The Pharma Innovation Journal 2022; 11(2): 2595-2600

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 2595-2600
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www.thepharmajournal.com
Received: 10-12-2021
Accepted: 16-01-2022

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Genetic variability and genetic parameters analysis of 143 fodder cowpea [*Vigna unguiculata* (L.) Walp] germplasm accessions for yield and yield attributing traits

Amritha Varanya, Gayathri G, Arya K, Usha C Thomas, Pratheesh P Gopinath and Priyanka Hulsure

Abstract
143 fodder cowpea (*Vigna unguiculata* (L.) Walp) genotypes along with 3 check varieties were evaluated for variability and genetic parameters in augmented block design at department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Trivandrum. The genotypes were evaluated for 20 biometric characters in which all the traits except secondary branches per plant and stem girth showed significant difference among the genotypes. Genetic parameter analysis revealed a high phenotypic and genotypic coefficient of variation for leaf area index (LAI), green fodder yield per plant, stem dry weight per plant, leaf dry weight per plant, seed yield per plant etc. and minimum for days to maturity. Heritability and genetic advance was high for number of leaves per plant, LAI, green fodder yield per plant, stem dry weight per plant, leaf dry weight per plant, plant height and seed yield per plant. Since these traits are governed by additive gene action, which indicate that there exists a better scope for improvement of these characters in fodder cowpea through selection.

Keywords: Fodder cowpea, genetic variability, PCV, GCV, heritability and genetic advance

1. Introduction
Agriculture and Animal husbandry are one of the highly dynamic sectors in India, where it is the primary source of income for around 58 per cent of Indians (Census, 2011) [2]. In 2020-21, India has observed a 3.4 per cent increase in GVA (Gross Value Added) of agricultural and allied sectors, despite the overall economy shrinking by 7.2 per cent which is sufficient to display the immense potential and resilience vested in agriculture and the allied sector. The livestock sector is anticipated to become a major driver of agricultural expansion since it possesses a multi-dimensional role in the upliftment of rural households. Livestock requires a balanced diet of three parts green grass and one-part leguminous fodder to balance the carbohydrate-protein proportion in the feed for optimal health and milk supply (Vendramini *et al*., 2012) [28]. Legume fodder is considered as 'Natural Protein Banks' as they synthesize and supply the majority of the world's plant protein to livestock. Feeding fresh green fodder ensures the availability of minerals and micronutrients to the animals.
Fodder cowpea (*Vigna unguiculata* (L.) Walp) is reported better than other forage legumes in terms of both quantity and quality in semiarid areas. The average protein content of cowpea fodder is 21%, with 60% dry-matter digestability (Singh and Tarawali, 1997) [23]. Due to its ability to restore soil fertility, improve soil physical properties and provide quality forage, it plays a vital role in the dairy farming sector in India (Roy *et.al*., 2016) [19].
For a successful breeding programme, it is necessary to quantify the genetic variability and to identify the most divergent individuals via biometric techniques, which can help to identify promising material that offers high mass production and a high nutritional value, and is also adapted to the soil and climate conditions and to the existing crop management. Genetic parameters *viz*., phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance provide an insight about the characteristics of different genotypes and thus can be utilized for the selection of best parents among the population. In this context, the present study was carried out in 143 fodder cowpea accessions with an objective of assessing the genetic variability and diversity among them.

2. Materials and Methods

Genetic variability evaluation of 143 fodder cowpea (*Vigna unguiculata* (L.) Walp) genotypes collected from NBPGR, New Delhi and released bush type cowpea varieties of KAU along with 3 checks was conducted in Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Trivandrum during December 2020 – May 2021. The 3 check varieties were Aiswarya, KBC-1 and EC- 4216. The experiment was carried out in augmented block design in which every accessions were sown in two rows of ten plants each and the check varieties were replicated in all the 13 blocks. The seeds were sown at a spacing of 15 cm x 30 cm during January 2021. The details of genotypes included in the present study are depicted in table 1. The genotypes were evaluated for 20 biometric characters *viz.*, number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, leaflet length (cm), leaflet width (cm), number of nodes per plant, internode length (cm), stem girth (cm), leaf area index, green fodder yield per plant (g), dry matter yield per plant (g), leaf dry weight per plant (g), stem dry weight per plant (g), leaf stem ratio, seed yield per plant (g), 1000 seed weight (g), number of seeds per pod, plant height (cm), days to 50% flowering and days to 90% maturity. Observation of vegetative traits were taken at 50 per cent flowering stage on five randomly selected plants. The statistical analysis like analysis of variance and genetic parameters were carried out using GRAPES software of KAU (Gopinath *et al*., 2020) [8]. The range of phenotypic and genotypic coefficient of variation data were estimated according to the scale of variation given by Sivasubramanian and Menon (1973) [25] and for heritability and genetic advance by Johnson *et al*. (1955) [10].

