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Genetic analysis in grain cowpea (*Vigna unguiculata* (L.) Walp) for yield and quality

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Abstract
An experiment was conducted with thirty genotypes of grain cowpea during 2019-21 at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. Observations were recorded on sixteen characters *viz*., number of days for germination, germination percentage, days to first flowering, days to 50% flowering, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, pod length (cm), number of pods plant^{-1}, number of seeds pod^{-1}, days to maturity, dry pod weight plant^{-1} (g), 100-seed weight (g), seed yield plant^{-1} (g), crude protein content (%) and crude fiber content (%). A wide range of variation exhibited for yield and yield attributing traits among the genotypes under study. The analysis of variance revealed significant variation among the genotypes for all the characters studied. PCV and GCV values were highest for seed yield per plant (g). High GCV values with reasonably high PCV values were seen for dry pod weight per plant, number of secondary branches per plant, plant height, germination percentage, 100 seed weight, and number of pods per plant. Heritability was high for all traits except number of pods per plant and number of primary branches per plant, and genetic gain was high for all traits except number of primary branches per plant, crude protein content, crude fibre content, and days to maturity.

Keywords: Grain cowpea, variability, GCV, PCV, heritability, genetic advance

Introduction
Fabeaceae family and has 22 chromosomes (2n=22). It is native to India (Vavilov, 1995) [27] but tropical and central Africa is also considered as secondary centre of origin. Cowpea, a self-pollinating plant species is cultivated worldwide (Musvosvi, 2009) [13]. It is an important legume crop in eastern, southern, central and western Africa (Emongor, 2007) [6]. Cowpea is adapted to Sub-Saharan Africa (SSA), where it contributes to rural and suburban residents' nutrition, health, and income (Boukar *et al.*, 2015) [2]. Cowpea is grown on 12.5 million hectares with an output of 7.3 million tonnes (FAO, 2018) [8].
Cowpea seeds are high in protein (24.8%), fat (1.9%), CHO (63.6%), vitamin A (mg) (0.00074), Thiamine (mg) (0.00014), Riboflavin (mg) (0.00042), and Niacin (mg) (0.00281) (Throat and Gadewar, 2013) [24].
Cowpeas may be used as either green or dry fodder. It is also used as a green manure crop, a nitrogen fixing crop, and for erosion control. The plant's main product is dry seeds for human consumption, but leaves, fresh peas, and fresh green pods are eaten by many poor people who do not have access to a diverse diet (Tchiagam *et al.*, 2011) [23].
Genetic improvement of cowpea grain yield is reliant on genetic variation within the diploid population, which has a wide range of traits to combat biotic and abiotic stresses (Huyhn *et al.*, 2018) [9]. Kerala has the most significant production of cowpeas, which are grown throughout India. Kerala has cultivated the crop since ancient times, resulting in a rich and diverse domestic germplasm. Despite its value as a popular vegetable crop, little research has been done to improve it by leveraging the variability in traditional cultivars.

Materials and Methods
The present investigation was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2019-2021. The experiment was conducted in Randomized Block Design with three replications. Seeds were dibbled in a row at a spacing of 30cm between rows and 15cm between plants and cultural operations and plant protection measures were adopted as per the "Package of Practices" of Kerala Agricultural University. The data recorded on yield and quality characters were subjected to analysis of variance as suggested by Panse and Sukhatme and genetic parameters (GCV, PCV, heritability and genetic advance as per cent of mean) were worked out.

Results

Analysis of variance

Analysis of variance revealed that all thirty genotypes differed significantly, indicating considerable variability among genotypes (table 1).

Table 1: Analysis of variance of yield and yield contributing characters of grain cowpea

Characters	Mean Sum of Square		
	Replication	Genotype	Error
Degrees of freedom(df)	2	29	58
Number of days for germination	0.000	0.772	0.000000
Germination percentage	630.562	1018.149	138.7920
Days to first flowering	3.211	107.220	9.831801
Days to 50% flowering	11.811	119.206	10.82260
Plant height (cm)	4806.104	6189.436	2039.265
No. of primary branches per plant	1.085	2.352	1.074
No. of secondary branches per plant	1130.736	472.093	134.594
Pod length (cm)	2.925	10.063	2.414
No. of pods per plant	26.190	19.904	8.146
No. of seeds per pod	0.105	12.819	3.568
Days to maturity	785.244	201.120	64.623
Dry pod wt. per plant (g)	1.142	11.846	4.206
100 seed weight (g)	4.691	28.182	1.699
Seed yield per plant (g)	7.566	4.261	1.646
Crude protein content (%)	0.038	10.282	0.139
Crude fibre content (%)	0.000778	0.548065	0.005835

