Biological Forum – An International Journal **15(5): 1247-1255(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Study on Morphological and Genetic Variations among Vegetable Cowpea [*Vigna unguiculata* (L.) Walp.] Genotypes in North-Eastern Ghat Region of India

Dipankar Barik[1], Subhrajyoti Chatterjee[2*] and Pritismita Nayak[1]

[1]M.Sc. Scholar, Department of Horticulture, M S Swaminathan School of Agriculture (MSSSoA), Centurion University of Technology and Management (CUTM), Paralakhemundi-761211, Gajapati (Odisha), India.

[2]Assistant Professor, Department of Horticulture, M S Swaminathan School of Agriculture (MSSSoA), Centurion University of Technology and Management (CUTM), Paralakhemundi-761211, Gajapati (Odisha), India.

(Corresponding author: Subhrajyoti Chatterjee[*])

(Received: 19 March 2023; Revised: 10 April 2023; Accepted: 19 April 2023; Published: 20 May 2023)

(Published by Research Trend)

ABSTRACT: In the present study, 10 morphological and 11 quantitative characters were recorded from 21 varieties of vegetable cowpea. The overall mean value of Shannon-Weaver diversity index was 1.276 which confirmed the existence of diversity among the genotypes. The genotypes 'CP-738', 'Kashi Kanchan', 'CP-1116', 'CP-863', 'EC-202526', 'Arka Garima' and 'IC-39856' were found most promising in respect to green pod yield per plant. Among various parameters of variability, high coefficients of variation (phenotypic and genotypic) were found for the characters pod length, number of green pods per plant, 10 green pod weight and green pod yield per plant. High heritability coupled with high genetic advance as per cent of mean was observed for days to first flowering, days to 50% flowering, pod length, pod diameter, number of green pods per plant, 10 green pod weight, protein content and green pod yield per plant indicated that these traits are predominantly governed by additive gene, so early generation selection would be rewarding for improving these traits. Number of green pods per plant, pod diameter and 10 green pod weight should be considered as the most important selection indices for enhancing green pod yield in cowpea.

Keywords: Cowpea, Shannon-Weaver diversity index, Genetic variability, Selection indices.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.], belonging to the family Fabaceae with diploid chromosome number of 2n=2x=22, is one of the most important self-pollinated legume vegetable crops in India. It is also commonly known as 'Southern pea', 'Lobiya', 'Black-eye bean', 'Kaffir pea' and 'Marble pea'. Cowpea is a native of West Africa (Vavilov, 1951) whereas Ethiopia and Africa are considered as the primary and secondary centre of diversity respectively (Steele, 1976). The genus *Vigna* consists of more than 80 different species which are very widely distributed throughout the tropical and subtropical regions of the world (Popoola *et al*., 2015). Verdcourt (1970) reported five subspecies of the species *unguiculata*. Those are *unguiculata*, *cylindrica*, *sesquipedalis*, *dekindtiana* (Harms.) and *mensensis* (Schweint.). Among which, first three are cultivated while last two are considered as wild species.

Cowpea is a multipurpose crop grown as green vegetable, grain legume mainly for dry beans and as forage, green manure and quick growing cover crop under a wide range of climatic conditions. It is also a good companion crop with several food, fodder and fibre crops. This is a nutritive vegetable that supplies 4.3 g protein, 80.0 mg calcium, 74.0 mg phosphorus, 2.5 mg iron, 0.07 mg thiamine, 0.09 mg riboflavin and 13.0 mg vitamin C per 100 g of edible green pods (Gopalan *et al*., 1982). Being rich source of protein (23-30%), cowpea provides complementary proteins to cereal based diets and also termed as 'vegetable meat'. This crop is having immense potential to solve the protein related malnutrition problem. Another important feature of cowpea is that it fixes atmospheric nitrogen through symbiosis with nodule bacteria (*Bradyrhizobium* spp.). 40-80 kg of N is added in the soil following cowpea cultivation (Quin, 1997).

In India, cowpea is grown in an area of 3.9 million ha with a production of 2.21 million tonnes. Although, the crop is grown in an area of 1.5 million ha in Odisha with a production of 0.49 million tonnes, the productivity of cowpea is low (420 kg/ ha) compared to the national productivity of 567 kg/ ha (Giridhar *et al*., 2020). Based on agro-climatic conditions and local preferences, the farmers are growing a large number of crop varieties all over the country (Nancee *et al*., 2014) but most of the present cultivars of this crop exhibit lower productivity because of non-synchronous flowering and fruiting, susceptibility to different biotic and abiotic stresses and poor harvest index. Most of the varieties which are cultivated in India are open pollinated types as because hybrids are not commercially exploited in this crop due to its complex

flower structure and problem in crossed fruit setting. Therefore, much emphasis needs to be given for the development of high yielding stress resistant varieties and hybrids to increase the productivity.

Informations about genetic variability, correlation and path analysis are limited for this very crop but all those things are essential for any concerted and specific breeding programme on genetic improvement. So, the present experiment was executed to study morphological and genetic variations among vegetable cowpea genotypes in North-Eastern Ghat region of India.

MATERIAL AND METHODS

Field experiment was conducted during *kharif* season of 2022-23 at Horticulture Research Farm (HRF) of M S Swaminathan School of Agriculture (MSSSoA), Centurion University of Technology and Management, Paralakhemundi, Gajapati, Odisha. Genotypes of cowpea were collected from different places of India constituted the plant materials for this study. The experiment was conducted in Randomized Complete Block Design (RCBD) with 21 treatments and 3 replications. The crop was grown in individual plots of 2.25 m × 1.2 m with a spacing of 45 cm × 15 cm from row to row and plant to plant respectively. Standard cultural practices and protective measures recommended in the 'Manual on Agricultural Production Technlogy' (Anonymous, 2008) were followed to ensure a healthy crop stand.