Table 1: List of Fodder cowpea (*Vigna unguiculata* (L.) Walp) genotypes used in the evaluation

Sl. No.	Accession name	Institute	Sl. No.	Accession name	Institute	Sl. No.	Accession name	Institute
1	C5-88	NBPGR	50	EC14966	NBPGR	99	IC26048	NBPGR
2	NR/18-105	NBPGR	51	EC4862	NBPGR	100	IC39908	NBPGR
3	NR/18-112	NBPGR	52	EC4208	NBPGR	101	IC249140	NBPGR
4	NR/18-99	NBPGR	53	EC4190	NBPGR	102	IC253278	NBPGR
5	NR/18-74	NBPGR	54	EC4185	NBPGR	103	IC257410	NBPGR
6	NR/18-62	NBPGR	55	EC2791	NBPGR	104	IC257413	NBPGR
7	SNAR-12-11	NBPGR	56	EC2790	NBPGR	105	IC257414	NBPGR
8	SNAR-12-08	NBPGR	57	EC4218	NBPGR	106	IC257422	NBPGR
9	IC553515	NBPGR	58	EC10734	NBPGR	107	IC257447	NBPGR
10	IC546525	NBPGR	59	EC14702	NBPGR	108	IC259061	NBPGR
11	IC546523	NBPGR	60	EC99566	NBPGR	109	IC259076	NBPGR
12	IC546516	NBPGR	61	EC99569	NBPGR	110	IC259084	NBPGR
13	IC536723	NBPGR	62	EC100090	NBPGR	111	IC259087	NBPGR
14	IC519621	NBPGR	63	EC101967	NBPGR	112	EC723987	NBPGR
15	IC398992	NBPGR	64	EC101970	NBPGR	113	EC723990	NBPGR
16	IC372642	NBPGR	65	EC101973	NBPGR	114	EC724033	NBPGR
17	IC372130	NBPGR	66	EC101978	NBPGR	115	EC724051	NBPGR
18	IC548288	NBPGR	67	EC101997	NBPGR	116	EC724352	NBPGR
19	IC402125	NBPGR	68	EC107119	NBPGR	117	EC724382	NBPGR
20	IC402115	NBPGR	69	EC107127	NBPGR	118	EC724498	NBPGR
21	IC402111	NBPGR	70	EC107185	NBPGR	119	EC724564	NBPGR
22	IC394237	NBPGR	71	EC107189	NBPGR	120	EC724591	NBPGR
23	IC363962	NBPGR	72	EC109493/3427-2	NBPGR	121	EC724313	NBPGR
24	IC337387	NBPGR	73	EC148714	NBPGR	122	EC723836	NBPGR
25	IC259069	NBPGR	74	EC149345	NBPGR	123	EC724768	NBPGR
26	IC97787	NBPGR	75	EC240630	NBPGR	124	EC724773	NBPGR
27	EC244217	NBPGR	76	EC240635	NBPGR	125	EC724774	NBPGR
28	EC244211	NBPGR	77	EC240671-1	NBPGR	126	EC724778	NBPGR
29	EC244021	NBPGR	78	EC240744-A	NBPGR	127	EC724779	NBPGR
30	EC241058	NBPGR	79	EC240856-1	NBPGR	128	EC724780	NBPGR
31	EC241056	NBPGR	80	EC240878	NBPGR	129	EC724787	NBPGR
32	EC241037	NBPGR	81	EC240885-2	NBPGR	130	EC724796	NBPGR
33	EC241023	NBPGR	82	EC240905	NBPGR	131	EC724807	NBPGR
34	EC241022	NBPGR	83	EC240912-1	NBPGR	132	EC724818	NBPGR
35	EC240801	NBPGR	84	EC239662	NBPGR	133	EC724824	NBPGR
36	EC240796-1	NBPGR	85	EC343036	NBPGR	134	EC734794	NBPGR
37	EC240755	NBPGR	86	EC343047	NBPGR	135	EC966551	NBPGR
38	EC240925	NBPGR	87	EC367714	NBPGR	136	EC99682	NBPGR
39	EC240891	NBPGR	88	EC390207	NBPGR	137	IC1255	NBPGR
40	EC148711	NBPGR	89	EC390241	NBPGR	138	EC546491	NBPGR
41	EC110599	NBPGR	90	IC3016	NBPGR	139	EC738173	NBPGR
42	EC109968	NBPGR	91	IC20647	NBPGR	140	DC-15	KAU
43	EC109112	NBPGR	92	IC20672	NBPGR	141	DCS-47-1	KAU
44	EC107183	NBPGR	93	IC20678	NBPGR	142	KBC-4	KAU
45	EC98668	NBPGR	94	IC20682/P3	NBPGR	143	KANAKAMONY	KAU
46	EC43203	NBPGR	95	IC20696	NBPGR	C1	AISWARYA	KAU
47	EC42956	NBPGR	96	IC20698	NBPGR	C2	KBC-1	KAU

