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Mukesh Chandra Joshi
 Research Scholar, Department
 of Horticulture, Babasaheb
 Bhimrao Ambedkar University
 Lucknow, Uttar Pradesh,
 India

Sanjay Kumar
 Professor, Department of
 Horticulture, Babasaheb
 Bhimrao Ambedkar University
 Lucknow, Uttar Pradesh,
 India

Shailendra Kumar
 Research Scholar, Department
 of Horticulture, Institute of
 Agricultural Sciences, Banaras
 Hindu University, Varanasi,
 Uttar Pradesh, India

Vipin
 Department of Vegetable
 Science, Punjab Agricultural
 University, Ludhiana, Punjab,
 India

Shubham Kumar
 Department of Horticulture,
 Anand Agricultural
 University, Anand, Gujarat,
 India

Ram Baboo
 Department of Horticulture,
 Udai Pratap College
 Autonomous College, Varanasi,
 Uttar Pradesh, India

Corresponding Author:
Shailendra Kumar
 Research Scholar, Department
 of Horticulture, Institute of
 Agricultural Sciences, Banaras
 Hindu University, Varanasi,
 Uttar Pradesh, India

Genetic variability, heritability, correlation and path analysis in cowpea [*Vigna unguiculata* (L.) Walp.]

Mukesh Chandra Joshi, Sanjay Kumar, Shailendra Kumar, Vipin, Shubham Kumar and Ram Baboo

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Abstract

The study titled "Genetic Variability, Heritability, Correlation, and Path Analysis in Cowpea [*Vigna unguiculata* (L.) Walp.]" was conducted during the summer season of 2018-19 at the Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareilly Road, Lucknow, Uttar Pradesh, India. This research involved 16 different cowpea genotypes obtained from BBAU, Lucknow, and was carried out using a Randomized Block Design (RBD) with three replications. In this study, it was observed that the phenotypic coefficient of variation (PCV) was consistently higher than the genotypic coefficient of variation (GCV) for all the traits being investigated. The traits with the widest range of variation were pod yield per plot, number of seeds per plant, Vitamin A content, pod weight per plant, days to the first pod picking, and the duration of the reproductive phase. On the other hand, the number of branches per plant exhibited the lowest range of variation among the traits studied. The Highest Genotypic Coefficient of Variation (GCV) was observed for number of primary branches per plant (22.97%) followed by number of pods per peduncle (9.82%), and it was moderate for pod diameter (8.52%) number of seeds per plant (7.53%) and low was recorded for 100 seeds weight (5.89%) and number of branches per plant (5.68%), and lowest was recorded for vitamin A (0.38%). Phenotypic coefficient of variance was higher for number of primary branches per plant (24.78%) followed by number of pods per peduncle (19.44%), peduncle length (17.61%), where as it was moderate for pod diameter (14.16%), pod length (12.89%), number of seeds per pod (12.55%) and low was recorded for 100 seeds weight (8.86%), number of pods per plant (7.45%), days to first pod picking and it was lowest recorded for vitamin A (3.97%).

Keywords: *Vigna unguiculata*, yield, PCV, GCV, genetic heritability, correlation

Introduction

The importance of vegetable crops in India is evident due to the fact that a significant portion of the Indian population follows a vegetarian diet. India is known for cultivating a wide variety of vegetables. Cowpea, scientifically known as *Vigna unguiculata* (L.) Walp., is an annual leguminous vegetable crop native to India and belonging to the Fabaceae family. It has a chromosome number of $2n=2x=22$, as determined by Darlington and Wylie in 1955. While it is native to India, tropical and central Africa is also considered an alternative center of origin for cowpea, where wild races of the plant are found, as noted by Ng and Marechal in 1985. Cowpea is a warm-season, annual herbaceous legume crop that typically exhibits a pole-type growth habit. It features a robust taproot system and can have green or pigmented stems. Its leaves are alternate and trifoliate, comprising one symmetrical terminal leaflet and two asymmetrical leaflets. Cowpea is known by various names such as crowder pea, black-eyed pea, lobia, barbatti, chawali, southern pea, long yard bean, asparagus bean, snake bean and China bean. This crop is highly significant and widely cultivated throughout India for its long, tender green pods, which are consumed as a vegetable, as well as for its seeds, which are used as a pulse (Srinivas *et al.*, 2016) [13]. In general, cowpea can be classified into two main types. Grain-type cowpea varieties produce short pods with a higher number of seeds and have an early maturity, while vegetable-type varieties produce long pods with fewer seeds, mature later, and have tender pods that remain delicate for a longer duration. In such scenarios, genetic diversity becomes extremely important and plays a pivotal role in the improvement of this crop, as emphasized by Sabale *et al.* in 2018 [12].

