International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 2211-2217, 2023; Article no.IJECC.105781
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Genetic Variability Analysis for Growth and Yield Parameters in Cluster Bean (*Cyamopsis tetragonoloba* L.) under Rainfed Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GK and LPY conceptualized and carried out the research work and drafted the initial manuscript. Authors AKV and VVAR carried out the statistical analysis and interpretated the results. Authors AKS and VY assisted in verification part. All authors edited the manuscript as well as read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102883

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105781

Original Research Article

Received: 28/06/2023
Accepted: 02/09/2023
Published: 05/09/2023

ABSTRACT

The experiment was carried out to study the genetic variability among 56 genotypes of cluster bean at Central Horticultural Experiment Station (ICAR-CIAH), Godhra, Gujarat during the year 2020, 2021 and 2022. Significant inter- genetic differences were recorded for all the plant characters. The highest estimates of genotypic co- efficient of variation (GCV) and phenotypic co- efficient of variation (PCV) were observed in case of pod yield per plant (86.50 and 86.30), pods per plant (65.27and 64.98) followed by pod weight (51.34 and 50.90), pods per plant (65.27and 64.98) and pod length (31.14 and 31.00) indicating that a greater amount of genetic variability which allow greater scope for selection in these traits. High heritability was recorded all the character under

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study viz., for plant height (98.60%), number of pods plant (99.10%), pod length (99.60%), pod girth (95.10%), pod weight (98.40%), days to first flowering (99.30), days to first harvest (95.60) and pod yield per plant (99.60%). High genetic advance as per cent mean was observed for plant height at (31.98%), number of pods per plant (133.30%), pod length (63.88%), pod girth (27.81%), pod weight (104.08%) and pod yield per plant (177.45%) whereas, the moderate genetic advance as per cent of mean was observed for days to first flower (14.83%) and days to first harvest (11.38%). Both high heritability (broad sense) and genetic advance were high for pod yield/ plant (99.60% and 177.45%), number of pods/ plant (99.10% and 133.30%) followed by pod weight (98.40% and 104.08%). Such high heritability, followed by such rapid genetic advancement, suggests that selection may be beneficial for such qualities. High heritability coupled with high genetic advance as per cent of mean traits were under the strong influence by additive gene action and hence simple selection based on phenotypic performance of these traits would be more effective and genetic improvement for these characteristics might be considered.

Keywords: Cluster bean; GCV; PCV; heritability; genetic advance; rainfed environment.

1. INTRODUCTION

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) is one of the unexploited leguminous crops which has the potential to provide the food, feed and fodder under adverse climatic and soil conditions. It can be grown on marginal lands with minimum resources as it can adapt and tolerate wide range of agro-climatic condition. Basically, there are two types of cluster bean viz. vegetable type and grain type. Its tender green pods are used as vegefig and seeds are used for making gum which used as industrial purpose. Its tender green pods are good source for nutrition and good source of energy, protein and fibre. According to [1], India is a centre of diversity for this crop, whereas [2] considered its probable centre of origin in tropical Africa. Though, it is grown and distributed throughout the country, arid and semi-arid areas dominate its area of cultivation. Being a short duration and hardy crop, it can give good economic return to the farmers with high productivity. Like other legumes, it also forms root nodules and fixes atmospheric nitrogen into the soil and thereby enriching the soil fertility. Considering the importance of cluster bean as a vegetable and grain for guar gum industry and its wide adaptability, it needs improvement for yield and other traits as per suitability of the specific agro-climatic conditions. Being a native crop India, the crop has great scope for improvement through systematic breeding approach [3].

"The genetic makeup plays an important role in determining the yield potential of any crop but environmental factors influence their expression to a great extent. The studies on genetic variability reveals that extent of variability present in the crop genotypes under consideration for their further improvement. However, variability alone particularly phenotypic one is not enough to give a real scenario of potential genotypic variability as it is influenced by the environment as well. Therefore, the knowledge of heritability and genetic advance is very important to know the extent of transmissibility of a characteristic in future generations which ultimately helps in crop improvement through selection" [3,4,5]. Thus, the present study was therefore aimed to study the variability, heritability and genetic advance among cluster bean genotypes.

