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Unveiling Diversity: Morphological and Genetic Characterization of Cowpea Germplasm in the Southern District of Odisha

Sumit Acharya[1], Manisha[1], Priti Smita Nayak[1], Subhrajyoti Chatterjee[1], Ganisetti Anitha[1], Mukhi Vinitha[1], Pratibha Bahuk[1]

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ABSTRACT

Background: Cowpea [*Vigna unguiculata* (L) Walp.] is one of the main vegetable crop, serving as an essential protein and carbohydrate source and lack of comprehensive information on genetic variability, correlation analysis, path analysis and genetic divergence all of which are necessary for focused breeding programmes that aim to improve cowpea cultivars.

Methods: The present investigation was executed during Zaid 2024 to know morphological and genetic variations in cowpea genotypes. Qualitative and quantitative analysis among 22 genotypes revealed the existence of genetic diversity capability in studied genotypes.

Result: The overall mean value of Shannon-Weaver diversity index was 1.284 which confirmed the existence of diversity among the genotypes. Among these, genotypes ‘IC-202926’, ‘IC-259071’, ‘C-1070’, ‘CP-732’, ‘Ankur Ketaki’, ‘Kashi Nidhi’ and ‘RHS-Kanakam’ and others stood out for their high green pod yield per plant. Traits like plant height and pod yield per plant showed high coefficients of variation (phenotypic and genotypic) indicating potential for improvement. Furthermore, high heritability coupled with substantial genetic advance was observed for Plant height (cm), pod diameter, chlorophyll content (mg/g), total vitamin C(mg/100g) and pod yield per plant(g). This suggests these traits are influenced by additive genes, making early generation selection effective. Pod diameter, number of pods per plant and 100 Seed weight emerged as the most crucial selection criteria for enhancing green pod yield in cowpea.

Key words: Cowpea, Genetic advance, Heritability, Shannon-Weaver diversity index.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L) Walp.] is a self-pollinated legume with multiple common names. According to Vavilov *et al*. (1951), it is native to West Africa and is cultivated for its green vegetables, dry beans and forage. India is a major producer, but it faces low productivity due to various factors. According to Steele *et al*. (1976) these include the cultivation of diverse varieties, non-synchronous flowering and fruiting, susceptibility to stresses and poor harvest index. To address these issues, breeding programs need to focus on developing high-yielding and stress-resistant varieties. This study aims to investigate the morphological and genetic variations among cowpea genotypes in Odisha to provide a foundation for future breeding efforts.

[1]Department of Horticulture, M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, Gajapati, Odisha, India.

Corresponding Author: Manisha, Department of Horticulture, M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, Gajapati, Odisha, India. Email: manisha@cutm.ac.in

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MATERIALS AND METHODS

The study investigated morphological and genetic variations in cowpea genotypes during the zaid season of 2024 at the Horticulture Research Farm of M S Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati, Odisha. The experiment involved 22 genotypes and 3 replications, with each genotype grown in individual plots. Observations were recorded on both qualitative and quantitative characteristics. Ten randomly chosen plants were evaluated for growth habit, pigmentation, leaf color, flower wing color, pod color, pod attachment to peduncle, pod curvature, seed color and pod height. The quantitative traits were plant height (cm), days to first flowering, days to 50% flowering, pod length (cm), pod diameter (cm), number of green pods per plant, green pod weight (g), 100 seed weight (g), number of seeds per pod, chlorophyll content (mg/g), green pod yield per plant (g) and total vitamin c (mg/100 g) (by titrimetric and colorimetric methods). Statistical analyses were performed using Windostat and the Shannon-Weaver diversity index was calculated for each character. To assess the extent of variation among the cowpea genotypes, the following statistical analyses were performed. Genotypic and phenotypic coefficients of variation were calculated based on the method proposed by Burton (1952) and heritability in Broad Sense (H) calculated using the method of Hanson *et al.* (1956) and expected genetic advance (GA) was estimated using the methods outlined by Lush (1949) and Johnson *et al*. (1955). The direct and indirect effects of various traits on green pod yield per plant were determined through path coefficient analysis, following the method established by Dewey and Lu (1959).