Cowpea is a valuable crop that provides nutritious grains and serves as an affordable source of protein. In cowpea breeding programs, the primary focus has been on the collection and preservation of genetic resources. Understanding the nature and extent of genetic variability within a crop species is crucial for designing effective breeding methods. Genetic diversity is a fundamental prerequisite for the success of a breeding program (Panchta *et al.*, 2021) ^[9]. Genetic advance refers to the improvement in the mean genotypic value of selected plant families over that of the base population. The extent of genetic advance depends on factors such as phenotypic variability, heritability, and the intensity of selection. These factors collectively influence how much progress can be made in enhancing the desired traits through selective breeding (Panchta *et al.*, 2021) ^[9].

Materials and Methods

The experimental materials of the present investigations were comprised sixteen cowpea genotypes of tropical and subtropical origin. The list of the genotypes (breeding lines) is given in Table 1 which were received from Indian Institute of Vegetable Research (IIVR), Varanasi (U.P.) and evaluated at the Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareilly Road, Lucknow (U.P.). Experimental field was laid out in randomized block design (RBD) with sixteen genotypes/ lines and replicated thrice, each block into 16-unit plots. The sixteen genotypes were allotted to the 16-unit plots of each block. There was total 48 experimental plots having size of each plot of 1.80 m X 0.90 m, row to row and plant to plant spacing was 60 cm and 15 cm, respectively. The plots were raised by 150 m from the ground level to avoid water-logging, if occurred. The plot to plot (0.90 m) and block to block (1.80 m) distance were continues. Each plot was divided into three rows and each row contained six plants web plot

accommodated 18 plants and total plants maintained in cultivated area were 864. All are genotypes and are collected from Indian Institute of Vegetable Research (IIVR), Varanasi (U.P.). In the analysis of this experiment, various observations were recorded, including plant height (In centimeter), the number of primary branches per plant, the number of branches per plant, days to the first open flower, the number of pods per plant, days to the first pod picking, pod length (In centimeters), pod diameter (In centimeters), the number of pods per peduncle, pod weight per plant, pod yield per plot, peduncle length (In centimeters), the number of peduncles per plant, the duration of the reproductive phase, the number of seeds per plant, the number of seeds per pod, 100 seeds weight, vitamin A content (in International Units - IU) and vitamin C content (In milligrams per 100 grams).

The analysis of variance was performed by partitioning the total variation into components attributed to the treatments and replications, as per the Panse and Sukhatme (1978) ^[10] method. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were determined according to the recommendations of Robinson *et al.* (1949) ^[11]. These coefficients were calculated using the formulas provided by Lush (1949) ^[7] and Burton and Devane (1953) ^[2]. The range of genetic advance, expressed as a percentage of the mean, was categorized following the guidelines of Johnson *et al.* (1955) ^[6]. Correlation coefficients between all possible combinations of traits at the phenotypic (rp) and genotypic (rg) levels were estimated using the formula developed by Johnson *et al.* (1955) ^[6]. A coefficient analysis was conducted with various factors as independent variables, and yield was considered the dependent variable. The relationships were derived by solving simultaneous equations that express the fundamental relationships among correlation and path coefficients, following the approach presented by Dewey and Lu (1959) ^[4].

Table 1: List of selected genotypes were used in the present investigation

S. No.	Name of the genotypes/ varieties	Source
1.	Kashi Shyamal	IIVR, Varanasi
2.	Kashi Nidhi	IIVR, Varanasi
3.	Kashi Unnati	IIVR, Varanasi
4.	Kashi Gouri	IIVR, Varanasi
5.	Kashi Kanchan	IIVR, Varanasi
6.	EC-9738	IIVR, Varanasi
7.	IC-559393	IIVR, Varanasi
8.	EC-528398	IIVR, Varanasi
9.	EC-15296	IIVR, Varanasi
10.	EC-399251	IIVR, Varanasi
11.	IC-3004	IIVR, Varanasi
12.	IC-559405	IIVR, Varanasi
13.	IC-551900	IIVR, Varanasi
14.	IC-34009	IIVR, Varanasi
15.	IC-559406	IIVR, Varanasi
16.	IC-536630	IIVR, Varanasi

Results and Discussion

The mean sum of squares due to genotypes exhibited significant differences for all traits at both the 1% and 5% levels of significance. This suggests the presence of a substantial amount of genetic variability among the cowpea genotypes. The genotypic correlation coefficients are presented in Table 6. Notably, pod yield per plant had a positive and significant genotypic correlation coefficient

with itself (1.000), followed by the number of peduncles per plant (0.0269).