Mean performance of genotypes

Mean performance of various genotypes exhibited wide range of variation for most of the traits studied. Number of days for germination (DAS) varied from 3 to 4, germination percentage (%) from 28.88 to 90, days to first flowering (DAS) from 30 to 60.33, days to 50% flowering (DAS) from 40.00 to 72.00, plant height (cm) from 55.02 to 197.78, number of primary branches per plant from 3.95 to 7.55, number of secondary branches per plant from 11.55 to 67.11, pod length (cm) from 10.40 to 16.94, number of pods per plant from 4.44 to13.22, number of seeds per pod from 6.02 to 13.39, days to maturity from 76.00 to 105.33, dry pod wt. per plant (g) from 1.60 to 9.74, 100 seed weight (g) from 6.93 to 22.46, seed yield per plant (g) from 0.91 to 5.25, crude protein content (%) from 18.84 to 25.75 and crude fibre content (%) from 4.93 to 6.46. Highest mean value for plant height (cm) was exhibited by the genotype GM 66. Genotype GM 77 recorded highest mean for number of pods per plant, GM 16 for dry pod weight per plant (g), GM 5 for number of seeds per pod and GM 39 for 100 seed weight (g). The genotype PCP 0306 had early flowering as indicated by the minimum days to 50% flowering and also showed lowest crop duration. The genotypes GC 1712 recorded highest seed yield per plant (g) whereas the genotypes GM 47 and GM 74 recorded highest seed protein content (%) and highest seed fibre content (%) respectively. The genetic parameters were estimated for the characters and presented in table 2.

Table 2: Genetic parameters of yield and yield contributing characters of grain cowpea

Character	Range	Mean	PCV (%)	GCV (%)	H2 (%)	GAM (%)
Number of days for germination		3.53	14.36	14.36	100	29.58
Germination percentage		61.29	30.05	27.93	86.37	53.47
Days to first flowering		39.72	15.05	14.34	90.83	28.16
Days to 50% flowering		47.65	13.22	12.61	90.92	24.77
Plant height (cm)		130.93	34.69	28.40	67.05	47.91
No. of primary branches per plant		5.37	16.47	12.14	54.31	18.43
No. of secondary branches per plant		32.64	38.43	32.49	71.49	56.59
Pod length (cm)		13.27	13.80	12.03	76.00	21.60
No. of pods per plant		7.63	33.75	25.94	59.07	41.07
No. of seeds per pod		10.11	20.43	17.36	72.17	30.38
Days to maturity		90.82	9.01	7.42	67.87	12.60
Dry pod wt. per plant (g)		4.82	41.21	33.09	64.49	54.75
100 seed weight (g)		11.17	27.42	26.58	93.97	53.09
Seed yield per plant (g)		2.66	44.71	35.02	61.35	56.51
Crude protein content (%)		22.76	8.13	8.07	98.64	16.52
Crude fibre content (%)		5.96	7.17	7.13	98.94	14.61

Genotypic and Phenotypic coefficients of Variation

Genotypic coefficient of variation (GCV) is a heritable component of variation found in plant populations and phenotypic coefficient of variation (PCV) is a measure of the extent of total variation in a population and is equal to the sum of GCV and environmental factors. GCV and PCV were categorised as suggested by Sivasubramanian and Menon as low (less than 10%), moderate (10-20%) and high (more than 20%).

The GCV values ranged from 7.13 to 35.02. Highest GCV was recorded for seed yield per plant (g) (35.02). High GCV was observed for dry pod wt. per plant (g) (33.09), no. of secondary branches per plant (32.49), plant height (cm) (28.40), germination percentage (%) (27.93), 100 seed weight (g) (26.58) and no. of pods per plant (25.94). GCV was moderate for no. of seeds per pod (17.36), number of days for germination (14.36), days to first flowering (14.34), days to 50% flowering (12.61), no. of primary branches per plant (12.14) and pod length (cm) (12.03) whereas it was low for crude fibre content (%) (7.13), days to maturity (7.42) and crude protein content (%) (8.07).

The PCV values ranged from 7.17 to 44.71. Highest PCV was observed for seed yield per plant (g) (44.71) followed by dry pod wt. per plant (g) (41.21), no. of secondary branches per plant (38.43), plant height (cm) (34.69), no. of pods per plant (33.75), germination percentage (%) (30.05), 100 seed weight (g) (27.42) and no. of seeds per pod (20.43).

