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Variability, Heritability and Genetic Advance Studies of Cowpea [*Vigna unguiculata* (L.) Walp.] Genotypes at Satna District of M.P. India

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A B S T R A C T

Fourteen diverse cultivars of Cowpea [*Vigna unguiculata* (L.) Walp.] grown in a Completely Randomized block design (CRBD) at AKS University, Satna, during *kharif* season on July to November 2022. The eleven quantitative characters studied for the estimation of variance, genetic variability, heritability and genetic advance. The design of the experiment indicated highly significant differences for all the characters due to treatments. The analysis of variance indicated the existence of sufficient amount of variability among genotypes for all the studied characters. The maximum GCV and PCV was observed in plant height (cm) followed by primary branches per plant, number of pods per plant, biological yield (g) and seed yield per plant (g). High heritability coupled with high genetic advance observed for plant height (cm), biological yield (g), primary branches per plant, seed yield per plant (g) indicating that these characters could be prominently governed by additive gene action. So the selection of these traits could be more effective for desired genetic improvement.

Introduction

Cowpea (*Vigna unguiculata* L. Walp.) with a diploid (2n=22) chromosome number belongs to the family (circle of relatives) Fabeaceae additionally known as southern pea and black eye pea, Kaffir pea, China pea is one of the major legume vegetables.

It is originated in Africa and is extensively grown in Africa, United States, Southeast Asia and in the Southern America. Vavilov (1939) taken into consideration India as the main centre of origin due to the fact in India, it has been recognized since the Vedic instances. The genus Vigna have included 170 species, 120 being in Africa, 22 in India and South-East Asia and a few in America and Australia Faris (1965). Verdcourt (1970) categorized *Vigna unguiculata* into five subspecies, three cultivated (*unguiculata, Sesquipedalis* and *Cylindrica* and two wild *Dekindtiana* and *Mensensis*).

The essentiality of increase in productivity is the present challenge to the crop improvement field. The present day cultivars exhibit lower productivity, non synchronous flowering and fruiting, unresponsive to high doses of

inputs like fertilizers, irrigation, and tillage etc., no suitability of the various cropping systems, lodging and shattering susceptible, long duration, complete or partial absence of genetic resistance to major insect pest and diseases like mosaic virus, rust, powdery mildew and bacterial blight which cause considerable damage and very poor harvest indices.

Development of cultivars with early maturity, acceptable grain quality, resistance to some important diseases and pests has significantly increased the yield and cultivated area Ehlers and Hall (2007). The improvement in crop yield depends upon the magnitude of genetic variability available in breeding material and the extent to which the yield component traits are heritable from generation to generation.

Genetic parameters viz., phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance provide an insight about the characteristics of different genotypes and thus can be utilized for the selection of best parents among the population.

Materials and Methods

The present investigation was conducted during *Kharif,* 2022 at Research farm, Genetics and Plant Breeding, AKS University, Sherganj, Satna, Madhya Pradesh. The material consist 14 varieties/strains of Cowpea (*Vigna unguiculata* L. Walp.) germplasm comprising indigenous genotypes, evaluated in Completely Randomized Block Design.

The entire experimental field divided in 3 blocks of equal size and each block had 14 plots. Each plot was consisted of three rows 1.35 meters length, following row to row spacing of 45 cm. and plant to plant spacing of 20 cm. Recommended cultural practices were applied to raise a good crop.

Eleven observations on yield and yield contributing characters were recorded. In each plot, five competitive plants were randomly selected for recording observations for all the eleven quantitative characters, which were recorded on the plot basis.

The analysis of variance for the design of the experiment was carried out according to the procedure outlined by Panse and Sukhatme (1967). The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and environmental coefficient of variation (ECV) was estimated by the formula suggested by Burton and de Vane (1953).

Heritability in broad sense (h^2b) was estimated using the formula suggested by Burton and de Vane (1953). Genetic advance was calculated by the method suggested by Johnson *et al.,* (1955).

Results and Discussion

The analysis of variance for the design of the experiment involving 14 cowpea strains/varieties were evaluated in Randomized Block Design with three replications for the twelve quantitative characters expressed in Table 1.

The design of the experiment indicated highly significant differences for all the characters. The maximum variances due to replication, treatment and error were found for number of pods per plant (15131.28, 12942.08** and 3376.27), respectively.