On the other hand, negative and significant correlations were observed for pod yield per plant with days to the first pod picking (-1.4504). Days to the first pod picking (0.9483) showed a positive and significant correlation, followed by the number of seeds per pod (-0.1115), while negative and significant correlations were recorded for plant height (-

0.6427). The number of pods per peduncle (0.5961), followed by the number of peduncles per plant (0.0096), showed positive and significant correlations, with negative and significant correlations for plant height (0.4931).

At the phenotypic level, as presented in Table 7, pod yield per plant had a positive and significant genotypic correlation coefficient (1.000), followed by the number of seeds per pod (0.0731). However, negative and significant correlations were recorded for vitamin C (0.0182). Vitamin A had a positive and significant correlation with pods per peduncle (0.0461), except for a negative and significant correlation with the number of branches per plant (-0.0114). The number of primary branches per plant (0.5696) showed a positive and significant correlation, followed by vitamin C (0.0103), with negative and significant correlations recorded for pod diameter (-0.4396). Vitamin C (0.5363), followed by peduncle length (0.0216), showed positive and significant correlations, with negative and significant correlations for the number of peduncles per plant (-0.2555). In a study by

Girish *et al.* (2006) [5], one hundred cowpea genotypes were evaluated for variability in eleven quantitative characters. Phenotypic path coefficients among different pod yield traits in cowpea were calculated to assess their associations. The highest positive direct effects on pod yield per plot (g) were exhibited by the number of peduncles per plant (51.324), pod length (20.684), pod diameter (17.183), number of seeds per pod (6.083), peduncle length (4.912), hundred seeds weight (3.162), and vitamin C (1.150).

Conversely, the highest negative and direct effect on pod yield per plot was exhibited by pod weight per plant (-3.163), followed by the number of branches per plant (4.741), days to the first open flower (-5.313), number of seeds per plant (-5.938), vitamin A (10.747), pods per peduncle (-11.249), and duration of the reproductive phase (48.599). Siddique and Gupta (1991) [1] observed a significant correlation of seed yield per plant with days to 50% flowering, days to maturity, number of clusters per plant, and number of pods per plant.

Table 2: Mean performance of 16 genotypes of cowpea on growth

S. No.	Genotypes	Characters						
		Plant height (cm)	No. of leaf per plant	No. of primary branches per plant	No. of branches per plant	Days to first open flowers	No. of pod per plant	Days to first pod picking
1.	Kashi Shyamal	26.30	31.96	3.78	4.16	44.76	45.92	55.17
2.	Kashi Nidhi	28.77	32.13	3.80	4.16	44.97	46.16	55.28
3.	Kashi Unnati	30.44	32.17	4.18	4.41	45.67	46.55	55.65
4.	Kashi Gouri	24.81	31.91	3.78	3.91	43.87	45.33	55.10
5.	Kashi Kanchan	32.83	32.35	4.50	4.50	45.98	49.41	56.78
6.	EC-9738	29.46	29.46	2.50	4.16	40.76	39.33	53.71
7.	IC-559393	31.96	31.40	2.73	3.83	42.29	39.41	55.18
8.	EC-528398	29.53	30.73	2.78	4.08	42.64	39.66	53.78
9.	EC-15296	32.13	31.59	3.14	3.75	43.83	40.92	53.28
10.	EC-399251	31.16	29.71	3.41	4.08	43.16	41.75	53.49
11.	IC-3004	29.19	29.19	2.14	3.83	42.50	40.83	54.90
12.	IC-559405	31.40	29.00	2.17	3.66	42.85	42.00	54.34
13.	IC-551900	27.37	30.31	2.48	3.50	43.76	40.50	54.76
14.	IC-34009	27.56	31.16	2.79	3.41	42.87	43.16	54.33
15.	IC-559406	27.66	29.53	3.09	3.67	42.62	40.00	53.62
16.	IC-536630	27.89	27.89	2.60	3.60	41.87	44.91	53.25
	S.Em(±)	1.53	1.67	0.16	0.20	2.39	2.39	3.01
	CD at 5%	4.57	4.52	0.48	0.59	7.06	7.06	8.88