2. MATERIALS AND METHODS

The present experiment was carried out to study the genetic variability among 56 genotypes of cluster bean using RCBD with three replications. The experiment was taken at experimental farms of ICAR-Central Horticultural Experiment Station, ICAR-CIAH, Godhra, Gujarat during the year 2020, 2021 and 2022. The experimental site was located at 22° 41" 38'' N latitude and 73° 33'38'' E longitude at an altitude of 113 to 115 m above mean sea level which is characterized by semi-arid hot climatic conditions. The mean highest temperature varies between 28.4 ºC to 46.5 ºC and lowest temperature varied 12.7 ºC to 26.70 ºC. The annual rainfall of varied from 293.24 mm to 941.25 mm and relative humidity 27.55 % - 92.50 %. The seeds were sown in ridges and furrows at a distance of 45cm × 45 cm. The crop was maintained by following the recommended package of practices till last harvest. The mean of five plants were taken for analysis in each genotype and observations were recorded. Genotypic and phenotypic coefficients of variance were estimated according to [6] based on estimate of genotypic and phenotypic variance as below.

Genotypic co-efficient of variation (GCV)

$$GCV\ (\%) = \frac{\sigma g}{X} \times 100$$

Phenotypic co-efficient of variation (PCV)

$$PCV\ (\%) = \frac{\sigma p}{X} \times 100$$

Where,

X = General mean, r = Number of replications
σg = Genotypic standard deviation
σp = Phenotypic standard deviation
0-10% : Low
10-20% : Moderate
20% and above: High

The broad sense heritability (h^2bs) was estimated by following the procedure suggested by [7] as indicated here below.

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

h^2 (%) = Heritability (Broad sense),
$\sigma^2 g$ = Genotypic variance, $\sigma^2 p$ = Phenotypic variance.

Genetic advance for each character was predicted by the formula given by [8].

$$GA = h^2 \times \sigma_p \times k$$

Where,

k = Selection differential (2.06) at 5 per cent selection intensity
h^2 = Heritability in broad sense
σ_p = Phenotypic standard deviation

Genetic advance as percentage over mean (GAM) was worked out as suggested by [8].

$$\text{Genetic advance over mean (GAM)} = \frac{GA}{X} \times 100$$

Where,

GA = Genetic advance
X = General mean

The genetic advance as per cent of mean was categorized as suggested by [8] and the same is given below.

0-10% : Low
11-20% : Moderate
>20% : High

3. RESULTS AND DISCUSSION

The analysis of variance for different characters for 56 genotypes of cluster bean results indicated that there was highly significant (P=0.01) difference among all the genotypes for all the characters (Table 1). The resulted indicated that presence of high degree of variation within the genotypes. One method of assessing variability in these traits is through a simple approach of measuring the range of variances. The range of variation observed for all variables in the current investigation (Table 2) revealed that there was considerable diversity among genotypes for all attributes. The similar results were reported by [9,4,3,10]. Various genetic parameters like phenotypic and genotypic co-efficient of variability (PCV, GCV), heritability, genetic advance (GA) and genetic advance as per cent of mean (GAM) for the eight characters like plant height, number pods per plant, pod length, pod girth pod weight, days to first flower, days to first harvest, pod yield per plant, have been discussed as below (Table 2 and Fig. 1).

High PCV was observed for characters like pods per plant (65.27) followed by pod length (31.14), pod weight (51.34) and pod yield per plant (86.50), whereas, high GCV was recorded for pods per plant (64.98) followed by pod length (31.00), pod weight (50.90) and pod yield per plant (86.30). Higher PCV and GCV value indicating maximum amount of variability present in the germplasm for these characters. The higher estimates of PCV than the GCV indicated towards the environmental influence in the expression of all the characteristics. The high GCV indicated that it was given greater emphasis to these traits which indicated the scope for plant breeding programme on which selection acts to evolve superior genotype. The same kind of results were reported by [11] in french bean, [12,13] in cluster bean and (5) in dolichos bean. The moderate PCV and GCV was observed for plant height (15.75 and 15.60) and pod firth (14.19 and 13.84) respectively. On the other hand the low PCV and GCV was noticed in days to first flowering (7.26 and 7.22) and days to first harvest (5.90 and 5.65) respectively which