Non-significant differences due to replications were observed for all the characters. This indicates that the present sufficient variability for most of the characters among different genotypes and thus suggested a substantial scope of selection.

Almost similar results have been presented by Paghadar *et al.,* (2019); Rukhsar *et al.,* (2020); Sirasapalli *et al.,* (2020); Amritha *et al.,* (2022); Gaiwal *et al.,* (2022); Patel *et al.,* (2022); Verma and Deepanshu (2022) and Kavyashree *et al.,* (2023) in their respective studies.

The comparison of mean performance of 14 varieties/genotypes for 11 quantitative characters revealed existence of very high level variability in the evaluated genotypes collections as given in Table 2. The grand means of 14 genotypes, range, GCV, PCV and ECV for 11 characters are presented in Table 4.

The most desirable genotypes identified in cowpea germplasm for 11 quantitative traits as per mean performance are used as a donor parent for respective traits given in Table 3.

The maximum GCV and PCV was observed for plant height (cm) followed by primary branches per plant, number of pods per plant, biological yield (g) and seed yield per plant (g). This is an indicative of less amenability of these characters to environmental

fluctuations and hence, greater emphasis should be given to these traits. The magnitude of GCV and ranged from harvest index (%) (3.50) to plant height (cm) (55.14) and magnitude of PCV ranged from harvest index (%) (5.38) to plant height (cm) (55.19).

The traits with high environmental coefficient of variation indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection programme because the environmental variations are unpredictable in nature and may mislead the results.

High estimates of GCV in cowpea have been also reported by Jogdhande *et al.,* (2017); Anjali *et al.,* (2018); Paghadar *et al.,* (2019); Yadav and Duddukur (2019); Ajayi and Gbadamosi (2020); Mofokenga *et al.,* (2020); Shrivas *et al.,* (2020); Kushwah *et al.,* (2022); Patel *et al.,* (2022); Vinay *et al.,* (2022) and Kavyashree *et al.,* (2023) in their respective studies.

Heritability estimates are used to predict expected advance under selection so that breeders are able to anticipate improvement from different of selection intensity. Burton and De Vane (1953) suggested that the GCV along with heritability estimate could provide better picture of the genetic advance to be expected by phenotypic selection.

Heritability h² (Broad Sense), h² (Broad Sense)%, Genetic Advancement @ 5%, and Genetic Advance as % of Mean 5% was estimated for all the characters and has been presented in Table: 5.

In general, higher estimates (h^2b) >80% were observed for all the characters except harvest index (%) (42.50%) and number of pods per plant (73.90). High heritability estimates were found for pod length (cm) (99.90%) followed by plant height (cm) (99.80%), days to 50 % flowering (99.30%), 100-seed weight (g) 99.30%), number of seeds per pod (99.20%), days to 90% maturity (98.90%) and primary branches per plant (92.40%) suggested that the characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflect the genotypic ability of strains to transmit the gene to their progenies. Similar results were obtained by Paghadar *et al.,* (2019); Yadav and Duddukur (2019); Ajayi and Gbadamosi (2020); Mofokenga *et al.,* (2020); Shrivas *et al.,* (2020); Kushwah *et al.,* (2022) in their respective studies. Genetic advance is a measure of genetic gain under selection which depends upon main factors viz., genetic variability, heritability, and selection index Allard (1960). The expected genetic advance for 11 characters of cowpea in percent of mean at (5%) ranged from harvest index (%) (4.70%) to plant height (cm) (113.47%). High estimate of expected genetic advance (5%) were found for plant height (cm) (153.48) followed by biological yield (g) (114.67) and number of pods per plant (100.01).

High heritability coupled with high genetic advance observed for plant height (cm), biological yield (g), primary branches per plant, seed yield per plant (g) indicating that these characters could be prominently governed by additive gene action. So the selection of these traits could be more effective for desired genetic improvement.

Low heritability coupled with low genetic advance indicates that the trait is highly influenced by environmental effect and selection would be not effective. These findings are in accordance with the findings observed for high genetic advance by Gupta *et al.,* (2019); Paghadar *et al.,* (2019); Yadav and Duddukur (2019); Ajayi and Gbadamosi (2020); Mofokeng *et al.,* (2020); Panchta *et al.,* (2020); Thapa *et al.,* (2021); Amritha *et al.,* (2022); Gaiwal *et al.,* (2022); Kushwah *et al.,* (2022); Megha *et al.,* (2022); Patel *et al.,* (2022); Verma and Deepanshu (2022); Vinay *et al.,* (2022) and Kavyashree *et al.,* (2023) in their respective studies.