Observations recorded. The following observations on both qualitative and quantitative characters were recorded from 10 randomly selected plants of each plot in each replication.

Qualitative parameters. Qualitative characters like twinning tendency, plant pigmentation, terminal leaflet shape, plant hairiness, leaf colour, flower wing colour, pod colour, pod attachment to peduncle, pod curvature and seed colour were recorded.

Quantitative parameters. Plant height (cm), days to first flowering, days to 50 % flowering, pod length (cm), pod diameter (cm), number of green pods per plant, 10 green pod weight (g), 100 seed weight (g), number of seeds per pod, protein content of green pod (%) and green pod yield per plant (g) were recorded. Total soluble protein content was estimated as per the method of Lowry *et al*. (1951).

Statistical analyses. Statistical analyses were done with Windostat (ver.8.0, Indostat Services, Hyderabad, India. The frequency distributions were used to calculate the Shannon-Weaver diversity index (H) for each character (Hennink and Zeven, 1991). The index is as follows:

$$H = -\sum_{1=1}^{S} Pi \ln Pi$$

Where,

H= Shannon-Weaver diversity index, S= the number of genera, Pi= ni/N as the proportion of type I (ni= the total number of individuals of microbe in total i type, N= the total number of all the individuals in total n).

The genotype and phenotypic co-efficient of variations were calculated as per Burton (1952). Heritability in broad sense (H) was estimated by the method proposed by Hanson *et al*. (1956). The expected genetic advance (GA) was calculated as per Lush (1949) and Johnson *et al*. (1955). Direct and indirect effects of component traits on green pod yield per plant were calculated through path coefficient analysis (Dewey and Lu, 1959).

RESULTS AND DISCUSSION

A. Morphological characterization of genotypes

10 morphological/ qualitative characters recorded in 21 vegetable cowpea genotypes as per descriptors of NBPGR are presented in Table 1. Frequency distribution patterns, percent of proportion and Shannon-Weaver Diversity Index (H) were estimated from the same 10 characters and results are presented in Table 2. Twinning tendency of different cowpea genotypes were grouped into three categories *i.e.*, slight, none and intermediate. Among all the genotypes 9 (42.8 %) were having slight twinning tendency while 11 (52.3 %) were showing no twinning. Only 1 (4.7 %) genotype was found to have intermediate twinning tendency. Previoulsly, Egbadzor *et al*. (2014) reported different types of plant growth habit among collected cowpea genotypes based on the twinning tendency of plant. Genotypes of the present study revealed great variation for the traits plant pigmentation, leaf colour and pod colour where those were grouped into 10 categories according to the Royal Horticultural Society Colour Chart (RHCC). Egbadzor *et al*. (2014) and Supriya (2022) also reported significant variation regarding these traits in cowpea and French bean respectively. 2 (9.50 %) genotypes had round whereas 15 and 4 genotypes showed ovate (71.4 %) and ovate-lanceolate (19 %) shaped leaflet respectively. This type of grouping corroborated the findings of Khan *et al*. (2020). A very little variation regarding the trait plant hairiness was found among the genotypes studied. All the genotypes were divided into 2 groups *i.e.*, glabrescent and short appraised hairs.

Except 5 genotypes, all other were found to have no hair (glabrescent) on the plants. Contrary to the present finding, Khan *et al*. (2020) classified the cowpea genotypes into 3 groups *i.e.*, glabrescent, sparse hairs and dense hairs regarding this trait. Flower wing colour of different cowpea genotypes were grouped into four categories *i.e.*, white, creamy white, light violet and yellowish in the present investigation. 5 genotypes were having white (23.8 %) and 9 were having creamy white (42.8%) flower wing colour whereas, light violet and yellowish flower wing colour was exhibited by 4 and 3 genotypes respectively. Earlier, Yasin *et al*. (2021) reported significant variability for the trait flower wing colour among the genotypes of cowpea they studied.

Table 1: Morphological characterization of 21 cowpea genotypes.