48	EC42726	NBPGR	97	IC20703	NBPGR	C3	EC 4216	NBPGR
49	EC14966-1	NBPGR	98	IC26012	NBPGR			

3. Results and Discussion

3.1 Analysis of variance

Analysis of variance showed significant differences among genotypes for all the characters except secondary branches per plant and stem girth (table 2). Similar wide variability in cowpea yield and yield contributing attributes are reported by several researchers in their work (Khanpara *et al*., 2016; Sharma *et al*., 2017; Singh *et al*., 2018; Devi and Jayamani, 2018 and Belay and Fisseha, 2020) [12, 21, 22, 5, 1]. Green fodder yield per plant varied widely from 16g to 260g with a mean value of 98.4g. Genotypes EC241037 and EC724787 recorded highest and lowest value for green fodder yield per plant respectively. Existence of high diversity in cowpea germplasm for green fodder yield has been reported by Girish *et al*. (2006) [7], Singh *et al*. (2010) [24] and Sanjeev *et al.* (2015) [20].

The days to 50 per cent flowering ranged from 30 to 56 days in this study. The genotype EC244021 flowered earliest (30 days) and genotype KBC-4 flowered late (54 days) to attain 50 per cent flowering. Different cowpea genotypes had reported varying numbers for days to 50 per cent flowering. Hadley *et al.* (1983) [9] have opined that flowering is highly controlled by environmental factors of which mainly temperature and photoperiod plays a very significant role.

The number of primary branches per plant ranged from 1 to 5, number of leaves per plant from 5 (IC519621) to 35 (EC14702), leaflet length from 7.1 cm (IC402111) to 15.7 cm (EC101978), leaflet width from 2.1 cm (IC1255) to 9.3 cm (EC724352), number of nodes per plant from 4 (SNAR-12-08) to 16 (EC101970), internode length from 0.5 cm (EC244021) to 5.4 cm (EC10734), stem girth from 1 cm (KBC-4) to 4.9 cm (IC253278), leaf area index from 0.5 (IC1255) to 15.5 (IC257413), dry matter yield per plant from 2.2 g (EC724787) to 36.7 g (EC241037), leaf dry weight per plant from 1.6 g (EC724787) to 19.6 g (EC241037), stem dry weight per plant from 1.08 g (KBC-4) to 17.02 g (EC241037), leaf stem ratio from 0.29 (EC101978) to 3.01 (EC546491), seed yield per plant from 4 g (IC546523) to 29.9 g (EC546491), 1000 seed weight from 54g (IC26012) to 237g (IC39908), number of seeds per pod from 6 (IC257410) to 17 (EC98668), plant height from 13.6 cm (EC2791) to 111.6 cm (EC101970) and days to maturity from 50 (EC244021) to 77 (Kanakamony). The results revealed that the accessions used in this study are widely diverse, which is a best population that allow for the selection of exceptional and desirable genotypes for further breeding programmes.