In the light of above findings it may be concluded that wide spectrum of exploitable variability in the material studied with respect to seed yield per plant and its component characters. As per mean performance the maximum yield was recorded by varieties/genotypes viz., Katki, Super Gomti, Malini, Gangotri, Boli-265 and Arkagarima. The maximum GCV and PCV was observed for plant height (cm) followed by primary branches per plant, number of pods per plant, biological yield (g) and seed yield per plant (g).

Higher estimates (h^2b) >80% were observed for all the characters except harvest index (%) and number of pods per plant. High heritability coupled with high genetic advance observed for plant height (cm), biological yield (g), primary branches per plant, seed yield per plant (g) indicating that these characters could be prominently governed by additive gene action. So the selection of these traits could be more effective for desired genetic improvement in cowpea.

Table.1 Analysis of variance (mean sum of squares) for 11 quantitative characters in cowpea

S.No.	Characters	Source of Variation		
		Replication	Treatments	Error
	Degree of Freedom	2	13	26
1	Days to 50 % flowering	8.24	189.86**	1.35
2	Plant height (cm)	16.65	16716.50**	31.43
3	Primary branches per plant	6.09	361.90**	27.61
4	Number of pods per plant	15131.28	12942.08**	3376.27
5	Pod length (cm)	4.34	89.14**	0.12
6	Number of seeds per pod	2.37	19.18**	0.15
7	Days to 90% maturity	4.00	661.99**	7.53
8	Biological Yield (g)	7420.87	12290.31**	1601.75
9	100-seed weight (g)	1.30	76.70**	0.53
10	Harvest Index (%)	1.26	8.08	11.52
11	Seed yield per plant (g)	642.50	910.41**	127.57

*Significant at 5% probability level.
**Significant at 1% probability level.

Table.2 Mean performance of 11 quantitative characters of cowpea genotypes

S.N.	Genotypes	Days to 50 % flowering	Plant height (cm)	Primary branches per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Days to 90% maturity	Biological Yield (g)	100-seed weight (g)	Harvest Index (%)	Seed yield per plant (g)
1	Katki	36.53	236.26	30.74	248.15	38.33	13.03	86.17	268.32	21.16	28.55	76.07
2	Boli-265	48.76	184.41	17.78	165.73	28.00	16.67	107.86	175.29	34.55	29.88	50.08
3	Malini	34.10	243.18	37.78	198.58	24.67	16.47	83.13	190.74	30.95	29.66	56.46
4	Super Gomti	51.39	267.78	38.78	246.76	21.40	16.01	112.92	239.84	24.69	28.61	68.23
5	Anant	56.49	56.37	18.11	85.19	25.20	17.87	114.71	119.06	29.64	30.02	36.30
6	PusaSukomal	43.14	79.63	17.74	86.98	23.87	15.53	104.17	70.69	31.72	31.27	22.13
7	Mohini	58.33	112.67	28.11	84.30	22.60	13.13	122.30	112.87	34.05	31.17	34.86
8	KashiKomal	42.48	64.26	11.56	69.65	23.40	11.43	106.43	93.12	37.53	30.14	28.28
9	Arkagarima	41.24	145.04	36.74	125.87	22.40	16.63	109.42	161.68	23.61	30.20	48.51
10	Pratap	50.50	179.89	21.96	104.74	22.07	10.23	113.36	102.37	37.72	32.79	34.04
11	KashiKanchan	42.46	114.82	24.52	79.94	23.00	13.43	111.80	66.42	31.55	31.00	20.82
12	Gangotri	52.53	80.26	8.11	145.40	24.93	16.27	125.02	171.34	29.45	30.45	52.30
13	Pragati	36.47	54.29	7.11	57.96	34.87	14.03	83.84	79.84	34.89	29.21	23.41
14	Gatika	36.20	74.78	10.78	62.35	34.27	19.27	80.73	85.58	27.37	34.74	29.64

Table.3 Most desirable genotypes of cowpea identified for 11 quantitative traits as per mean performance

