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ASSESSMENT OF VARIABILITY AND ASSOCIATION ANALYSIS FOR FORAGE TRAITS IN COWPEA (*VIGNA UNGUICULATA* (L). WALP)

DEVINDER PAL SINGH*, MOHIT JAIN AND MEENAKSHI GOYAL

Department of Plant Breeding and Genetics,
Punjab Agricultural University, Ludhiana (Punjab), India
**(e-mail : devinderpal301@pau.edu)*

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SUMMARY

The present study was conducted with 13 germplasm accessions along with two checks at experimental area of Department of Plant Breeding and Genetics, PunjabAgricultural University, Ludhiana during *Kharif* 2021. The objective of the study was to determine the extent of variability, correlations and path coefficients amongdifferent forage and qualitytraits. The high value of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was observed for Leaf-stem Ratio followed by Stem Girth, Green Fodder Yield and Vine Length. High heritability(> 90%) was estimated for Vine Length, Number of Leaves and Neutral Detergent Fibre, while more than 85% heritability was observed for most of the characters such as green fodder yield, dry matter yield, crude protein, acid detergent fibre, *In-vitro d*ry matter digestibility, leaf length, branches per plant and leaf stem ratio. Higher genetic advance was observed for Leaf-Stem Ratio (79.20%) and Vine Length (52.15%). Traits like Dry Matter Yield (0.96) and Vine Length (0.44) had positive and significant correlation with green fodder yield. Positive and direct effect of Vine Length (0.156), Leaf Length (0.184), Leaf Breadth (0.122), Stem Girth (0.043) and Leaf-Stem Ratio (0.154).The results suggest that traits like Vine Length, Leaf length, Leaf Breadth, Stem girth and Leaf-stem Ratio are the main fodder yield components. So, selection for these traits should be practiced in future breeding programme for improving the green fodder yield in cowpea.

Key words : Cowpea, forage, correlations, path coefficients

Cowpea is a quick growing, single cut nutritious legume cultivated in both *Kharif* and summer season in Northern India, But in peninsular regions, cowpea is grown throughout the year. It is gaining importance in the recent years due to its high food value, good fodder and used as an excellent green manure crop. Cowpea provides excellent quality forage and gives a heavy vegetative growth that covers the ground so well that it checks the soil erosion. (Sahu, 2021).

Among the forage traits, improvement of green fodder yield along with its quality is a major objective for plant breeder, but fodder yield in cowpea is a complex character which depends on the expression of various independent characters, therefore, it is essential to know the association among the various qualitative and quantitative forage traits so as to initiate an effective selection programme aiming at the improvement of forage yield and its quality. For selecting the desired genotypes for future breeding programmes, the assessment of genetic variability for various forage traits is of great importance (Baranda *et al.,* 2018).

Genotypic and Phenotypic coefficients of variability, heritability and genetic advance are considered as very important parameters for the yield improvement (Denton and Nwangburuka, 2011). Heritability of a character is important for a cowpea breeder because it provides an idea of the genetic control for the expression of a particular character (Chopra, 2000). Therefore, the present study was carried out to assess the variability with the help of genetic parameters like the coefficient of variability, heritability, genetic advance and association analysis.

MATERIALS AND METHODS

The present study was conducted during the *Kharif* season of 2021 with 15 genotypes being maintained at Forage, Millet and Nutrition Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana which is situated at 30.56^{o} N latitude, 75.52^{o} E longitude, at an height of 247 m above mean sea level and represents the Indo-Gangetic Alluvial Plains. The average annual rainfall of the area is 705 mm and a greater amount is received