Table 2: Analysis of variance for quantitative traits in fodder cowpea genotypes

Source of variation	Blocks	Checks	Treatment Test	Test v/s Check	Error
Degrees of freedom	12	2	142	1	24
Number of primary branches per plant	3.012**	1.783	1.888*	44.242**	NA
Number of secondary branches per plant	NA	NA	NA	NA	NA
Number of leaves per plant	3.216**	1.886	12.416**	324.31**	NA
Leaflet length (cm)	1.128	0.526	1.849*	2.612	NA
Leaflet width (cm)	1.715	1.229	1.822*	0.330	NA
Stem girth(cm)	2.032	6.154**	1.514	31.19**	NA
Number of nodes per plant	3.676**	6.152**	3.331**	39.030**	NA
Internode length (cm)	1.757	7.583**	2.207**	5.479*	NA
Days to 50% flowering	3.49**	121.421**	9.357**	279.346**	NA
Leaf Area Index	1.629	2.183	5.701**	82.461**	NA
Green fodder yield per plant (g)	5.311**	4.335*	4.212**	64.922**	NA
Dry matter yield per plant(g)	4.659**	3.552*	4.012**	68.502**	NA
Leaf Stem Ratio (LSR)	3.333**	3.562*	1.47	16.077**	NA
Leaf dry weight per plant(g)	3.496**	4.188*	3.116**	37.893**	NA
Stem dry weight per plant(g)	6.885**	1.766	5.835**	118.87***	NA
Number of seeds per pod	1.094	0.545	1.962*	3.251	NA
1000 seed weight (g)	1.226	222.199**	50.011**	86.377**	NA
Seed yield per plant(g)	1.149	24.23**	10.051**	169.59**	NA
Plant height (cm)	3.526**	4.61*	7.832**	3.065	NA
Days to maturity	5.071**	22.22**	3.782**	46.96**	NA

3.2 Estimation of Genetic Parameters

The genetic parameters like phenotypic and genotypic coefficients of variation, broad sense heritability and genetic advance are most important ones which are used for the selection of best parents from the population (Ubi *et al.*, 2001 and Denton and Nwangburuka, 2011) [27, 4].

In the present study genetic parameters for twenty biometric characters were estimated and for all the traits PCV had higher value than GCV indicating the environmental influence on these quantitative characters. However, the difference between them was minimal indicating a higher influence of the genes in the expression of the characters. The estimates of genetic parameters of various biometric traits in fodder cowpea genotypes are depicted in table 3.

High PCV and GCV was recorded for number of primary branches per plant, number of leaves per plant, internode length, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant, leaf area index, 1000 seed weight, seed yield per plant and plant height. Similar result was reported for number of primary branches per plant by (Khan *et al*., 2015 and Sharma *et al*., 2017) [11, 21], for number of leaves per plant by (Nath and Tajane, 2013 and Gerrano *et al*., 2015) [15, 6]. As the difference between PCV and GCV for number of leaves per plant, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant, leaf area

index, 1000 seed weight, seed yield per plant and plant height is low, a reliable selection using these characters can guarantee consistent results. Gerrano *et al.* (2015) [6], Phogat *et al*. (2017) [17] and Singh *et al.* (2018) [22] got similar high PCV and GCV for green fodder yield per plant and dry matter yield per plant. For leaf dry weight per plant and stem dry weight per plant, Malarvizhi *et al.* (2005) [13] and Singh *et al.* (2010) [24] obtained comparable result. High value of PCV and GCV was also reported by Thorat and Gadewar (2013) [26] and Gerrano *et al*. (2015) [6] for Leaf Area Index. Highest PCV and GCV for cowpea seed yield per plant obtained in this study was in agreement with the reports of Singh *et al*. (2018) [22], Devi and Jayamani (2018) [5] and Belay and Fisseha (2020) [1] and for plant height by Khanpara *et al.* (2016) [12], Khan *et al.* (2015) [11], Sharma *et al.* (2017) [21] and Singh *et al.* (2018) [22].

Lower value for both PCV and GCV was observed only for 90 per cent maturity in the current study. Sharma *et al*. (2017) [21], Devi and Jayamani (2018) [5] and Belay and Fisseha (2020) [1] reported similar result in their respective studies.