Sr. No	Genotypes	Growth and Flower characters						Pod characters			
		TT	PP	LS	PH	LC	FWC	PC	PAP	PCU	SC
1.	**EC-34009**	Slight	137 (B)	138 (B)	Glabrescent	137 (B)	White	137 (B)	Pendant	Slightly curved	Light brown
2.	**EC-58905**	Slight	138 (A)	Ovate (1.71)	Glabrescent	138 (A)	Creamy White	138 (A)	30-90 degree down from erect	Straight	Cream
3.	**CP-797**	None	N 186 (B)	Ovate (1.71)	Short appressed hairs	N 186 (B)	Light violet	N 186 (B)	Pendant	Straight	Dark Brown
4.	**EC-202526**	Slight	N 186 (B)	Ovate (1.86)	Short appressed hairs	N 186 (B)	Light violet	N 186 (B)	30-90 degree down from erect	Slightly curved	White
5.	**CP-1116**	Slight	137 (A)	Ovate (1.69)	Glabrescen	137 (A)	Creamy White	137 (A)	30-90 degree down from erect	Slightly curved	Cream
6.	**KASHI NIDHI**	None	N137 (A)	Ovate (1.64)	Glabrescent	N137 (A)	Creamy White	N137 (A)	Pendant	Straight	Buff
7.	**CP-1107**	None	138 (A)	Ovate (1.75)	Glabrescent	138 (A)	Creamy White	138 (A)	30-90 degree down from erect	Slightly curved	Cream
8.	**IC-39856**	None	146 (A)	Ovate (1.75)	Glabrescent	146 (A)	Yellowish	146 (A)	Pendant	Straight	Cream
9.	**V-585**	None	N 186 (B)	Ovate (1.68)	Short appressed hairs	N 186 (B)	Light Violet	N 186 (B)	30-90 degree down from erect	Straight	Light brown
10.	**CP-738**	None	N 187 (A)	Ovate- lanceolate (2.01)	Short appressed hairs	N 187 (A)	Light Violet	N 187 (A)	30-90 degree down from erect	Straight	Buff
11.	**C-1013**	Slight	146 (A)	Ovate- lanceolate (2.00)	Glabrescent	146 (A)	Yellowish	146 (A)	30-90 degree down from erect	Straight	Light Brown
12.	**CP-1135**	Slight	138 (A)	Ovate (1.60)	Glabrescent	138 (A)	Yellowish	138 (A)	30-90 degree down from erect	Straight	Light Brown
13.	**CP-863**	None	N 187 (A)	Ovate (1.74)	Short appressed hairs	N 187 (A)	Creamy White	N 187 (A)	Pendant	Slightly curved	Buff
14.	**C-1006**	Slight	146 (C)	Ovate (1.63)	Glabrescent	146 (C)	Creamy White	146 (C)	Pendant	Straight	Light brown
15.	**FTC-27**	None	146 (B)	Ovate- lanceolate (2.05)	Glabrescent	146 (B)	White	146 (B)	Pendant	Straight	Cream
16.	**IC-202804**	None	146 (A)	Ovate (1.81)	Glabrescent	146 (A)	White	146 (A)	Pendant	Slightly curved	Buff
17.	**KASHI KANCHAN**	None	137 (A)	Ovate (1.66)	Glabrescent	137 (A)	White	137 (A)	Pendant	Straight	Light brown
18.	**ARKA GARIMA**	Intermediate	137 (A)	Ovate (1.60)	Glabrescent	137 (A)	Creamy White	137 (A)	Pendant	Straight	Dark brown
19.	**C-1089**	Slight	N 137 (B)	Ovate- lanceolate (2.03)	Glabrescent	N 137 (B)	Creamy White	N 137 (B)	Pendant	Slightly curved	White
20.	**GC-3**	Slight	137 (B)	Ovate (1.51)	Glabrescent	137 (B)	White	137 (B)	Pendant	Slightly curved	Cream
21.	**C-1045**	None	137 (A)	Round (1.49)	Glabrescent	137 (A)	Creamy White	137 (A)	Pendant	Straight	Cream

Where, TT = Twinning tendency, 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

Regarding the trait pod attachment to peduncle, cowpea genotypes were grouped into two categories *i.e.,* pendant and 30-90 degrees down from erect. 13 genotypes (61.9 %) were classified as pendant and rest 8 (38 %) were categorized under 30-90 degrees down from erect type. Contrary to the present finding, Toyin (2019) divided cowpeas genotypes in 4 categories regarding this trait**.** Pod curvature of different cowpea genotypes were grouped into 2 categories in the present study *i.e.,* straight and slightly curved. Among the 21 genotypes, 8 genotypes (38 %) were classified as slightly curved and rest 13 (61.9 %) were categorized under straight type. High variability was found regarding seed colour of cowpea and genotypes were classified into 5 categories *viz.,* light brown, cream, dark brown, buff and white. 7 cream seeded genotypes were observed whereas 6, 4, 2 and 2 genotypes were having light brown, dark brown, buff and white coloured seed. These findings are in line with the previous findings of Egbadzor *et al*. (2014) ; Khan *et al*. (2020).

Biodiversity in any crop species can be summarized with two of its components *i.e*. allelic evenness and allelic richness. The descriptor and descriptor states are parallel to the locus and alleles, respectively in morphological evaluation. The allelic evenness in this study was measured using the Shannon-Weaver Diversity Index, whereas the allelic richness was measured by counting the descriptor states for each descriptor without considering their individual frequencies. The Shannon-Weaver index values can range from 0 to 4.6. A low H indicates unbalance frequency class and lack of diversity for the traits studied. A higher H' value indicates presence of variability or diversity for the trait (Hennink and Zeven 1991). The value of Shannon-Weaver diversity index (H) in the present study varied from 0.548 (plant hairiness) to 2.164 (plant pigmentation, leaf and pod colour). The mean diversity index (H') was 1.276, indicating high level of diversity of studied germplasm. Previously, Yasin *et al*. (2021) also studied the Shannon-Weaver diversity index and observed highly divergent qualitative traits of 36 cowpea genotypes in Ethiopia.

B. Mean performances of genotypes

Genotypes showed highly significant variations for all the 11 quantitative characters under study (Table 3). Wide variation in plant height was observed among cowpea genotypes ranging from 42.06 cm in 'Kashi Nidhi' to 73.53 cm in 'Arka Garima' with a mean of 56.55 cm. Previously, Khanpara *et al*. (2015) and Devi and Jayamani (2018) found similar range of plant height under Gujarat and Tamil Nadu conditions respectively. Early flowering leads to early production of pods which can fetch higher market price. Days to first flowering also varied widely between 28.66 in 'CP-738' to 46.33 days in 'C-1013' with a mean of 36.82 days. Similar trend was found for the trait days to 50 % flowering. The minimum days taken to 50 % flowering was recorded in 'CP-738' (35.33 days) whereas 'C-1013' (53.33 days) was found to take maximum days for 50 % flowering. Ijas *et al*. (2021); Saidaiah *et al*. (2021) observed similar range regarding the flowering traits.

Combination of both pod length and pod diameter determines pod shape. Pod length varied widely between 23.17 cm in 'Kashi Kanchan' and 9.69 cm in 'CP-1107', the mean being 15.87 cm. Similarly, minimum pod diameter was observed in 'C-1013' (0.49 cm) and the maximum was observed in 'CP-863' (0.80 cm). Devi and Jayamani (2018) ; Verma *et al*. (2019) also found similar range among genotypes regarding pod length and diameter respectively.