Table 3: Mean performance of 16 genotypes of cowpea on growth characters

S. No.	Genotypes	Characters						
		Pod length (cm)	Pod Diameter	No. of pod per peduncle	Pod weight per plant	Peduncle length (cm)	Number of peduncle per plant	Duration of reproductive phase
1.	Kashi Shyamal	13.98	6.65	7.46	385.75	7.77	14.56	35.49
2.	Kashi Nidhi	14.23	6.76	7.54	388.54	8.06	14.67	35.76
3.	Kashi Unnati	14.50	6.79	7.88	389.56	8.13	14.66	36.66
4.	Kashi Gouri	13.87	6.43	7.34	385.67	7.76	11.89	34.32
5.	Kashi Kanchan	14.86	6.98	8.24	390.25	9.91	14.73	36.78
6.	EC- 9738	12.40	5.89	6.47	383.76	5.89	13.56	34.63
7.	IC- 559393	12.85	5.34	5.35	360.74	4.50	14.34	33.75
8.	EC-528398	13.24	5.87	4.98	363.34	6.09	13.98	35.45
9.	EC-15296	11.98	6.21	4.78	370.54	6.42	12.97	32.16
10.	EC-399251	11.30	6.34	4.75	375.87	7.69	12.54	30.15
11.	IC-3004	11.98	5.65	7.22	374.89	7.55	11.98	34.45
12.	IC-559405	11.80	6.34	5.55	372.56	7.72	13.77	32.54
13.	IC-51900	12.78	4.56	5.83	369.34	6.71	13.67	31.76
14.	IC-34009	13.21	5.76	6.84	376.98	7.58	12.65	34.87
15.	IC-559406	11.87	5.98	6.84	376.87	7.57	13.87	32.68
16.	IC-536630	12.98	5.83	6.87	365.98	6.63	12.89	33.78
	S.Em(±)	0.68	0.35	0.33	20.59	0.40	0.71	1.93
	CD at 5%	1.99	1.04	0.98	60.75	1.19	2.09	5.70

Table 4: Mean performance of 16 genotypes of cowpea on yield and quality characters

S. No.	Genotypes	Characters					
		Number of seeds per pod	Number of seeds per plant	100 seed weight	Vitamin A (IU)	Vitamin C (mg/100 g)	Pod yield per plot
1.	Kashi Shyamal	14.26	304.43	5.27	972.56	17.18	3781.00
2.	Kashi Nidhi	14.87	309.00	5.30	978.88	17.46	3825.00
3.	Kashi Unnati	15.23	309.95	5.38	985.49	17.47	3856.00
4.	Kashi Gouri	14.08	303.68	5.13	972.51	17.14	3758.00
5.	Kashi Kanchan	16.18	312.73	5.63	989.56	17.89	3881.00
6.	EC-9738	12.80	268.58	4.70	947.18	15.29	3658.00
7.	IC-559393	13.28	373.02	4.64	938.52	15.38	3754.00
8.	EC-528398	12.45	247.14	5.02	956.14	16.81	3581.00
9.	EC-15296	12.98	236.96	4.93	963.76	16.42	3692.00
10.	EC-399251	13.55	275.16	4.54	992.69	18.47	3688.00
11.	IC-3004	12.87	277.63	5.04	924.41	17.11	3728.00
12.	IC-559405	13.44	266.11	4.98	928.25	15.48	3685.00
13.	IC-551900	12.55	284.53	4.92	970.28	16.32	3691.00
14.	IC-34009	11.52	274.67	5.01	923.38	16.10	3725.00
15.	IC-559406	13.45	301.02	4.57	926.54	16.13	3659.00
16.	IC-536630	12.64	283.95	4.94	936.52	15.90	3693.00
	S.Em(±)	0.79	15.30	0.27	52.35	4.49	0.99
	CD at 5%	2.30	44.22	0.80	154.44	12.78	3.55

Table 5: Estimates of variability, heritability and genetic advance as per cent of mean for nineteen characters in cowpea

Character	Range		Mean	Variance		PCV (%)	GCV (%)	h ² (%)	Genetic Advance	GA % of mean
	Min.	Max.		Phenotypic	Genotypic					
Plant height (cm)	24.81	32.83	29.28	5.18	2.83	7.77	5.75	0.54	2.56	8.76
No. of leaf per plant	27.89	32.35	30.65	1.90	-0.88	4.50	3.07	-0.46	-1.32	-4.32
Number of primary branches per plant	2.14	4.50	3.11	0.51	0.49	23.05	22.47	0.95	1.40	45.12
Number of branches per plant	3.60	4.50	3.92	0.10	0.06	8.11	6.26	0.59	0.39	9.97
Days to first open flower	40.76	45.98	43.40	1.98	-3.72	3.24	4.44	1.87	-5.44	-12.54
Number of pods per plant	39.33	49.41	42.86	9.69	3.93	7.26	4.63	0.40	2.60	6.08
Days to first pod picking	53.25	56.78	54.53	0.97	-8.09	1.81	5.81	-8.28	16.86	-30.92
Pod length (cm)	11.30	14.86	12.99	1.14	0.67	8.24	6.31	0.58	1.29	9.96
Pod diameter (cm)	4.56	6.98	6.08	0.37	0.24	10.09	8.20	0.66	0.83	13.73
Number of pods per peduncle	4.75	8.24	6.49	1.30	1.19	17.56	16.78	0.51	2.14	33.05
Pod weight per plant (g)	363.34	390.25	376.91	90.80	-333.46	2.52	4.84	-3.67	-72.08	-19.12
Peduncle length (cm)	4.50	9.91	7.25	1.95	1.29	16.65	15.66	0.88	2.20	30.36
Number of peduncles per plant	11.89	14.76	13.54	0.91	0.40	7.05	4.67	0.43	0.86	6.37
Duration of reproductive phase	30.15	36.78	34.07	3.38	-0.34	5.40	1.72	-0.10	-0.38	-1.12
Number of seeds per pod	11.52	16.18	13.51	1.38	0.75	8.72	6.44	0.54	1.32	9.80
Number of seeds per plant	236.96	312.73	283.04	510.80	276.48	7.98	5.87	0.54	25.20	8.90
100 seeds weight	4.57	5.63	5.02	0.07	-0.00	5.45	1.09	-0.04	-0.02	-0.45
Vitamin A(IU)	923.38	989.56	954.79	520.99	-2219.62	2.39	4.93	-4.26	-200.32	-20.98
Vitamin C (mg/100g)	15.29	17.79	16.66	0.87	-0.01	5.60	0.69	-0.01	-0.02	-0.17
Pod yield per plot (g)	3581.00	3881.00	3724.68	5151.29	-36707.47	1.92	5.14	-7.12	-1053.57	-28.28