3.3 Heritability and genetic advance as per cent mean

High heritability accompanied with high genetic advance as per cent of mean was observed for number of leaves per plant, number of nodes per plant, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant, leaf area index, 1000 seed weight and plant height. Manggoel *et al.* (2012) [14] and Rashwan (2010) [18] suggested that high broad sense heritability values showcase the preponderance of additive gene action in that trait. It provides an idea about the extent of genetic control for the expression of a particular character (Chopra, 2000) [3]. But according to Johnson *et al*. (1955) [10] and Ubi *et al.* (2001) [27] high broad sense heritability accompanied with high genetic advance confirm additive gene effect and are more reliable indexes for selection.

Malarvizhi *et al.* (2005) [13] reported high heritability and genetic advance for number of leaves per plant, number of nodes per plant, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant and plant height as in the present study results.

High heritability and genetic advance estimates for green fodder yield per plant and dry matter yield per plant were earlier reported by Nath and Tajane (2013) [15] and Phogat *et al*. (2017) [17].

Characters like number of primary branches per plant, internode length, leaf stem ratio has high genetic advance with a moderate heritability. These characters can also be used for selection since this medium heritability is due to environmental effect. Days of 50 per cent flowering showed high heritability with moderate genetic advance. Results from this study are in accordance with observations by Malarvizhi *et al.* (2005) [13] and Nwosu *et al.* (2013) [16]. In the present investigation 1000 seed weight had highest heritability (98 per cent) and leaf stem ratio had the lowest (32 per cent).

PCV, GCV, heritability and GA were highest for number of leaves per plant, number of nodes per plant, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant, leaf area index, 1000 seed weight and plant height revealed these characters are very much effective for selection and further improvement study of fodder cowpea.