Higher number of green pods per plant leads to more pod yield per plant. Number of green pods varied widely among genotypes, ranging from 14.66 to 40.66 with an average value of 27.93. The maximum number of green pods was produced by 'CP- 738' (40.66) followed by 'Kashi Kanchan' (39.66) and 'CP-1116' (38.00) whereas the lowest was recorded in 'C-1013' (14.66). 10 green pod weight varied between 68.65 g in 'C-1013' and 124.66 g in 'CP-738', the mean being 93.49 g. Previously, Kumar *et al*. (2015) ; Khanpara *et al*. (2015) reported similar range regarding these traits among the genotypes studied.

In case of the trait 100 seed weight, 'C-1013' exhibited minimum value (10.44 g) whereas 'CP-738' showed maximum value (13.44 g). Number of seeds per pod ranged from 8.00 to 13.00 with a mean value of 10.61. The maximum and minimum value regarding this trait was exhibited by the genotype 'Kashi Kanchan' (13.00) and 'EC- 58905' (8.00). Ranges of these two traits in the present study corroborated the previous findings of Singh *et al*. (2020); Ijas *et al*. (2021); Vinay *et al*. (2022).

Regarding the trait protein content of green pod, minimum and maximum value was observed in 'CP-1135' (2.79 %) and 'Arka Garima' (4.03 %) respectively with a mean value of 3.32 %. The range of protein content of green pod in the present study is in line with the findings of Ijas *et al*. (2021). Green pod yield per plant ranged from 101.83 g in 'C- 1013' to 502.07 g in 'CP- 738' with a mean value of 273.62 g. Das *et al*. (2020); Singh *et al*. (2020) ; Vinay *et al*. (2022) previously found wider variability among the genotypes of this crop regarding this trait.

C. Genetic variability and heritability

The result of analysis of variances (ANOVA) using randomized block design revealed that the genotypes exhibited highly significant differences for all the characters under study even at 1% level of significance (Table 4) which clearly supports the justification of studying genetic variability of different characters employing these genotypes. Coefficient of variation was widely different ranging from minimum of 1.16 in protein content of green pod to maximum of 14.88 in green plant height (Table 3).

Table 2: Frequency distribution, proportion, and Shannon-weaver diversity index (H') of qualitative traits of 21 cowpea genotypes.

Characters	Morphological description	Frequency distribution		H'-index
		No. of genotypes in the group	Percent (%)	
Twinning tendency	Slight	9	42.8	0.843
	None	11	52.3	
	Intermediate	1	4.7	
Plant pigmentation	137B	2	9.523	2.164
	138A	3	14.2	
	N186B	3	14.2	
	N137A	1	4.7	
	146A	3	14.2	
	146C	1	4.7	
	146B	1	4.7	
	N137B	1	4.7	
	N187A	2	9.523	
	137A	4	19	
Leaflet shape	Round	2	9.5	0.777
	Ovate	15	71.4	
	Ovate-lanceolate	4	19	
Plant hairiness	Glabrescent	16	76.1	0.548
	Short appressed hairs	5	23.8	
Leaf colour	137B	2	9.523	2.164
	138A	3	14.2	
	N186B	3	14.2	
	N137A	1	4.7	
	146A	3	14.2	
	146C	1	4.7	
	146B	1	4.7	
	N137B	1	4.7	
	N187A	2	9.523	
	137A	4	19	
Flower wing colour	White	5	23.8	1.295
	Creamy white	9	42.8	
	Light violet	4	19	
	Yellowish	3	14.2	
Pod colour	137B	2	9.523	2.164
	138A	3	14.2	
	N186B	3	14.2	
	N137A	1	4.7	
	146A	3	14.2	
	146C	1	4.7	
	146B	1	4.7	
	N137B	1	4.7	
	N187A	2	9.523	
	137A	4	19	
Pod attachment	Pendant	13	61.9	0.663
	30 – 90 degrees down from erect	8	38	
Pod curvature	Slightly curved	8	38	0.663
	Straight	13	61.9	
Seed Colour	Light brown	6	28.571	1.483
	Cream	7	33.3	
	Dark brown	2	9.5	
	Buff	4	19	
	White	2	9.5	
Overall mean of H'				**1.276**

Table 3: Mean performance of 21 cowpea genotypes.

Genotype	Plant height (cm)	Days to first flowering	Days to 50% flowering	Pod length (cm)	Pod diameter (cm)	Number of green pods per plant	10 green pod weight (g)	100 seed weight (g)	Number of seeds per pod	Protein content (%)	Green pod yield per plant (g)
EC-34009	46.53	43.66	49.00	11.20	0.55	21.66	78.66	10.77	10.00	3.05	173.67
EC-58905	67.73	36.00	45.00	15.24	0.66	28.66	96.64	11.88	8.00	3.58	282.18
CP-797	68.53	36.00	44.00	15.19	0.63	28.00	91.66	11.55	8.66	2.95	255.02
EC-202526	54.60	31.66	41.66	18.73	0.70	32.33	103.33	12.10	9.83	2.98	331.98
CP-1116	64.20	30.00	38.00	19.91	0.79	38.00	116.66	13.10	10.66	3.96	446.80
KASHI NIDHI	42.06	33.00	41.66	16.80	0.67	32.33	100.00	11.99	12.55	3.71	323.83
CP-1107	42.40	44.66	52.33	9.69	0.49	16.33	69.52	10.66	11.00	2.80	112.09
IC-39856	42.53	31.00	41.00	18.24	0.69	31.66	104.33	12.77	9.33	3.81	336.33
V-585	64.53	42.33	47.66	11.93	0.55	23.00	79.10	10.99	11.33	3.10	179.12
CP-738	71.40	28.66	35.33	22.53	0.77	40.66	124.66	13.44	11.00	2.95	502.07
C-1013	47.13	46.33	53.33	10.32	0.49	14.66	68.65	10.44	12.00	2.89	101.83
CP-1135	52.13	44.33	51.33	10.02	0.50	18.33	70.85	10.66	12.16	2.79	129.97
CP-863	63.66	30.66	38.00	21.84	0.80	36.33	114.50	12.88	9.16	2.98	413.72
CP-1006	54.13	31.00	40.66	19.21	0.74	34.66	110.00	12.66	10.00	3.93	382.10
FTC-27	66.03	38.00	44.66	13.47	0.60	26.33	86.00	11.55	11.66	3.41	228.10
IC-202804	48.46	41.00	47.66	12.63	0.56	24.00	81.46	11.33	10.50	3.22	194.57
KASHI KANCHAN	65.46	29.66	37.33	23.17	0.74	39.66	120.00	13.11	13.00	4.00	468.80
ARKA GARIMA	73.53	34.00	44.00	21.90	0.74	30.00	97.65	12.10	11.50	4.03	293.16
C-1089	44.13	37.33	44.66	17.17	0.62	26.33	90.66	11.55	11.66	3.43	240.76
GC-3	58.20	40.33	45.33	13.21	0.57	25.00	85.00	11.44	10.00	3.29	211.20
C-1045	50.13	43.66	51.00	10.80	0.51	18.66	74.09	10.77	9.00	2.98	138.82
Mean	**56.55**	**36.82**	**44.46**	**15.87**	**0.63**	**27.93**	**93.49**	**11.80**	**10.61**	**3.32**	**273.62**
C.D. at 5%	13.89	2.49	2.69	3.61	0.04	4.33	18.81	NA	1.79	0.06	11.63
C.V. (%)	14.88	4.10	3.67	13.79	4.53	9.40	12.19	10.10	10.25	1.16	2.57