Table 1. Analysis of variance (mean squares) for growth and yield parameters in cluster bean

Sl. No	Character	Replication	Treatments	Error
	Degrees of freedom	**2**	**55**	**110**
1	Plant height (cm)	272.91	738.61**	10.42
2	Number of pods per plant	486.04	22192.04**	192.27
3	Pod length (cm)	0.248	13.56**	0.05
4	Pod girth (cm)	0.049	0.275**	0.013
5	Pod weight (g)	0.079	2.09**	0.033
6	Days to first flower	0.038	21.28**	0.154
7	Days to first harvest	0.743	22.88**	1.01
8	Pod yield per plant (g)	44.83	201852.30**	791.03

***=Highly significant (1% level of significance)*

Table 2. Range, mean, variability, heritability and genetic advance for growth and yield parameters in cluster bean

Sl. No.	Character	Range		Mean	PCV (%)	GCV (%)	Heritability (%)	GA	GAM (%)
		Minimum	Maximum						
1	Plant height	60.50	126.37	99.62	15.75	15.60	98.60	31.86	31.98
2	No. of pods per plant	24.97	339.33	131.77	65.27	64.98	99.10	175.64	133.30
3	Pod length (cm)	3.80	11.33	6.82	31.14	31.0	99.60	4.36	63.88
4	Pod girth (cm)	1.58	3.04	2.13	14.19	13.84	95.10	0.59	27.81
5	Pod weight (g)	0.59	3.93	1.62	51.34	50.90	98.40	1.69	104.08
6	Days to first flowering	33.05	41.35	36.72	7.26	7.22	99.30	5.44	14.83
7	Days to first harvest	42.70	52.48	47.76	5.90	5.65	95.60	5.43	11.38
8	Pod yield plant (g)	72.56	1271.49	299.89	86.50	86.30	99.60	532.25	177.45

GCV- Genotypic co-efficient of variation, GAM- Genetic advance as per cent of mean, PCV- Phenotypic co-efficient of variation, GA- Genetic advance and h^2- Broad sense heritability