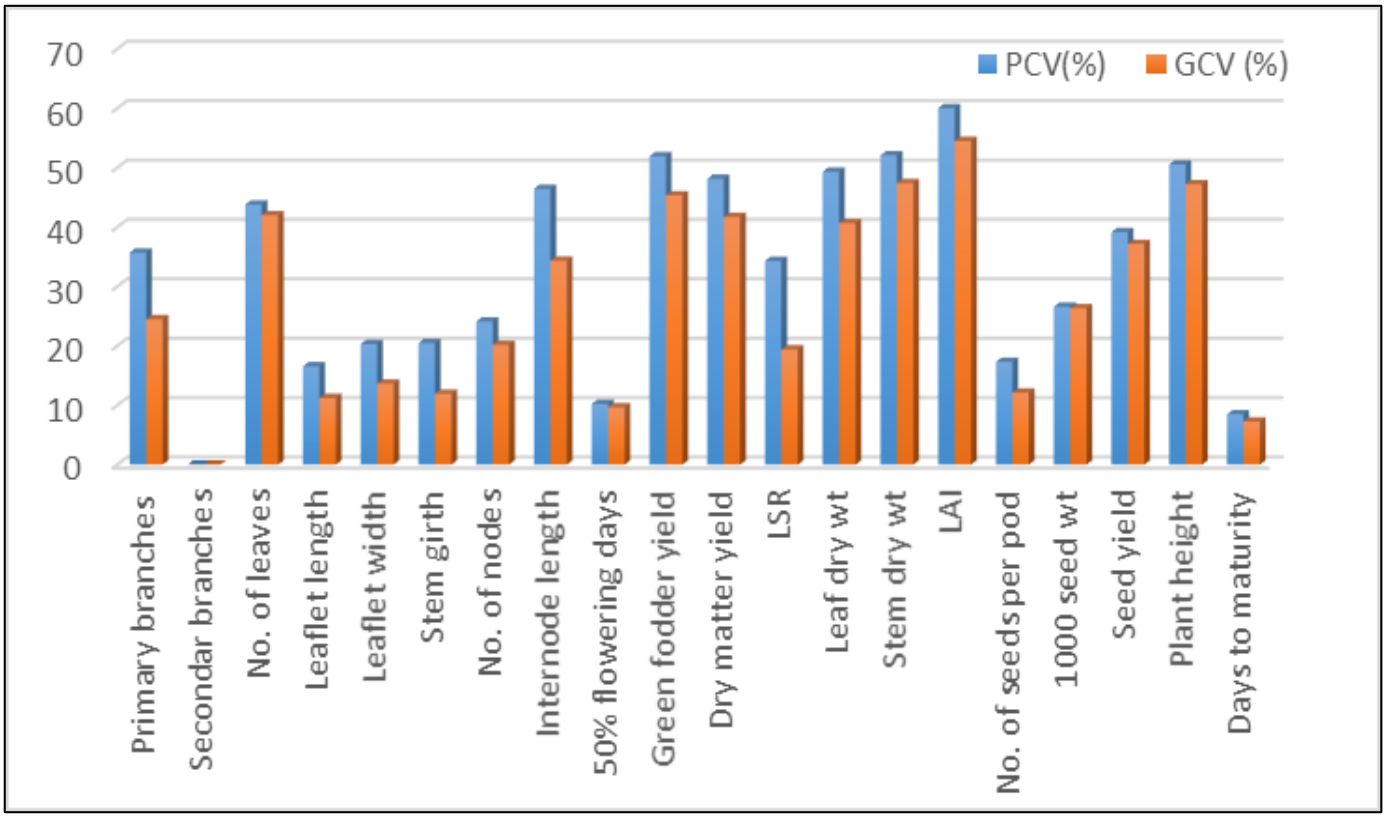

Fig 1: PCV & GCV for twenty biometric characters

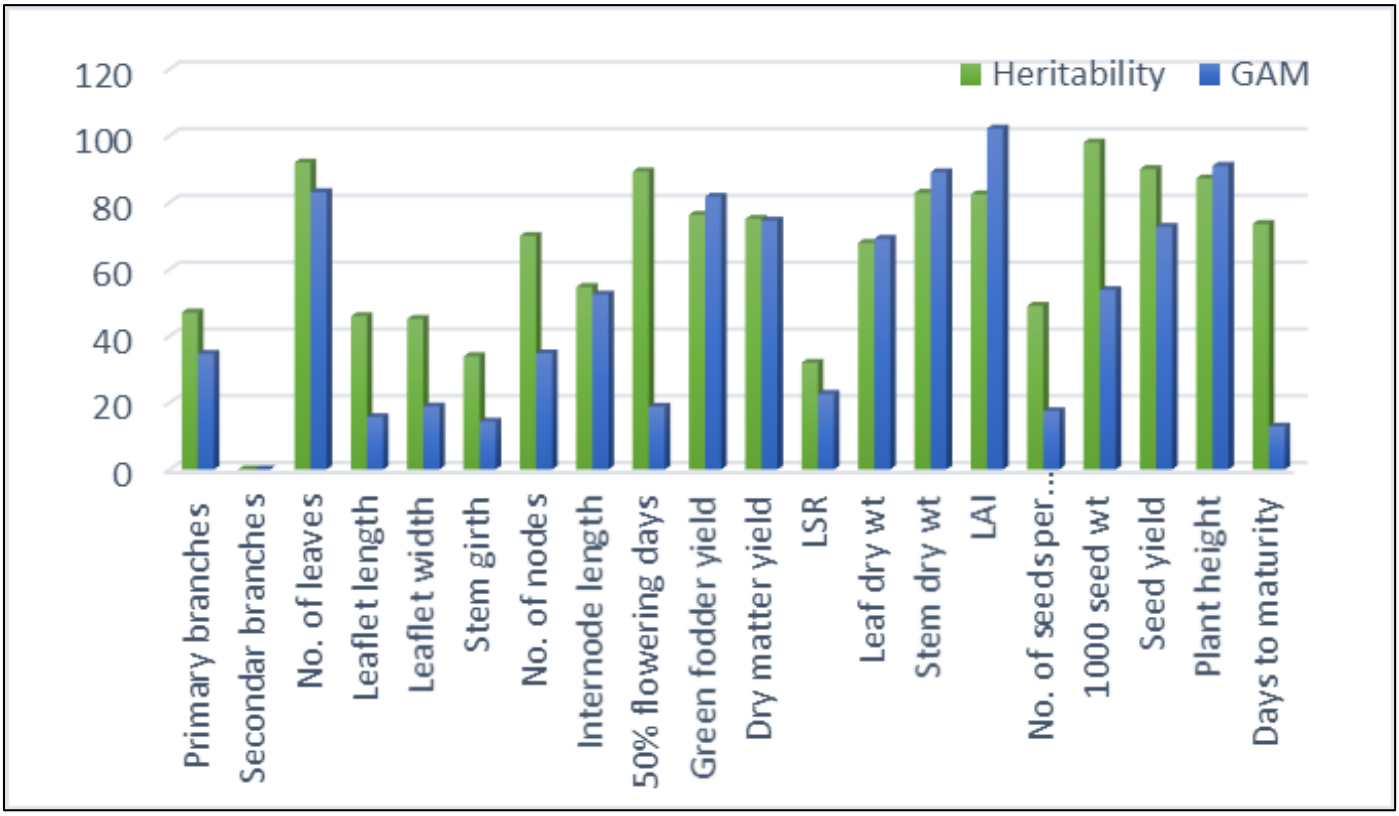

Fig 2: Heritability & Genetic Advance for twenty biometric characters

Table 3: Genetic parameters of twenty quantitative traits in fodder cowpea genotypes

Sl. No.	Traits	Mean±SE	Range		Variance		Coefficient of Variability		h^2 (Broad sense) (%)	GA (%)
			Min	Max	PV	GV	PCV (%)	GCV (%)		
1	Number of primary branches per plant	2.83±0.084	1	5	1.004	0.472	35.70	24.49	47.03	34.64
2	Number of secondary branches per plant	0	0	0	0	0	NA	NA	NA	NA
3	Number of leaves per plant	15.80±0.574	5	35	47.09	43.3	43.80	42.01	91.95	83.09
4	Leaflet length (cm)	10.31±0.143	7.1	15.7	2.91	1.34	16.56	11.22	45.92	15.69
5	Leaflet width (cm)	5.91±0.100	2.1	9.3	1.44	0.65	20.29	13.63	45.12	18.89
6	Stem girth(cm)	3.37±0.058	1	4.9	0.47	0.16	20.48	11.93	33.93	14.34
7	Number of nodes per plant	8.55±0.172	4	16	4.22	2.95	24.09	20.16	69.98	34.79
8	Internode length (cm)	2.58±0.101	0.5	5.4	1.45	0.79	46.45	34.35	54.69	52.40
9	Days to 50% flowering	43.43±0.372	30	56	19.75	17.64	10.21	9.65	89.31	18.82
10	Green fodder yield per plant (g)	98.37±4.252	16	260	2584.8	1971	51.93	45.35	76.26	81.70

Table 4: Genetic parameters of twenty quantitative traits in fodder cowpea genotypes (Contd…)

Sl. No.	Traits	Mean±SE	Range		Variance		Coefficient of Variability		h^2 (Broad sense) (%)	GA (%)
			Min	Max	PV	GV	PCV (%)	GCV (%)		