Table 6: Genotypic Correlation coefficient for different pairs of characters in 16 parents of cowpea.

Character	No. of leaf per plant	No. of primary branches per plant	No. of branches per plant	Days to first open flowers	No. of pod per plant	Days to first pod picking	Pod length (cm)	Pod diameter	No. of pod per peduncle	Pod weight per plant	Peduncle length (cm)	Number of peduncles per plant	Duration of reproductive phase	Number of seeds per pod	Number of seeds per plant	100 seed weight	Vitamin A (IU)	Vitamin C (mg/100g)	Pod yield per plot
Plant height (cm)	0.67	-0.73	0.31	0.77	-0.89	0.33	-0.85	0.10	-0.69	0.95	-0.25	-0.07	1.71	0.41	-1.30	2.54	0.71	4.55	0.79
No. of leaf per plant		-0.99	-1.13	-0.12	-0.71	0.26	-0.71	-0.60	-0.21	-0.40	-0.15	0.15	0.03	-1.21	0.05	-0.50	-0.07	-0.29	0.36
No. of primary branch pre plant			0.88	-0.47	1.13	-0.20	0.84	0.93	0.52	-0.23	0.65	0.51	-0.22	1.19	0.73	-2.84	-0.25	-4.62	-0.11
Branches per plant				-0.26	0.95	0.14	0.80	1.21	0.45	-0.05	0.44	0.77	-2.62	1.50	0.42	-3.66	-0.00	-4.53	0.15
Days to first flower open					0.18	-0.05	0.00	-0.37	-0.13	-0.67	-0.31	0.40	-0.02	-1.48	0.21	0.16	-0.64	-1.47	-0.70
Number of pods per plant						-0.16	1.14	1.18	1.00	0.38	1.15	-0.21	-0.60	1.08	0.89	-3.81	0.24	-4.48	0.45
Days to first pod picking							-0.19	0.13	-0.10	-0.53	0.00	0.22	-0.21	-0.24	-0.00	-0.83	-0.30	-1.01	-0.45
Pod length (cm)								0.44	0.81	0.21	0.45	0.47	-2.63	1.24	0.58	-2.52	0.26	1.57	0.13
Pod diameter									0.54	-0.29	0.88	0.25	-1.10	1.20	0.50	-2.98	-0.10	-0.18	-0.10
No. of pod per peduncle										-0.12	0.64	0.05	-1.79	0.81	0.97	-1.99	0.09	-0.93	-0.00
Pod weight per plant											-0.10	0.80	-1.30	-0.41	0.34	-2.37	-0.78	-2.95	-0.96
Peduncle length												-0.056	-0.52	0.95	0.71	-2.98	0.01	-4.11	0.05
No. of peduncle per plant													0.19	0.79	-0.05	0.94	0.51	3.55	0.71
Duration reproductive phase														-1.36	-0.26	-2.21	-0.43	-2.05	-1.48
NO. of seed per pod															1.35	-5.20	-0.42	-8.57	-0.22
No. of seed per plant																0.05	0.42	0.46	0.46
100 seed weight																	-0.41	-0.49	-0.47
Vitamin A (IU)																		-3.35	-0.71
Vitamin C																			-3.07
Pod yield per plot																			1.00

Table 7: Phenotypical Correlation coefficient for different pairs of characters in 16 parents of cowpea