RESULTS AND DISCUSSION

A study was conducted on 22 vegetable cowpea genotypes to analyze their morphological characteristics using NBPGR descriptors. Ten qualitative characters were recorded and analyzed, leading to the categorization of growth habits into five groups, with variations reported in plant pigmentation, leaf color and pod color. The genotypes also showed diversity in seed shape, plant hairiness, flower wing color, pod attachment to peduncle and pod curvature. Variations were observed in seed color as well, with different genotypes showing a range of colors such as brown, white, dark brown, red and dark red. Previous studies by Egbadzor *et al.* (2014) also reported significant variations in the morphological characteristics of cowpea genotypes, highlighting the genetic diversity within this crop. Biodiversity in crops is assessed through allelic evenness and allelic richness, with allelic evenness measured using the Shannon-Wiener Diversity Index and allelic richness determined by counting descriptor states. The richness signifies the number of genotypes in an area, while evenness represents the relative abundance of each genotype. A study on 22 cowpea genotypes revealed a mean diversity index (H') of 1.284, indicating a high level of diversity (Table 1). Traits like plant pigmentation and pod colour showed the highest diversity index values. Traits with H'e≥0.60 included pod colour, plant pigmentation and leaf colour. Intermediate diversity was observed in traits like plant hairiness and pod curvature. Studies by Yasin *et al*. (2021) in Ethiopia also showed high diversity in cowpea genotypes. The Shannon-Weaver index ranges from 0 to 4.6, with a value of 0 indicating uniformity and 4.6 showing even distribution among genotypes. A low H' suggests a lack of diversity, while a higher value suggests variability. Overall, values below the mean indicate imbalanced frequency and lack of diversity in traits.

The study aimed to analyze variations in 12 quantitative characteristics of 22 cowpea genotypes. Panse (1957) suggested the analysis and revealed that mean squares due to genotypes were highly significant for all traits, indicating the justification of studying genetic variability using these genotypes (Table 2). The top four characters with the highest variance were green pod yield per plant, 10 pod weight, plant height and number of pods per plant, indicating a wide range of diversity. The mean performance pertaining to 12 quantitative characters of 22 cowpea genotypes was presented in Table 3. Plant height varied among genotypes, with the maximum being 'Ankur Ketaki' (94.86 cm) followed by 'CP-645' (94.00 cm). Early flowering leads to early production of pods, which can fetch higher market prices. Days to first flowering ranged from 35.00 to 41.66 days, with the minimum days taken in 'Ankur Ketaki' and 'IC-259071' (35.00 days) followed by 'CP-732' and 'NS-24/8-2' (35.33 days). The genotype 'Arka Samrudhi' took the maximum days for first flowering, similar to previous studies in Indian and African conditions.

Days to opening of first flower in 50% population ranged from 40.66 to 46.00 days, with the minimum days taken in 'RHS-Kanakam' (40.66 days) followed by 'Arka Suman' and 'CP-601' (41.66 days). The genotype 'Arka Samrudhi' took the maximum days for 50% flowering, similar to previous studies in Karnataka, Tamil Nadu, Rajasthan and Telangana conditions.

The study analyzed the pod diameter, pod weight, chlorophyll content, total vitamin C and total vitamin C content of cowpea genotypes. The pod diameter ranged from 0.51 cm to 0.76 cm, with the maximum and minimum pod diameters observed in genotypes IC-259071, C-1070 and Arka Samrudhi. The number of pods per plant also varied widely among genotypes, with the highest pod number produced by IC-202926 (33.73) and the lowest recorded by IC-202803. The mean seed weight was 11.89 g, with the maximum being CP-421 (12.87 g) followed by Ankur Ketaki (12.50 g) and the minimum in NS-24/8-2 (11.02 g). Chlorophyll content varied from 4.07 to 8.65 mg/g, with the maximum found in Ankur Ketaki (8.65 mg/g) and the minimum in C-1070 (4.07 mg/g). The maximum pod yield per plant was produced by genotype IC-202926 (394.47 g), followed by genotype IC-259071 (367.40 g). The maximum total vitamin C was found in genotype C-1133 (16.61 mg/100 g), while the minimum was in genotype C-1070 (9.50 mg/100 g). The genotypes IC-202926, IC-259071, C-1070, CP-732, Ankur Ketaki, Kashi Nidhi and RHS-Kanakam were found to be most promising in terms of green pod yield per plant. Ankur Ketaki had the highest chlorophyll content among all genotypes studied, suggesting that these genotypes could be utilized in future breeding programs in cowpea. In conclusion, the study provides valuable insights into the pod diameter, pod weight, chlorophyll content, total vitamin C and total vitamin C content of cowpea genotypes. These findings can be useful for future breeding programs and can help improve the quality and yield of cowpea.