11	Dry matter yield per plant(g)	15.43±0.618	2.22	36.7	54.55	40.95	48.12	41.70	75.07	74.53
12	Leaf Stem Ratio (LSR)	1.47±0.042	0.29	3.01	0.26	0.08	34.31	19.41	31.99	22.64
13	Leaf dry weight per plant(g)	8.93±0.367	1.6	19.6	19.28	13.09	49.33	40.65	67.90	69.10
14	Stem dry weight per plant(g)	6.50±0.282	1.08	17.02	11.33	9.39	52.09	47.41	82.86	89.04
15	Leaf Area Index	4.63±0.230	0.5	15.53	7.59	6.26	60.04	54.52	82.46	102.13
16	Number of seeds per pod	12.18±0.176	6	17	4.43	2.17	17.30	12.11	49.03	17.50
17	1000 seed weight (g)	124.16±2.76	54	237	1087.4	1065.7	26.59	26.33	98	53.77
18	Seed yield per plant(g)	12.29±0.400	4	29.9	22.87	20.59	39.15	37.15	90	72.73
19	Plant height (cm)	30.13±1.272	13.6	111.6	231.40	201.90	50.55	47.22	87.23	90.97
20	Days to maturity	61.46±0.435	50	77	27.11	19.90	8.46	7.26	73.56	12.84

4. Conclusion

Based on the present investigation, it can be concluded that significant difference was present among 143 fodder cowpea genotypes under study. Characters like number of leaves per plant, green fodder yield per plant, dry matter yield per plant, leaf dry weight per plant, stem dry weight per plant, leaf area index, 1000 seed weight, seed yield per plant and plant height can be taken for reliable improvement study of fodder cowpea

5. Acknowledgments

Author conducted the research work under the guidance of Dr. Gayathri G. Author is thankful to Kerala Agricultural University for providing the funds for the research.

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