Table 4: ANOVA for 11 quantitative characters of cowpea.

Source of Variation	Mean sum of square		
	Replication	Treatments	Error
DF	2	20	40
Plant height (cm)	1234.66	6624.08**	2833.89
Days to first flowering	0.41	2053.07**	91.58
Days to 50% flowering	2.03	1598.98**	106.63
Pod length (cm)	11.24	1211.62**	191.84
Pod diameter (cm)	0.0005	0.62**	0.03
Number of green pods per plant	20.03	3467.74**	275.96
10 green pod weight (g)	87.30	18002.32**	5197.26
100 seed weight (g)	4.63	50.79**	56.89
Number of seeds per pod	4.59	108.35**	47.40
Protein content (%)	0.0001	11.18**	0.06
Green pod yield per plant (g)	88.53	866875.81**	1987.47

Table 5: Mean, range and estimates of genetic parameters of 21 cowpea genotypes.

Character	Mean	Range	GCV*(%)	PCV*(%)	GCV: PCV	h^2 in broad sense (%)	Genetic advance as % of mean
Plant height (cm)	56.55	42.06-73.53	16.47	22.20	74.18	55.06	25.17
Days to first flowering	36.82	28.66-46.33	15.70	16.23	96.73	93.59	31.30
Days to 50% flowering	44.46	35.33-53.33	11.41	11.99	95.16	90.62	22.38
Pod length (cm)	15.87	9.69-23.17	27.17	30.47	89.16	79.50	49.90
Pod diameter (cm)	0.63	0.49-0.80	15.77	16.41	96.09	92.36	31.22
Number of green pods per plant	27.93	14.66-40.66	26.66	28.27	94.30	88.94	51.80
10 green pod weight (g)	93.49	68.65-124.66	17.13	21.03	81.45	66.40	28.76
100 seed weight (g)	11.80	10.44-13.44	5.17	11.35	45.55	20.75	4.85
Number of seeds per pod	10.61	8.00-13.00	11.18	15.17	73.69	54.35	16.98
Protein content (%)	3.32	2.79-4.03	12.94	13.00	99.53	99.19	26.56
Green pod yield per plant (g)	273.62	101.83-502.07	43.90	43.97	99.84	99.66	90.28

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

Table 6: Phenotypic path analysis for 11 characters of 21 genotypes.

Character	PH	DFF	D50F	PL	PD	NGPPP	10GPW	100SW	NSPP	PC	Correlation with GPYPP at phenotypic level
PH	**0.001**	0.066	0.078	0.020	0.091	0.088	0.048	0.008	-0.004	-0.007	0.388*
DFF	0.000	**-0.195**	-0.208	-0.038	-0.202	-0.214	-0.105	-0.014	0.005	0.026	-0.945**
D50F	0.000	-0.177	**-0.230**	-0.037	-0.190	-0.216	-0.107	-0.014	0.000	0.023	-0.949**
PL	0.001	0.167	0.191	**0.045**	0.190	0.186	0.098	0.012	0.003	-0.024	0.868**
PD	0.001	0.182	0.202	0.039	**0.216**	0.209	0.101	0.013	-0.004	-0.026	0.933**
NGPPP	0.001	0.181	0.215	0.036	0.195	**0.231**	0.106	0.014	-0.002	-0.024	0.952**
10GPW	0.001	0.162	0.196	0.035	0.173	0.193	**0.126**	0.013	-0.004	-0.022	0.872**
100SW	0.001	0.128	0.156	0.027	0.137	0.157	0.077	**0.021**	-0.005	-0.018	0.679**
NSPP	0.000	-0.020	-0.001	0.003	-0.017	-0.008	-0.011	-0.002	**0.050**	-0.006	-0.013
PC	0.000	0.114	0.118	0.025	0.125	0.127	0.061	0.008	0.007	**-0.044**	0.541**

Residual effect = **0.1941**, Direct effect = Bold diagonals.

PH =Plant height; DFF= Days to first flowering; D50F= Days to 50% flowering; PL=Pod length (cm); PD=Pod diameter (cm); NGPPP =Number of green pods per plant; 10 GPW= 10 green pod weight (g); 100 SW= 100 seed weight (g); NSPP= Number of seeds per pod; PC= Protein content (%); GPYPP= Green pod yield per plant (g)

The nature and magnitude of genetic variability is one of the most important criteria in formulation of an efficient breeding programme of any specific crop. Knowledge of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is much helpful in predicting the amount of variation present in a given assemblage of genotypes.