Analysis of components of pod yield

Scientists have analyzed cowpea genotypes to determine their significance in fruit yield. This study examines genetic diversity and yield component analyses to identify important fruit yield components, aiming to define an ideal plant ideotype for cowpea crops.

Analysis of genetic variability and heritability

Genotypic and phenotypic coefficients of variation are commonly used to assess variability in a genetic

Table 1: Morphological characterization of 22 cowpea genotypes.

Genotypes	Growth and flower characters						Pod characters			
	GH	P P	L S	P H	LC	FWC	PC	PAP	PCU	SC
Arka Samrudhi	Bushy	134 (C)	Ovate (1.73)	Glabrescent	141 (A)	Creamy white	138 (A)	30°-90° erect	Straight	Dark brown
Arka Suman	Bushy	134 (A)	Ovate-lanceolate (2.414)	Glabrescent	141 (B)	Light violet	137 (B)	Pendant	Slightly curve	Molted red
RHS-Kanakam	Bushy	134 (C)	Ovate (1.64)	Short appressed hairs	141 (A)	Yellowish	N 186 (B)	Pendant	Slightly curve	Molted red
Kashi Kanchan	Erect	60 (B)	Ovate-lanceolate (2.28)	Short appressed hairs	141 (B)	White	137 (A)	Pendant	Slightly curve	Molted red
Kashi Nidhi	Erect	63 (A)	Ovate-lanceolate (2.85)	Glabrescent	143 (A)	Creamy white	137 (A)	Pendant	Slightly curve	Molted red
Ankur Ketaki	Semi erect	140 (B)	Round (1.42)	Glabrescent	141 (C)	Creamy white	137 (B)	Pendant	Straight	Molted brown
CP-732	Bushy	140 (D)	Ovate (1.85)	Glabrescent	141 (A)	Creamy white	137 (A)	30°-90° erect	Straight	Molted brown
CP-601	Bushy	63 (B)	Ovate (1.98)	Glabrescent	141 (C)	Violet	146 (A)	Pendant	Slightly curve	Molted brown
CP-645	Spreading	140 (C)	Ovate (1.58)	Short appressed hairs	141 (B)	Creamy white	138 (A)	Pendant	Slightly curve	Molted brown
NS-24/8-2	Bushy	140 (D)	Ovate-lanceolate (2)	Glabrescent	140 (A)	Yellowish	146 (C)	Pendant	Slightly curve	Deep red
CP-421	Semi erect	142 (A)	Round (1.46)	Glabrescent	N 134 (A)	Violet	146 (B)	30°-90° erect	Slightly curve	Molted brown
IC-202803	Erect	163 (A)	Ovate (1.7)	Glabrescent	141 (C)	Yellowish	146 (A)	Pendant	Slightly curve	Red
V-585	Bushy	140 (C)	Ovate - lanceolate (2.4)	Short appressed hairs	143(A)	Yellowish	N 187 (A)	Pendant	Slightly curve	Molted brown
IC-259071	Semi erect	140 (D)	Ovate1.75)	Glabrescent	141 (C)	Creamy white	137 (A)	Pendant	Slightly curve	Red
C-1070	Bushy	142 (A)	Ovate (1.85)	Short appressed hairs	141 (B)	Violet	63 (B)	Pendant	Straight	Dark Brown
C-1126	Erect	163 (A)	Ovate (1.95)	Glabrescent	143 (A)	Violet	146 (A)	30°-90° erect	Slightly curve	Molted red
IC-253281	Semi erect	140 (C)	Round (1.39)	Glabrescent	141 (B)	Yellowish	137 (B)	Pendant	Slightly curve	White
IC-202926	Semi erect	63 (B)	Ovate (1.95)	Glabrescent	141 (C)	Violet	138 (A)	Pendant	Slightly curve	Red
IC-370499	Spreading	63 (B)	Ovate - lanceolate (2.18)	Glabrescent	141 (B)	Violet	137 (A)	30°-90° erect	Slightly curve	Molted red
C-951	Spreading	140 (C)	Round (1.26)	Glabrescent	141 (A)	Creamy white	138 (A)	Pendant	Slightly curve	Molted brown
C-1133	Bushy	141 (D)	Round (1.33)	Glabrescent	141 (A)	Yellowish	146 (A)	30°-90° erect	Straight	White
CP-411	Bushy	141 (C)	Round (1.3)	Glabrescent	141 (A)	Violet	138 (A)	30°-90° erect	Straight	Dark brown