Phenotypical Correlation Matrix																			
Character	No. of leaf per plant	No. of primary branches per plant	No. of branches per plant	Days to first open flowers	No. of pod per plant	Days to first pod picking	Pod length (cm)	Pod diameter	No. of pod per peduncle	Pod weight per plant	Peduncle length (cm)	Number of peduncles per plant	Duration of reproductive phase	Number of seeds per pod	Number of seeds per plant	100 seed weight	Vitamin A (IU)	Vitamin C (mg / 100 g)	Pod yield per plot
Plant height(cm)	0.04	0.03	0.32	0.09	-0.7	0.09	-0.16	0.17	-0.34	-0.16	-0.03	0.31	-0.06	0.24	-0.35	0.07	0.06	0.04	0.05
No. of leaf per plant		0.67	0.50	0.76	0.49	0.66	0.71	0.44	0.31	0.49	0.28	0.42	0.52	0.56	0.34	0.58	0.70	0.43	0.64
No. of primary branch pre plant			0.71	0.83	0.78	0.58	0.71	0.75	0.52	0.72	0.61	0.41	0.46	0.83	0.65	0.71	0.80	0.70	0.69
Branches per plant				0.53	0.50	0.53	0.55	0.69	0.38	0.63	0.39	0.50	0.57	0.79	0.40	0.61	0.70	0.59	0.48
Days to first flower open					0.77	0.71	0.69	0.59	0.48	0.61	0.70	0.45	0.41	0.78	0.58	0.84	0.79	0.68	0.75
Number of pods per plant						0.65	0.79	0.71	0.75	0.70	0.77	0.28	0.58	0.74	0.72	0.88	0.61	0.55	0.78
Days to first pod picking							0.75	0.35	0.66	0.55	0.52	0.46	0.63	0.72	0.67	0.71	0.53	0.38	0.80

Pod length (cm)								0.46	0.71	0.56	0.42	0.51	0.84	0.62	0.64	0.77	0.66	0.34	0.70
Pod diameter									0.45	0.72	0.66	0.29	0.45	0.75	0.42	0.66	0.48	0.55	0.53
No. of pod per peduncle										0.76	0.64	0.22	0.72	0.57	0.84	0.60	0.28	0.28	0.70
Pod weight per plant											0.74	0.23	0.51	0.70	0.71	0.64	0.56	0.51	0.67
Peduncle length												0.10	0.32	0.64	0.63	0.74	0.40	0.66	0.52
No. of peducle per plant													0.46	0.54	0.34	0.30	0.42	0.01	0.36
Duration reproductive phase														0.46	0.45	0.63	0.33	0.15	0.53
NO. of seed per pod															0.70	0.70	0.72	0.58	0.75
No. of seed per plant																0.51	0.43	0.42	0.73
100 seed weight																			
Vitamine A (IU)																	0.70	1767789786j.680.68	0.68
Vitamin C																			0.54
Pod yield per plot																			0.44

Table 8: Genotypic path coefficient analysis (direct and indirect effect) of growth, yield and quality attributes of Cowpea