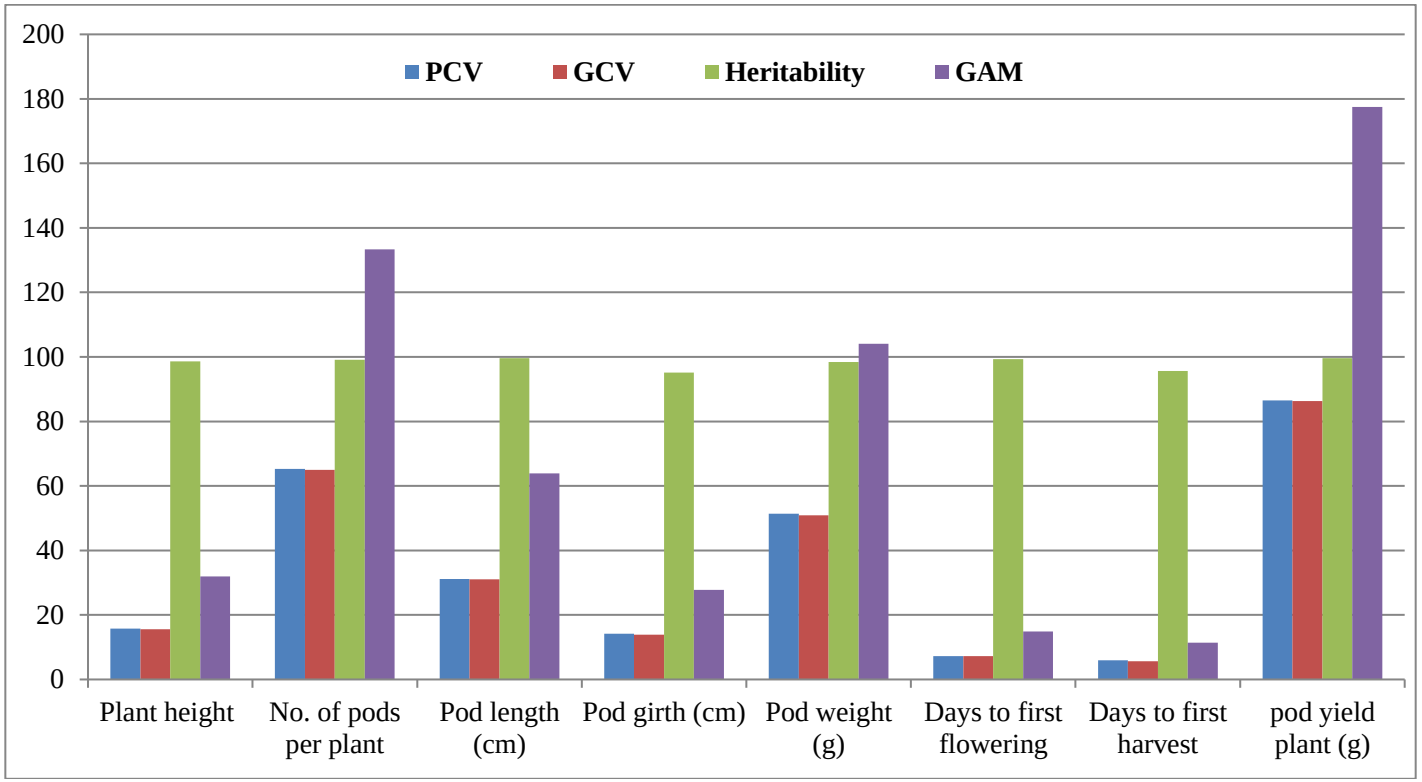

Fig. 1. Estimates of genetic parameters for various characters in cluster bean

indicating the existence of limited variability in the germplasm evaluated for these traits whereas, low PCV and GCV which indicated that minimum variation existed among the genotypes. These results are concurred with earlier studies given by [12,13].

Selection for any feature is effectively determined not just by the quantity of phenotypic and genotypic diversity, but also by estimates of broad sense heritability. High heritability in the broad sense is important in finding acceptable characters for selection and enables the breeder to choose superior genotypes based on phenotypic expression of quantitative traits. High heritability (Table 2 and Fig. 1) was recorded for all the character under study viz. plant height (98.60%), number of pods plant (99.10%), pod length (99.60%), pod girth (95.10%), pod weight (98.40%),days to first flowering (99.30), days to first harvest (95.60) and pod yield per plant (99.60%), high heritability indicates that these characters are less influenced by environmental factors and are under the control of additive gene effects and selection for improvement of such characters would be greatly helpful in the cluster bean breeding programmes. The similar high heritability in cluster bean was reported by [12,13,10]. “GCV along with heritability estimates would provide a better picture of the amount of advance expected by phenotypic selection” [6]. “Heritability estimates in conjunction with genetic gains are more effective and dependable in predicting the improvement through selection” [8]. Since the units of measurements influence the magnitude of genetic advance (GA), the GA as per cent of mean is considered as an essential selection parameter. High genetic advance as per cent mean (Table 2 and Fig. 1) was observed for plant height at (31.98%), number of pods per plant (133.30%), pod length (63.88%), pod girth (27.81%), pod weight (104.08%) and pod yield per plant (177.45%) whereas, the moderate genetic advance as per cent of mean was observed for days to first flower (14.83%) and days to first harvest (11.38%). The characters having higher magnitude of genetic advance as per cent of mean explains that these characters are controlled by additive gene action. Thus, selection for these characters will improve the green pod yield in the cluster bean. These results are agreement with earlier workers reported by [4,3,14,12,13,15] in cluster bean.

4. CONCLUSION

The higher PCV and GCV were observed for pods per plant, pod length, pod weight and pod yield per plant, indicating that a greater amount of genetic variability which provide a greater scope for selection in these traits. High heritability coupled with high genetic advance as per cent of mean was observed for plant height, number pods per plant, pod length, pod girth pod weight and pod yield per plant these traits were under the strong influence of additive gene action and hence simple selection based on phenotypic performance of these traits would be more effective.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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