Where, GH= Growth Habit, PP= Plant pigmentation, LS= Leaflet shape, PH= Plant hairiness LC= Leaf colour, FWC= Flower wing colour, PC= Pod colour, PAP= Pod attachment to peduncle, PCU= Pod curvature, SC= Seed colour.

population. The relative value of these types of coefficients gives an idea about the magnitude of variability present in a genetic population. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) are categorized as low (0-10%), moderate (11-20%) and high (>20%). Phenotypic coefficient of variation (PCV) was marginally higher than the corresponding genotypic coefficient of variation (GCV), indicating that the apparent variation was not only due to genotypes but also due to the influence of environment in the expression of traits. In Table 4, PCV values varied between 3.45% and 27.41% for days to 50% flowering and pod yield per plant, while GCV values varied from 2.10% to 25.74% for days to 50% flowering and pod yield per plant. High PCV values were recorded for plant height (24.50%) and pod yield per plant (27.41%), while moderate PCV values were observed for pod length (12.77%), number of pods per plant (13.13%), pod diameter (12.99%), chlorophyll content (15.67%) and Total Vitamin C (13.88%). High to moderate magnitude of GCV and PCV generally indicated ample scope for improvement through selection. The present findings suggest the worth of all traits for the study of genetic variability in cowpea. The wide difference between phenotypic and genotypic coefficient of variation indicates their sensitivity to environmental fluctuation, while narrow differences show less environmental influence on the expression of these traits. Genotypic coefficients of variation do not estimate heritable variations, making heritability estimation necessary. Heritability is important for plant breeders as it measures the value of selection for character in various types of progenies and as an index of transmissibility. The heritability value becomes a measure of the genetic relationship between parent and progeny. Heritability, a concept proposed by Lush (1940), measures the proportion of genetic variation transmitted to offspring. It is classified as low (below 30%), medium (30-60%) and high (above 60%) by Johnson *et al*. (1955). High heritability estimates were recorded for plant height, pod length, pod diameter, number of pods per plant, chlorophyll content, total vitamin C and pod yield per plant. Medium heritability estimates were recorded for days to first flowering, days to 50% flowering, 10 pod weight, 100 seed weight and number of seeds per pod.

Singh *et al*. (1974) suggested that high heritability indicates less environmental influence in observed variation, suggesting that selection based on phenotypic expression could be relied upon. However, this broad sense heritability value may be overestimated as it cannot exclude variation due to different genetic components and their interrelations. Heritability alone cannot provide information on the amount of genetic progress that would result from selecting the best individuals. Genetic advance is the improvement in performance of selected lines over the original population. Johnson *et al*. (1955) suggested that heritability estimate combined with substantial amount of genetic advance would be more helpful than heritability alone in predicting the resultant effect from selecting the best individuals. GA was expressed as percentage of mean, with high heritability coupled with high genetic advance observed for plant height, pod diameter, chlorophyll content, total vitamin C and pod yield per plant. Moderate genetic advance was exhibited by traits pod length and number of pods per plant (Fig 1). Low values of genetic advance were found for traits days to first flowering, days to 50% flowering, 10 pod weight, 100 seed weight and number of seeds per pod, as they indicated dominance and epistatic effects, making selection for these traits unlikely and it was also observed by Dipankar *et al*. (2023) and Songsri *et al*. (2008).

Table 2: ANOVA for twelve quantitative characters of cowpea.

Source	Mean sum of squares (MSS)		
	Replication	Treatment	Error
Degrees of freedom	2	21	42
Plant height (cm)	4.1910	736.482**	12.809
Days to 1st flowering	1.7730	6.307**	1.947
Days to 50% flowering	4.2270	3.847**	1.386
Pod length (cm)	0.6440	10.118**	0.987
Pod diameter (cm)	4.5454	0.018**	0.001
Number of pods per plant	0.9510	32.53**	4.089
10 Pod weight (g)	38.7350	66.23**	19.298
100 Seed weight (g)	0.6690	0.534**	0.222
Number of seeds per pod	0.0850	1.093**	0.433
Chlorophyll content (mg/g)	0.1320	3.263**	0.232
Pod yield per plant (g)	9.5580	15325.07**	656.36
Total Vitamin C (mg/100 g)	0.5010	11.497**	0.374

** Significant at 1 per cent level of significance.

Table 3: Mean performance of twenty-two cowpea genotypes.