Characters	Plant height (cm)	No. of leaf per plant	No. of primary branches/plant	Branches/plant	Days to first flower open	No. of pod/plant	Days to first picking	Pod length	Pod diameter	No. of pod /peduncle	Pod weight / plant	Peduncle length	No. of peduncle /plant	Duration reproductive phase	No. of seed/ pod	No. of seed/ plant	100 seed weight	Vit. A (IU)	Vit. C	Pod yield /plot
Plant height (cm)	0.83	-1.07	-0.07	0.31	-2.52	-0.89	-1.62	-0.85	0.10	-0.69	-29.37	-0.25	-0.07	-1.69	0.41	-1.30	-0.23	-56.76	-0.88	-257.21
No. of leaf per plant	-1.07	-0.88	0.65	0.26	-0.12	1.33	0.26	0.55	0.28	0.22	-0.40	0.17	-0.09	0.03	0.99	-0.82	-0.50	-0.07	-0.29	-0.36
No. of primary branch pre plant	-0.08	0.65	0.49	0.88	0.64	1.13	0.40	0.84	0.93	0.52	3.05	0.65	0.51	0.50	1.19	0.73	0.11	8.45	0.37	15.44
Branches per plant	0.13	0.26	0.15	0.06	0.12	0.95	-0.09	0.80	1.21	0.45	0.23	0.44	0.77	0.37	1.50	0.42	0.04	0.11	0.12	-7.27
Days to first flower open	-2.52	-0.22	0.64	0.12	-3.72	-0.70	-0.05	-0.00	0.36	0.27	-0.67	0.69	-0.50	-0.02	0.80	-6.42	0.16	-0.64	-1.47	-0.70
Number of pod per plant	-3.00	1.33	1.58	0.46	-0.70	3.93	0.92	1.14	1.80	1.00	-13.87	1.15	-0.21	0.70	1.08	0.89	0.41	-23.16	1.02	-173.84
Days to first pod picking	-1.62	0.71	0.40	-0.09	-0.27	0.92	-8.09	0.46	-0.18	0.31	-0.53	-0.01	-0.41	-0.21	0.61	0.00	-0.83	-0.30	-1.01	-0.45
Pod length (cm)	-1.18	0.55	0.48	0.16	-0.00	1.87	0.46	0.67	0.44	0.18	-3.22	0.45	0.47	1.26	1.27	0.58	0.11	-10.39	-0.14	-21.23
Pod diameter	0.08	0.28	0.32	0.14	0.36	1.17	-0.18	0.18	0.24	0.54	2.72	0.88	0.25	0.32	1.20	0.50	0.08	2.37	0.24	10.05
No. of pod per peduncle	-1.28	0.22	0.39	0.12	0.27	2.16	0.31	0.72	0.29	1.19	2.39	0.64	0.07	1.15	0.81	0.97	0.11	-4.92	0.11	1.65
Pod weight per plant	-29.37	-6.95	3.05	0.23	-23.69	-18.87	-27.54	-3.22	2.72	2.39	-333.46	2.22	-9.29	-1.30	6.55	-104.13	-2.37	-0.78	-2.95	-0.96
Peduncle length	-0.48	0.17	0.51	0.12	0.69	2.60	-0.01	0.42	0.50	0.79	2.22	1.29	-0.05	0.34	0.95	0.71	0.18	-0.61	0.53	-12.71
No. of peducle per plant	-0.08	-0.09	0.22	0.11	-0.50	-0.26	-0.41	0.24	0.08	0.05	-9.29	-0.04	0.40	-0.07	0.79	-0.05	-0.03	-15.389	-0.25	-86.31
Duration reproductive phase	-1.69	0.01	0.50	0.37	-0.03	0.70	-0.35	1.26	0.32	1.15	-13.97	0.34	-0.07	-0.34	0.69	2.54	-2.21	-0.43	-2.05	-1.48
NO. of seed per pod	0.60	0.99	0.72	0.32	0.80	1.86	0.61	0.91	0.52	0.77	6.55	0.94	0.43	0.69	0.70	1.35	0.24	17.51	0.86	37.79
No. of seed per plant	-36.41	-0.82	8.58	1.75	-6.82	29.56	0.00	7.99	4.20	17.72	-104.13	13.51	-0.55	2.54	19.63	276.48	-0.04	-332.30	-0.89	-1487.75
100 seed weight	-0.23	-0.02	0.11	0.04	0.01	0.41	-0.13	0.11	0.08	0.11	-2.38	0.18	-0.03	-0.07	0.24	-0.04	-0.00	-0.41	-0.49	-2.47
Vitamine A(IU)	-56.76	-3.45	8.45	0.11	-58.71	-23.16	-40.58	-10.39	2.37	-4.92	-672.88	-0.61	-15.38	-11.92	17.51	-332.30	-1.08	-	-3.35	-0.71
Vitamin C	-0.88	-0.03	0.37	0.12	-0.32	1.02	-0.33	-0.14	0.24	0.11	-6.24	0.53	-0.25	-0.13	0.86	-0.89	-0.00	-18.24	-0.01	-3.05
Pod yield per plot	-257.21	-66.13	15.44	-7.27	-261.11	-173.84	-248.18	-21.23	10.05	1.65	-3371.28	-12.71	-86.31	-166.81	37.79	-14.87	-26.13	-	-	-

Table 9: Phenotypic path coefficient analysis (direct and indirect) of growth, yield and quality attributes of cowpea