The genetic coefficient of variation measures the range of genetic variability shown by the plant character and help to compare the genetic variability present in various characters (Singh *et al*., 1974). In the present investigation, the phenotypic coefficient of variations were slightly higher than the corresponding genotypic coefficient of variations for all the characters studied (Table 5) which indicated that the apparent variation was not only due to genotypes but also due to the influence of environment in the expression of the traits. Phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) were categorized as low (0-10%), moderate (10-20%) and high (>20%) as described by Sivasubramanian and Madhava Menon (1973). Accordingly, very high PCV and GCV values were recorded for green pod yield per plant (PCV 43.97; GCV 43.90) which indicated the highest magnitude of variability for this character. High magnitude of PCV and GCV, respectively were recorded for pod length (PCV 30.47; GCV 27.17) and number of green pods per plant (PCV 28.27; GCV 26.66). Whereas the traits plant height and 10 green pod weight had high PCV values (22.20 and 21.03) and moderate GCV values (16.47 and 17.13). Moderate PCV and GCV were registered for the traits days to first flowering (PCV 16.23; GCV 15.70), days to 50 % flowering (PCV 161.99; GCV 11.41), pod diameter (PCV 16.41; GCV 15.77), number of seeds per pod (PCV 15.17; GCV 11.18) and protein content of green pods (PCV 13.00; GCV 12.94). High to moderate magnitude of PCV and GCV generally indicated ample scope for improvement through selection. The present findings clearly suggested the worth of all the traits for the study of genetic variability in cowpea. Similar findings were previously reported by Khanpara *et al*. (2015); Kumar *et al*. (2015); Devi and Jayamani (2018); Kumar *et al*. (2018); Saidaiah *et al*. (2021); Vinay *et al*. (2022). The proportion of GCV to PCV noticed in this investigation ranged from 45.55 % in 100 seed weight to 99.84 % in pod yield per plant.

Genotypic coefficients of variation do not estimate the variations that are heritable hence, estimation of heritability is absolutely necessary (Falconer, 1960). Heritability is of prime interest to the plant breeders primarily as a measure of the value of selection for particular character in various types of progenies and as an index of transmissibility (Hayes *et al*., 1955). Heritability is classified as low (below 30 %), medium (30-60 %) and high (above 60 %) as suggested by Johnson *et al*. (1955).

Among the characters studied, high heritability estimate was recorded for days to first flowering (93.59 %), days to 50 % flowering (90.62 %), pod length (79.50 %), pod diameter (92.36 %), number of green pods per plant (88.94 %), 10 green pod weight (66.40 %), protein content of green pod (99.19 %) and pod yield per plant (99.66 %). Medium heritability estimate was recorded for plant height (55.06 %) and number of seeds per pod (54.35 %) whereas low heritability was observed for the trait 100 seed weight (20.75 %) (Table 5). High heritability indicates less environmental influence in the observed variation (Songsri *et al*., 2008) which suggested that selection based on phenotypic expression could be relied upon as there was major role of genetic constitution in the expression of these characters. At the same time, heritability value alone cannot provide information on amount of genetic progress that would result from selection of best individuals.

Heritability estimates along with genetic advance as percentage of mean is usually more helpful than the heritability alone in predicting the resultant effect from selecting the best individuals. Genetic advance as percentage of mean is classified as low (0-10 %), moderate (10-20 %) and high (>20 %) as suggested by Johnson *et al*. (1955). High heritability coupled with high genetic advance as per cent of mean was observed for days to first flowering (31.30 %), days to 50% flowering (22.38 %), pod length (49.90 %), pod diameter (31.22 %), number of green pods per plant (51.80 %), 10 green pod weight (28.76 %), protein content (26.56 %) and green pod yield per plant (90.28 %). These characters can be regarded as most reliable for selection because these characters are controlled by

additive gene action (Panse, 1957) and selection based of these traits would be rewarding for the improvement of these traits. Whereas medium heritability coupled with high and moderate genetic advance as per cent of mean were exhibited by traits plant height (25.17 %) and number of seeds per pod (16.98 %). Only the trait, 100 seed weight was found to have low values of both heritability and genetic advance as per cent of mean (4.85 %) indicated the prevalence of dominance and epistatic effect hence selection for this trait might not be possible (Panse, 1957).

D. Selection indices

Linear correlation between any two characters may present a confusing picture because any character may exert simultaneous influence on many characters of the plant. Path coefficient analysis is more useful in establishing direct and indirect relationship among any characters, which is more realistic interpretation regarding influence of a character on a particular trait (Mondal *et al*., 2020). The path coefficient analysis using phenotypic correlation coefficients among pair of characters depicting direct and indirect effect on green pod yield per plant has been presented in Table 6. Green pods in cowpea are important as this is utilized as vegetable throughout the world. Therefore, the direct effect and positive association with green pod yield per plant was considered essential. Among the yield component traits, number of green pods per plant (0.231) showed high positive direct effects on green pod yield per plant followed by pod diameter (0.216) and 10 green pod weight (0.126). Other traits like number of seeds per pod (0.050), pod length (0.045), 100 seed weight (0.021) and plant height (0.001) expressed low positive direct effects on green pod yield per plant. The indirect effects via other characters were negligible. Hence, direct selection through number of green pods per plant, pod diameter and 10 pod weight could be beneficial for yield improvement of cowpea. Some other characters like days to first flowering, days to 50 % flowering and protein content of green pod showed direct negative effects on green pod yield per plant. Residual effect of the path analysis was very low (0.194) suggesting the inclusion of maximum pod yield determining characters in the present study. Previously, Meena *et al*. (2015); Patel *et al*. (2016); Srinivas *et al*. (2017) reported similar kind of association ship of the traits with green pod yield in vegetable type of cowpea.