Genotypes	Plant height (cm)	Days to 1st flowering	Days to 50% flowering	Pod length (cm)	Pod diameter (cm)	Number of pods per plant	10 Pod weight (g)	100 weight (g)	Seed Number of seeds per pod	Chlorophyll content (mg/g)	Pod yield per plant (g)	Total Vitamin C (mg/100g)
Arka Samrudhi	67.467	41.667	46	12.41	0.513	28.13	92.487	11.843	9.733	7.767	179.4	16.3
Arka Suman	63.933	36.667	41.667	16.287	0.527	27.6	86.217	11.373	9.667	7.233	199.6	16.55
RHS-Kanakam	57.73	36	40.667	14.56	0.68	25.47	93.75	11.93	10.667	7.197	332.87	15.447
Kashi Kanchan	45	37	42.667	16.62	0.683	28.333	104.157	11.663	10.603	7.723	279.337	16.46
Kashi Nidhi	45.867	36.667	42.667	16.287	0.68	29.067	102.09	12.02	10.797	7.47	317.467	16.477
Ankur Ketaki	94.863	35	43	14.56	0.7	33.333	96.09	12.503	10.8	8.653	365.867	14.337
CP-732	64.6	35.333	42.333	15.157	0.67	24.733	99.44	12.217	11.597	6.18	305.4	13.72
CP-601	68.533	38	41.667	18.497	0.593	25.863	91.47	11.66	11.4	6.2	216.933	13.213
CP-645	94	37.333	42.667	15.957	0.683	32	92.523	12.2	11.397	8.063	282.4	13.14
NS-24/8-2	54	35.333	43.333	15.133	0.57	29.8	90.063	11.02	11.6	6.12	295.867	14.687
CP-421	61.067	36.667	44.333	17.527	0.673	24.667	91.337	12.867	10.2	7.597	345.667	14.48
IC-202803	45.797	38	42.333	16.81	0.537	22.267	92.587	11.217	11.27	7.273	153.667	12.223
V-585	71.067	37	44.667	16.4	0.56	29.87	97.84	11.797	11.467	6.787	208.933	15.397
IC-259071	67.863	35	42.667	14.383	0.76	33.467	92.173	12.127	10.8	5.477	367.4	10.287
C-1070	47.73	38	44	14.887	0.757	25.533	97.293	12.153	11.8	4.067	347.4	9.5
C-1126	45.933	38	43	13.083	0.64	25.667	97.023	12.063	10.867	8.13	234.733	14.103
IC-253281	82.133	37	43.667	15.063	0.543	31.603	94.707	11.777	11.267	8.24	263.4	15.933
IC-202926	52.8	38	43	18.803	0.703	33.733	98.29	12.13	10.997	7.973	394.467	14.657
IC-370499	75.067	37	43.667	18.827	0.67	28.8	96.683	11.667	11	7.063	281.467	15.607
C-951	84.133	38.333	44	17.51	0.667	25.067	94.997	12.197	10.73	6.55	253.533	16.383
C-1133	56.797	38	43.333	14.497	0.563	27.737	91.487	11.553	11.6	7.147	188.4	16.613
CP-411	84.867	37	42.667	12.777	0.517	24.4	84.15	11.553	11.867	7.603	162.8	14.777
Mean	65.06	37.14	43.09	15.73	0.63	28.05	94.4	11.89	11.01	7.11	271.68	14.56
SE	2.07	0.81	0.68	0.57	0.02	1.17	2.54	0.27	0.38	0.28	14.79	0.35
CD at 5%	5.9	2.3	1.94	1.64	0.05	3.33	7.24	0.78	1.08	0.79	42.21	1.01
CV	5.5	3.76	2.73	6.32	4.85	7.21	4.65	3.97	5.98	6.77	9.43	4.2

Table 4: Estimates of genetic parameters of twenty-two cowpea genotypes.

Characters	Var Genotypical	GCV (%)	Var Phenotypical	PCV (%)	h^2 (Broad Sense)	Genetic Advancement 5%	Gen.Adv as % of Mean 5%
Plant height (cm)	241.23	23.87	254.03	24.50	94.96	31.18	47.92
Days to 1st flowering	1.45	3.25	3.40	4.97	42.73	1.62	4.37
Days to 50% flowering	0.82	2.10	2.21	3.45	37.18	1.14	2.64
Pod length (cm)	3.04	11.09	4.03	12.77	75.50	3.12	19.85
Pod diameter (cm)	0.01	12.05	0.01	12.99	86.03	0.15	23.02
Number of pods per plant	9.48	10.98	13.57	13.13	69.86	5.30	18.90
10 pod weight (g)	15.64	4.19	34.94	6.26	44.77	5.45	5.78
100 seed weight (g)	0.10	2.71	0.33	4.81	31.85	0.38	3.15
Number of seeds per pod	0.22	4.26	0.65	7.34	33.67	0.56	5.09
Chlorophyll content (mg/g)	1.01	14.13	1.24	15.67	81.35	1.87	26.26
Pod yield per plant (g)	4889.57	25.74	5545.93	27.41	88.17	135.25	49.78
Total Vitamin C (mg/100 g)	3.71	13.23	4.08	13.88	90.85	3.78	25.97