Moderate PCV values were observed for the characters no. of primary branches per plant (16.47), days to first flowering (15.05), number of days for germination (14.36), pod length (cm) (13.80) and days to 50% flowering (13.22) whereas it was low for crude fibre content (%) (7.17), crude protein content (%) (8.13) and days to maturity (9.01).

Heritability and Genetic advance

Heritability and genetic advance as per cent of mean were categorized as suggested by Johnson *et al*. High estimates of heritability was observed for the traits number of days for germination (100%), crude fibre content (98.94%), crude protein content (98.64%), 100 seed weight (g) (93.97%), days to 50% flowering (90.92%), days to first flowering (90.83%), germination percentage (86.37%), pod length (cm) (76%), no. of seeds per pod (72.17%), no. of secondary branches per plant (71.49%), days to maturity (67.87%), plant height (cm) (67.05%), dry pod wt. per plant (g) (64.49%) and seed yield per plant (g) (61.35%) whereas moderate heritability estimates were recorded for the traits no. of pods per plant (59.07%) and no. of primary branches per plant (54.31%).

High genetic advance (as per cent of mean) was exhibited by the traits no. of secondary branches per plant (56.59%), seed yield per plant (g) (56.51%), dry pod wt. per plant (g) (54.75%), germination percentage (53.47%), 100 seed weight (g) (53.09%), plant height (cm) (47.91%), no. of pods per plant (41.07%), no. of seeds per pod (30.38%), number of days for germination (29.58%), days to first flowering (28.16%), days to 50% flowering (24.77%) and pod length (cm) (21.60%). Moderate values were recorded for the traits no. of primary branches per plant (18.43%), crude protein content (16.52%), crude fibre content (14.61%) and days to maturity (12.60%).

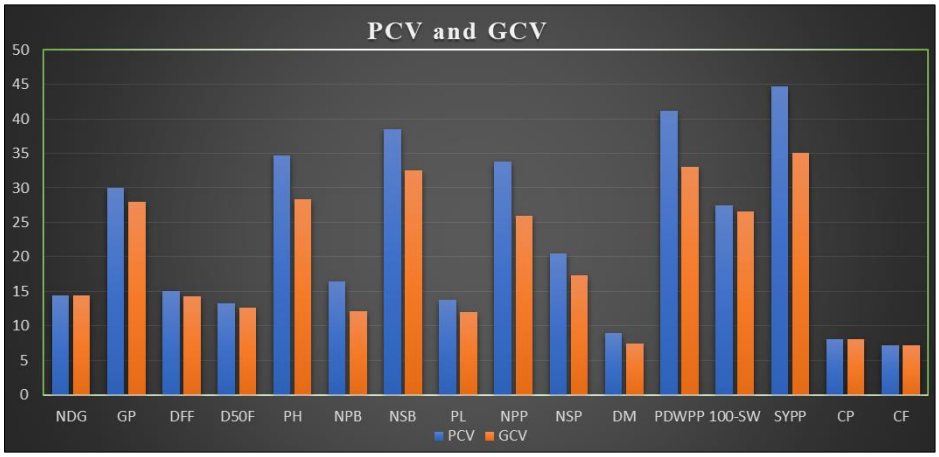
Discussion

The significant difference exhibited by the genotypes indicates the presence of substantial amount of variability for the characters studied. All sixteen characters were subjected to genetic parameter analysis, and for all of them, PCV values were greater than GCV values, with the exception of the number of days for germination, which had similar values for both PCV and GCV. The PCV and GCV estimates were in conformity with the findings of Pal *et al.* (2003) [17], Nigude *et al.* (2004) [15], Annasaheb (2013) [1], Thouseem (2017) [25], and Darshana and Bindu (2021) [4] in grain cowpea. The results were consistent with the findings of Suganthi and Murugan (2008) [22] for seed yield per plant, Nehru *et al.* (2009) [14] for plant height, number of pods per plant, and seed yield per plant, Manggoe *et al.* (2012) [12] for grain yield and number of pods per plant, Shanko *et al.* (2014) [20] and Verma *et al.* (2015) [28] for plant height, seed yield per plant, number of pods per plant, and Dinesh *et al.* (2017) [5] for plant height and number of pods per plant.