CONCLUSIONS

The present study illustrated significant variation among genotypes for both qualitative and quantitative traits. The overall mean of Shannon-Weaver diversity index (H) value of 1.276 amply suggest the existence of diversity among the genotypes under study. Days to first flowering, days to 50% flowering, pod length, pod diameter, number of green pods per plant, 10 green pod weight, protein content and green pod yield per plant exhibited high heritability in conjunction with high genetic advance which suggests that the characters concerned are conditioned by additive gene action and therefore, these characters would be more reliable for effective selection. The maximum positive direct effects were exerted by number of green pods per plant, pod diameter and 10 pod weight on green pod yield per plant. The genotypes 'CP-738', 'Kashi Kanchan', 'CP-1116', 'CP-863', 'EC-202526', 'Arka Garima' and 'IC-39856' were found most promising in respect to green pod yield per plant.

FUTURE SCOPE

The information generated through this study will help the breeders to develop high yielding varieties of vegetable cowpea in future. The present investigation reveals that above mentioned genotypes of cowpea can be introduced in this geographical region for better yield, productivity and nutritional quality.

Acknowledgement. The authors want to duly acknowledge the Department of Horticulture, MSSSoA, CUTM for providing all the support during the period of the research work.

Conflict of Interest. None.

REFERENCES

Anonymous (2008). Manual on Agricultural Production Technology, Published by 'Directorate of Agriculture & Food Production, Bhubaneswar, Odisha' with technical support from Odisha University of Agriculture and Technology, Bhubaneswar, p. 69-70.

Burton, G. W. (1952). Quantitative inheritance in grasses. In. *Proceedings of 6th International Grassland Congress*, August 17-23, 1952, Pennsylvania State College, USA, *1*: 277-283.

Das, S., Karak, C. & Roy, S. (2020). Genetic variability, correlation and path analysis studies in cowpea [*Vigna unguiculata* (L.) Walp.]. *International Journal of Economic Plants*, *7*(3), 123-128.

Devi, S. M. & Jayamani, P. (2018). Genetic variability, heritability, genetic advance studies in cowpea germplasm [*Vigna unguiculata* (L.) Walp.]. *Electronic Journal of Plant Breeding*, *9*(2), 476-481.

Dewey, D. R. & Lu, K. H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, *51*(9), 515-518.

Egbadzor, K. F., Danquah, E. Y., Ofori, K., Yeboah, M. & Offei, S. K. (2014). Diversity in 118 cowpea [*Vigna unguiculata* (L.) Walp] accessions assessed with 16 morphological traits. *International Journal of Plant Breeding and Genetics*, *8*(1), 13-24.

Falconer, D. S. (1960). *Introduction to Quantitative Genetics*. Oliver and Boyd Limited, Edinburgh and London, UK, p. 365.

Giridhar, K., Raju, P. S., Pushpalatha, G. & Patra, C. (2020). Effect of plant density on yield parameters of cowpea [*Vigna unguiculata* (L.) Walp.]. *International Journal of Chemical Studies*, *8*(4), 344-347.

Gopalan, C., Ramashastri, B. V. & Balasubramaniam, S. C. (1982). Nutritive values of Indian foods (ICMR). National Institute of Nutrition, Hyderabad, p.161.

Hanson, C. H., Robinson, H. F. & Comstock, R. E. (1956). Biometrical studies of yield in segregating populations of Korean Lesedezo. *Agronomy Journal*, *48*(6), 268-272.

Hayes, H. K, Immer, F. R. & Smith, D. C. (1955). *Methods of Plant Breeding*. Tata McGraw-Hill Publishing Company Limited, USA, pp. 55.

Hennink, S. & Zeven, A. C. (1991). The interpretation of Nei and Shannon-Weaver within population variation indices. *Euphytica*, *51*, 235-240.

Ijas Ahmed, K. T., Deepanshu & Prasad, V. M. (2021). Genetic divergence studies in cowpea [*Vigna unguiculata* (L.)

Walp.]. *Biological Forum- An International Journal*, *13*(3), 460-465.

Johnson, H. W., Robinson, H. F. & Comstock, R. E. (1955). Genotypic and phenotypic correlation in soyabean and their implication in selection. *Agronomy Journal*, *47*(10), 477-483.

Khan, M. M. H., Rafii, M. Y., Ramlee, S. I., Jusoh, M. & Mamun, A. (2020). Genetic variability, heritability, and clustering pattern exploration of bambara groundnut (*Vigna subterranea* L. Verdc.) accessions for the perfection of yield and yield-related traits. *Biomed Research International*, p.1-31.

Khanpara, S. V., Jivani, L. L., Vachhani, J. H. & Kachhadia, V. H. (2016). Genetic variability, heritability, and genetic advance studies in vegetable cowpea [*Vigna unguiculata* (L.) Walp.]. *Electronic Journal of Plant Breeding*, *7*(2), 408-413.

Kumar, N. M., Gangaprasd, S. & Sunil, M.G. 2015. Genetic variability and heritability studies in cowpea [*Vigna ungiculata* (L.) Walp]. *Research Journal of Agricultural Sciences*, *6*(4), 763-766.

Kumar, S., Patel, P. S. & Kumar, P. (2018). Genetic variability, heritability and genetic advance in cowpea [*Vigna unguiculata* (l.) Walp] *Plant Archives*, *18*(2), 1268-1270.

Lowry, O. H., Rosbrough, N. J., Farr, A. L. & Randall, R. J. (1951). Total protein estimation by Lowry's method. *The Journal of Biological Chemistry*, *193*(1), 265-275.

Lush, J. L. (1949). Heritability of quantitative characters in farm animals. *Hereditas*, *35*, 356-375.