GCV = Genotypic coefficient of variation; PCV = Phenotypic coefficient of variatio

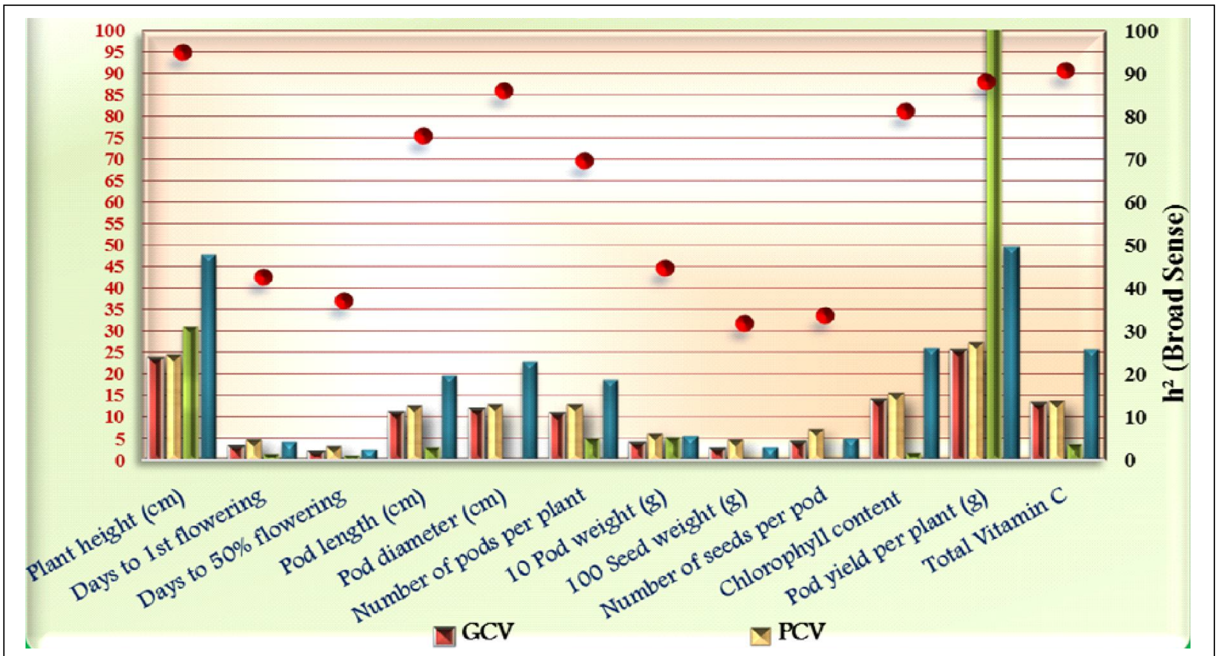

Fig 1: Genetic parameters.

CONCLUSION

The experiment found that genotypes IC-202926, IC-259071, C-1070, CP-732, Ankur Ketaki, Kashi Nidhi and RHS-Kanakam were most promising for green pod yield per plant. Ankur Ketaki had the highest Chlorophyll content, making it suitable for future breeding programs in cowpea. The yield component traits, pod diameter, number of pods per plant and 100 Seed weight, showed high positive direct effects on pod yield per plant. Other traits, like pod length and 10 pod weight, had low positive effects. D2 values showed significant genetic diversity among the genotypes. Cluster I contained sixteen genotypes, while cluster II contained four. The maximum inter-cluster value between cluster II and III indicated that these genotypes could be used as parents in hybridization programs to develop higher heterotic hybrids. Other genotypes, such as C-1133, Arka Samrudhi, Arka Suman, Kashi Kanchan, CP-601, V-585 and C-1126, could be considered good for breeding programs.

Conflict of interest

All authors declared that there is no conflict of interest.

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