malaghan *et al.* (2013) [8] and Kapoor (2014) [5].

Table 2: Analysis of variance for seed yield and other traits of clusterbean

Source of variation	d.f.	Day to 50% Flowering	Plant height (cm)	Number of branches/ plant	Number of clusters/ plant	Number of pods/ plant	Number of seeds/ pod	Pod length (cm)	Day to maturity	100-seed weight (g)	Biological yield/plant (g)	Harvest Index (%)	Seed yield/plant (g)
Replication	2	0.16	234.1	0.56	2.95	7.86	0.43	0.41	3.66	0.01	49.45	18.83	1.76
Genotype	39	37.90**	882.84**	24.73**	62.90**	390.82**	0.75**	0.48**	153.86**	0.23**	463.31**	13.29*	34.43**
Error	78	3.97	90.39	0.44	3.04	18.27	0.31	0.24	9.03	0.03	38.15	7.42	1.59

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

Table 3: Estimates of genetic parameters of variation for 12 characters of clusterbean

Characters	Mean	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Heritability (%)	G.A. as % of mean
					Genotypic	Phenotypic		
Days to 50% flowering	46.24	38.33-51.66	11.31	15.28	7.27	8.45	74.01	12.89
Plant height (cm)	118.97	81.53-162.40	264.15	354.54	13.66	15.83	74.50	24.29
Number of branches/plant	7.35	1.20-13.20	8.10	8.54	38.74	39.78	94.83	77.71
Number of clusters/plant	19.22	11.13-26.00	19.95	22.99	23.24	24.95	86.77	44.59
Number of pods/plant	50.67	29.07-76.13	124.18	142.45	21.99	23.56	87.18	42.30
Pod length (cm)	5.61	5.07-7.55	0.08	0.32	5.03	10.06	24.94	5.17
Number of seeds/pod	8.16	7.27-8.93	0.15	0.46	4.68	8.28	31.85	5.44
Days to maturity	115.19	98.00-124.00	48.28	57.31	6.03	6.57	84.24	11.40
100-seed weight (g)	3.50	2.99-3.90	0.07	0.10	7.34	8.93	67.44	12.41
Biological yield/ plant (g)	50.76	32.21-75.14	141.72	179.87	23.45	26.42	78.79	42.89
Harvest index (%)	27.55	24.47-31.55	1.96	9.38	5.08	11.12	20.89	4.79
Seed yield/plant (g)	13.88	8.10-19.84	10.95	12.54	23.83	25.50	87.35	45.88

Conclusion

Analysis of variance showed considerable amount of variability present among 40 genotypes for all the characters under study. Genotypes RGC 986, RARI-CB-18-25, HG 2-20, RGC 1017 and RARI-CB-18-20 substantially displayed higher mean values for seed yield/plant and other related traits. High GCV, PCV, high heritability with high genetic advance per cent mean was recorded for characters like number of branches/plant, number of clusters/plant, number of pods/plant, biological yield/plant and seed yield/plant indicated that these were controlled by additive gene effects.

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