Meena, H. K., Krishna, K. R. & Singh, B. (2015). Character associations between seed yield and its components traits in cowpea [*Vigna unguiculata* (L.) Walp.]. *Indian Journal of Agricultural Research*, *49*(6), 567-570.

Mondal, R., Banerjee, S., Maurya, P. K., Bhattacharjee, T., Dutta, S., Dutta, T., Lalramhlimi, B., Mukherjee, D., Acharya, B., Islam, S. K. M., Saha, S., Chattopadhyay, A. & Hazra, P. (2020). Morphological and genetic variations among advance breeding lines and varieties of brinjal grown in Eastern Gangetic plains of India. *International Journal of Current Microbiology and Applied Sciences 9*(4), 2008-2028.

Nancee, Rana, M. K., Pratap, P. S. & Ranjan, R. (2014). Genetic characterization in vegetable cowpea. *Vegetable Science*, *41*(2), 214-218.

Panse, V. G. (1957). Genetics of quantitative characters in relation to plant breeding. *Indian Journal of Genetics and Plant Breeding*, *17*, 318-328.

Patel, U. V., Parmar, V. K., Patel, P. B. & Malviya, A. V. (2016). Correlation and path analysis study in cowpea [*Vigna unguiculata* (L.) Walp]. *International Journal of Science, Environment and Technology*, *5*(6), 3897-3904.

Popoola, J. O., Aremu, B. R., Daramola, F. Y., Ejoh, S. A., & Adegbite, A. E. (2015). Morphometric analysis of some species in the genus *Vigna* (L.) Walp.: implication for utilization for genetic improvement. *Journal of Biological Sciences*, *15*(4), 156–166.

Quin, F. M. (1997). *Introduction* (Eds. Singh, B.B., Mohan Raj, D.R., Dashiell, K.E and Jackai, L.E.N) Advances in Cowpea Research, Co publication of Indian Institute of Tropical Research (IITA) and Japan *International Research Centre for Agricultural Sciences (JIRCAS)*, IITA, Ibadan, Nigeria, p. ix-xv.

Saidaiah, P., Pandravada, S. R., Geetha, A. & Kamala, V. (2021). Investigations on per se performance, genetic variability and correlations in vegetable cowpea [*Vigna unguiculata* (L.) Walp]. germplasm for yield and its attributing traits. *Legume Research-An International Journal*, *44*(11), 1267-1277.

Singh, K., Malik, Y. S., Kalloo, G. & Mehrotra, N. (1974). Genetic variability and correlation studies in bhindi (*Abelmoschus esculentus* (L.) Moench). *Vegetable Science*, *1*, 47-54.

Singh, O. V., Shekhawat, N., Singh, K. & Gowthami, R. (2020). Assessment of genetic variability and inter-character association in the germplasm of cowpea [*Vigna unguiculata* (L.) Walp] in hot arid climate. *Legume Research-An International Journal*, *43*(3), 332-336.

Sivasubramanian, S. & Madhava Menon, P. (1973). Genotypic and phenotypic variability in rice. *Madras Agricultural Journal*, *60*(9-12), 1093-1096.

Songsri, P., Joglloy, S., Kesmala, T., Vorasoot, N., Akkasaeng, C. P. A. & Holbrook, C. (2008). Heritability of drought resistant traits and correlation of drought resistance and agronomic traits in peanut. *Crop Science*, *48*, 2245-2253.

Srinivas, J., Kale, V. S. & Nagre, P.K. (2017). Correlation and path analysis study in cowpea [*Vigna unguiculata* (L.) Walp.] genotypes. *International Journal of Current Microbiology and Applied Sciences*, *6*(6), 3305-3313.

Steele, W. M. (1976). *Cowpeas, Vigna unguiculata* (Eds. Simmonds, N.W.) Evolution of Crop Plants, Longmans, London, UK, p. 183-185.

Supriya, T. (2022). Genetic studies for yield and quality traits in French bean (*Phaseolus vulgaris* L.). M.Sc. Dissertation, Centurion University of Technology and Management, Odisha, India.

Toyin, A. A. (2019). Variability among accessions of cowpea [*Vigna unguiculata* (L.) Walp]. from qualitative scoring to quantitative analyses. *South Asian Research Journal of Agriculture and Fisheries*, *1*(2), 54-64.

Vavilov, N. I. (1951). The origin, variation, immunity and breeding of cultivated plants (Translated by S. K. Chestitee). *Chronica Botanica*, *13*, 1-366.

Verdcourt, B. (1970). Studies in the Leguminosae-Papilionoïdeae for the 'Flora of tropical East Africa': III. *Kew Bulletin*, *24*(3), 379-447.

Verma, A. K., Mehta, A. K., Gontia, A. S., Sharma, D., Singh, R. P. & Singh, P. (2019). Genetic variability, heritability, and genetic advance studies for yield components in F_2 generation of cowpea [*Vigna unguiculata* (L.) Walp]. *International Journal of Chemical Studies*, *7*(6), 3084-3088.

Vinay, K., Rao, P. J. M., Sandhya Kishore, N. & Hari, Y. Genetic variability studies for seed yield and yield component traits in cowpea [*Vigna unguiculata* (L.) Walp.]. *Electronic Journal of Plant Breeding*, *13*(2), 544-548.

Yasin, G., Elias, U., Walelign, W. & Hussein, M. (2021). Assessment of genetic diversity in cowpea [*Vigna unguiculata* (L.) Walp]. genotypes in southern Ethiopia based on morpho-agronomic traits. *International Journal of Agricultural Technology*, *17*(4), 1631-1650.

How to cite this article: Dipankar Barik, Subhrajyoti Chatterjee and Pritismita Nayak (2023). Study on Morphological and Genetic Variations among Vegetable Cowpea [*Vigna unguiculata* (L.) Walp.] Genotypes in North-Eastern Ghat Region of India. *Biological Forum – An International Journal*, *15*(5): 1247-1255.