S. No.	Traits	Genotypes
1	Days to 50 % flowering	Malini, Gatika, Pragati, Katki, Arkagarima, KashiKanchan and KashiKomal.
2	Plant height (cm)	Pragati, Anant, KashiKomal, Gatika, PusaSukomal and Gangotri.
3	Primary branches per plant	Gomti, Malini, Arkagarima, Katki and Mohini.
4	Number of pods per plant	Katki, Super Gomti, Malini, Boli-265, Gangotri, Arkagarima and Pratap.
5	Pod length (cm)	Katki, Pragati, Gatika, Boli-265, Anant and Gangotri.
6	Number of seeds per pod	Anant, Boli-265, Arkagarima, Malini, Gangotri and Super Gomti.
7	Days to 90% maturity	Gatika, Malini, Pragati, Katki, PusaSukomal and KashiKomal.
8	Biological Yield (g)	Katki, Super Gomti, Malini, Boli-265, Gangotri and Arkagarima.
9	100-seed weight (g)	Pratap, KashiKomal, Pragati, Boli-265, Mohini, PusaSukomal, KashiKanchan and Malini.
10	Harvest Index (%)	Gatika, Pratap, PusaSukomal, Mohini, KashiKanchan and Gangotri.
11	Seed yield per plant (g)	Katki, Super Gomti, Malini, Gangotri, Boli-265 and Arkagarima.

Table.4 Mean, Range, Genotypic, Phenotypic, environmental variances, and coefficient of variation for 11 quantitative characters in cowpea.

S.N.	Characters	Grand mean	Range		GCV	PCV	ECV	CV	C.D. 5%
			Min.	Max.					
1	Days to 50 % flowering	45.04	34.10	58.33	17.60	17.66	2.58	2.58	1.95
2	Plant height (cm)	135.26	54.29	267.78	55.14	55.19	4.15	4.15	9.41
3	Primary branches per plant	22.13	7.11	38.78	47.70	49.63	23.74	23.74	8.82
4	Number of pods per plant	125.83	57.96	248.15	44.88	52.20	46.18	46.18	97.52
5	Pod length (cm)	26.36	21.40	38.33	20.67	20.68	1.31	1.31	0.58
6	Number of seeds per pod	15.00	10.23	19.27	16.79	16.86	2.59	2.59	0.65
7	Days to 90% maturity	104.42	80.73	125.02	14.15	14.23	2.63	2.63	4.61
8	Biological Yield (g)	138.37	66.42	268.32	43.14	46.26	28.92	28.92	67.17
9	100-seed weight (g)	30.63	21.16	37.72	16.45	16.51	2.37	2.37	1.22
10	Harvest Index (%)	30.55	28.55	34.74	3.50	5.38	11.11	11.11	2.54
11	Seed yield per plant (g)	41.51	20.82	76.07	38.92	41.97	27.21	27.21	18.96

Table.5 Heritability (%) in broad sense, Genetic advancement (5%) and genetic advance as percent of mean (5%) for 11 quantitative characters in cowpea

S.N.	Characters	Heritability (h^2b)	Heritability (h^2b %)	Genetic Advance 5%	Gen. Adv. as 5% of Mean
1	Days to 50 % flowering	9.93	99.30	16.27	36.12
2	Plant height (cm)	9.98	99.80	153.48	98.75
3	Primary branches per plant	9.24	92.40	20.90	94.45
4	Number of pods per plant	7.39	73.90	100.01	79.48
5	Pod length (cm)	9.99	99.90	11.21	42.55
6	Number of seeds per pod	9.92	99.20	5.17	34.45
7	Days to 90% maturity	9.89	98.90	30.25	28.97
8	Biological Yield (g)	8.70	87.00	114.67	82.87
9	100-seed weight (g)	9.93	99.30	10.35	33.77
10	Harvest Index (%)	4.25	42.50	1.44	4.70
11	Seed yield per plant (g)	8.60	86.00	30.86	74.34

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Author Contribution

Keshav Pal: Investigation, formal analysis, writing—original draft. Brindaban Singh: Validation, methodology, writing—reviewing. Ayodhya Prasad Pandey:—Formal analysis, writing—review and editing. Rajbeer Singh Gaur: Investigation, writing—reviewing. Deepak kumar: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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