Character	Plant height (cm)	No. of leaf per plant	No. of primary branches/plant	Branches/plant	Days to first flower open	No. of pod/plant	Days to first picking	Pod length	Pod diameter	No. of pod/peduncle	Pod weight/plant	Peduncle length	No. of peduncle/plant	Duration reproductive phase	No. of seed/pod	No. of seed/plant	100 seed weight	Vit. A (IU)	Vit. C	Pod yield / plot
Plant height(cm)	5.18	0.04	0.03	0.32	0.09	-0.07	0.09	-0.16	0.17	-0.34	-0.16	-0.03	0.31	-0.06	0.24	-0.35	0.07	0.06	0.04	0.05
No. of leaf per plant	0.15	1.90	0.76	0.50	0.76	0.49	0.66	0.71	0.44	0.31	0.49	0.28	0.42	0.52	0.56	0.34	0.58	0.70	0.43	0.64
No. of primary branch pre plant	0.06	0.75	0.51	0.71	0.83	0.78	0.58	0.71	0.75	5.52	0.72	0.61	0.41	4.46	0.83	0.65	0.71	0.80	0.70	0.69
Branches per plant	0.23	0.22	0.16	0.10	0.53	0.50	0.53	0.55	0.69	0.38	0.63	0.39	0.50	0.57	0.79	0.40	0.61	0.70	0.59	0.48
Days to first flower open	0.30	1.49	0.84	0.23	1.98	0.77	0.71	0.69	0.59	4.48	0.61	0.70	0.45	0.41	0.78	0.58	0.84	0.79	0.68	0.75
Number of podper —plant	-0.56	2.14	1.75	0.50	3.40	9.69	0.65	0.79	0.71	0.75	0.70	0.77	0.28	0.58	0.74	0.72	0.88	0.61	0.55	0.78
Days to first pod picking	0.20	0.90	0.41	0.16	1.00	2.00	0.97	0.75	0.35	0.66	0.55	0.52	0.46	0.63	0.72	0.67	0.71	0.53	0.38	0.80
Pod length (cm)	-0.41	1.05	0.55	0.18	1.04	2.64	0.79	1.14	0.46	0.71	0.56	0.42	0.51	0.84	0.62	0.64	0.77	0.66	0.34	0.70
Pod diameter	0.25	0.37	0.33	0.13	0.51	1.37	0.21	0.30	0.37	0.45	0.72	0.66	0.29	0.45	0.75	0.72	0.66	0.48	0.55	0.53
No. of pod per peduncle	-0.89	0.500	0.43	0.14	0.78	2.66	0.74	0.87	0.32	1.30	0.76	0.64	0.22	0.72	0.57	0.84	0.60	0.28	0.28	0.70
Pod weight per plant	-3.61	6.55	4.94	1.91	0.22	20.86	5.26	5.80	4.2	8.27	90.80	0.74	0.23	0.51	0.70	0.71	0.64	0.56	0.51	0.67
Peduncle length	-0.09	0.47	0.53	0.15	1.19	2.89	0.62	0.55	0.49	0.89	8.60	1.45	0.10	0.32	0.64	0.63	0.76	0.40	0.66	0.52
No. of peducle per plant	0.68	0.56	0.28	0.15	0.61	0.85	4.43	0.52	0.17	0.24	2.13	0.12	0.91	4.46	0.54	0.34	0.30	0.42	0.01	0.36
Duration reproductive phase	-0.29	1.32	0.62	0.33	1.06	3.35	1.16	1.66	0.52	1.53	9.10	0.71	0.81	3.38	0.46	0.45	0.63	0.33	0.15	0.53
NO. of seed per pod	0.66	0.91	0.70	0.29	1.30	2.74	0.84	0.78	0.54	0.77	7.97	0.92	0.61	1.00	1.38	0.70	0.70	0.72	0.58	0.75
No. of seed per plant	-18.05	10.87	10.57	2.92	18.65	50.96	15.04	15.48	5.93	21.86	154.85	17.40	7.36	18.84	18.77	510.80	0.51	0.43	0.42	0.73
100 seed weight	0.04	0.22	0.14	0.05	0.32	0.75	0.19	0.22	0.11	0.18	1.69	0.25	0.07	0.32	0.22	3.17	0.07	0.70	0.68	0.68
Vitamine A(IU)	3.52	22.27	13.28	5.12	25.53	43.51	11.99	16.22	6.82	7.54	122.02	11.26	9.34	14.09	19.44	223.67	4.38	520.99	0.64	0.54
Vitamin C	0.08	0.55	0.47	0.17	0.90	1.62	0.35	0.34	0.31	0.30	4.58	0.74	0.01	0.27	0.64	9.05	0.17	13.81	0.87	0.44
Pod yield per plot	8.36	63.68	36.09	11.12	76.71	175.24	57.04	53.87	23.53	58.08	462.46	45.76	24.86	70.75	63.53	1194.02	13.58	899.74	29.57	5151.23

Conclusion

On the basis of above result obtained in the present investigation. The experimental materials consisting sixteen genotypes of cowpea i.e., Kashi Shyamal, Kashi Nidhi, Kashi Unnati, Kashi Gouri, Kashi Kanchan, EC-9738, IC-559393, EC-528398, EC-15296, EC-399251, IC-3004, IC-559405, IC-551900, IC-34009, IC-559406 and IC-536630. The maximum phenotypic and genotypic variance, genetic advance was observed for average pod yield per plot. The maximum PCV and GCV were recorded in number of primary branches. The maximum correlation coefficient at genotypic level and phenotypic level was observed for average pod yield per plot. The result of path coefficient for parent is high.

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