For all the characters high heritability was estimated (except for the traits no. of pods per plant and no. of primary branches per plant) indicates the highly heritable nature of these characters and the minimum influence of environment in its expression. These findings were in agreement with results of Chandrakar *et al.* for plant height, days of maturity, 50% flowering, and 100 seed weight, Sarath and Reshma for plant height, seed yield per plant, and pod length. The findings were also supported by the observations of Singh and Mehndiratta, for 100-grain weight, pod length, and days to maturity.

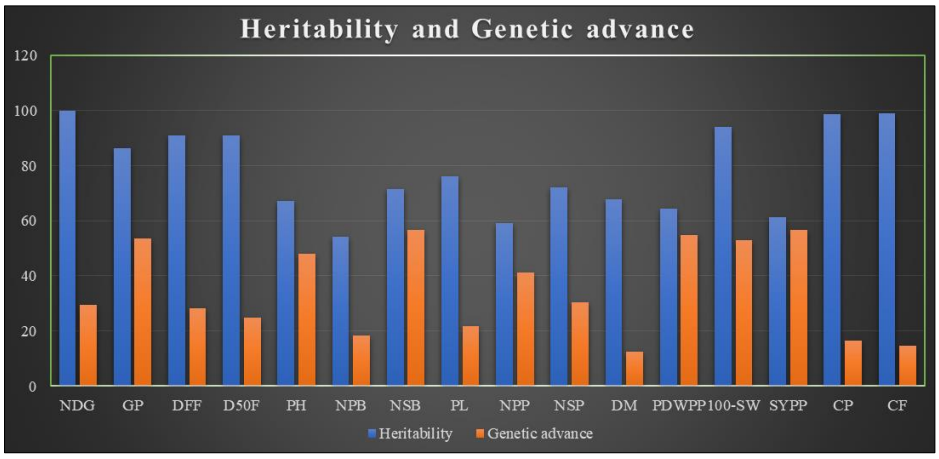
Genetic advance is the measure of genetic gain under selection. Genetic gain was high for all traits except number of primary branches per plant, crude protein content, crude fibre content, and days to maturity. The GAM estimates obtained were in conjunction with results of Pal *et al.* (2003) [17], Nigude *et al.* (2004) [15], Eswaran *et al.* (2007) [7], Suganthi and Murugan (2008) [22], Nehru *et al.* (2009) [14], and Nwofia *et al.* (2013) [16] for seed yield per plant, number of seeds per pod, plant height, number of pods per plant, number of primary branches per plant, pod length, days to 50% flowering, and 100-seed weight.

According to Manggoel *et al.* (2012) [12] and Rashwan (2010) [19], high broad-sense heritability values usually suggest the predominance of additive gene action in trait expression. This means that the characters can be improved by using direct phenotypic selection whereas characters showing moderate GAM may be governed by non - additive gene action. Hence can be improved by heterosis breeding. Heritability estimates in association with genetic advance are more beneficial in estimating the subsequent effect of selecting the best individuals from a population (Ubi *et al.*, 2001) [26].



NDG Number of days for germination	NPP	No. of pods per plant
GP% Germination percentage	NSP	No. of seeds per pod
DFF Days to first flowering	DM	Days to maturity
D50F Days to 50% flowering	PDWPP	Pod dry wt. per plant (g)
PH Plant height (cm)	100SW	100 seed weight (g)
NPB No. of primary branches per plant	SYPP	Seed yield per plant (g)
NSB No. of secondary branches per plant	CP	Crude protein content (%)
PL Pod length (cm)	CF	Crude fibre content (%)

Fig 1: PCV and GCV for the grain cowpea genotypes



NDG	Number of days for germination	NPP	No. of pods per plant
GP%	Germination percentage	NSP	No. of seeds per pod
DFF	Days to first flowering	DM	Days to maturity
D50F	Days to 50% flowering	PDWPP	Pod dry wt. per plant (g)
PH	Plant height (cm)	100SW	100 seed weight (g)
NPB	No. of primary branches per plant	SYPP	Seed yield per plant (g)
NSB	No. of secondary branches per plant	CP	Crude protein content (%)
PL	Pod length (cm)	CF	Crude fibre content (%)

Fig 2: Heritability and genetic advance for grain cowpea genotypes

Conclusion

Based on the present evaluation, it can be concluded that considerable variability was present among the genotypes for all the characters studied along with high values of genetic parameters for most of the characters. Hence the genotypes can be used in future breeding programs for improvement of these traits in grain cowpea.

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