during the monsoon season i.e. from July to September. The weather was favourable during the growth period of the crop. The material was evaluated in randomized block design in single row of two meter with row to row spacing 30 cm along with two checks in three replications. Recommended package of practices was followed to raise a good crop. Observations were recorded on five random plants selected from each entry for thirteen quantitative characters *viz.,* Green Fodder Yield (kg/plot), Dry Matter Yield (kg/plot), Crude Protein (%), Acid Detergent Fibre (%), Neutral Detergent Fibre (%), *In-vitro* Dry Matter Digestibility (%), Vine Length(cm), Number of Leaves, Leaf Length (cm), Leaf Breadth (cm), Branches per Plant, Stem Girth (cm), Leaf Stem Ratio. The data was analyzed for correlation and path coefficient study. Statistical procedure for estimating phenotypic and genotypic coefficient of variation (Burton and De Vane (1953), heritability in-broad sense (Hanson *et al*., 1956), genetic advance (Allard, 1960), correlation (Johnson *et al*., 1955) and path analysis (Dewey and Lu, 1959) were followed in the present study.

TABLE 1
Genetic parameters of different forage and quality characters in cowpea

Traits	h^2 (%)	GA (%)	PCV	GCV	GM	Range	
						Min.	Max.
GFY	90.72	50.47	27.00	25.72	11.56	8	17
DMY	91.50	51.84	27.38	26.09	2.60	1.7	4.1
CP (%)	95.00	16.55	8.45	8.24	14.50	13.1	17.8
ADF (%)	93.33	7.38	3.84	3.71	42.64	39.4	44.8
NDF (%)	96.94	4.71	2.35	2.32	67.25	63.8	69.4
IVDMD (%)	96.41	11.81	5.94	5.83	55.00	50.2	60.8
VL	99.69	52.15	25.39	25.35	155.36	100.5	247.8
NOL	99.56	49.25	24.01	23.96	166.24	100	218
LL	88.66	43.56	23.85	22.45	10.34	6.5	14.8
LB	83.12	30.03	17.53	15.99	7.54	5.5	10.4
B/P	87.06	47.72	26.61	24.99	6.66	3.5	10.5
SG	66.53	47.25	34.47	28.12	1.2	0.7	1.5
LSR	96.44	79.20	39.85	39.13	0.70	0.34	1.4

GFY=Green Fodder Yield/plot; DMY=Dry matter yield/plot; CP (%) =Crude Protein (%); ADF (%) = Acid Detergent Fibre (%); NDF (%) = Neutral Detergent Fibre (%); IVDMD (%) = In vitro dry matter digestibility (%); VL=Vine length/plant; NOL= Number of leaves/plant; LL= Leaf length per plant; LB=Leaf breadth per plant; B/P= Branches per plant; SG= Stem girth; LSR= Leaf Stem ratio.

RESULTS AND DISCUSSION

Green fodder yield is a complex trait and it is affected by many characters. Being a quantitative trait, it is affected by the different environments. So, there is a need to deeply understand the interrelationship between green fodder yield and its contributing traits.

Genetic Variability

The estimates of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits understudy (Table 1), which indicates the influence of environment on the expression of these traits. The highest value of PCV was observed for Leaf-Stem Ratio (39.85) followed by Stem Girth (34.47) and Dry Matter Yield (27.38). The highest value of GCV was observed for Leaf-Stem Ratio (39.13) followed by Stem Girth (28.12) and Dry Matter Yield (26.09). The low GCV was observed for Neutral Detergent Fiber (2.35) followed by Acid Detergent Fiber (3.84) and *In-vitro* Dry Matter Digestibility (5.94). These results were in the accordance to the results obtained by Phogat *et al.* (2018), Khan *et al.* (2015) and Rohila (2020).Above results suggested that due to higher values of PCV and GCV for Leaf-Stem Ratio, Stem Girth and Dry Matter Yield, so selection for these traits will be effective in future for increasing the green fodder yield.

Heritability and Genetic Advance

Perusal from the Table 1 indicates that high heritability was present for the characters such as vine length (99.69%) followed by number of leaves (99.56%) and neutral detergent fibre (96.94%), whereas heritability was higher than 85 % for most of the characters such as green fodder yield, dry matter yield, crude protein, acid detergent fibre, *In-vitro d*ry matter digestibility, leaf length, branches per plant and leaf stem ratio. Similar results were reported by Phogat *et al.* (2017) for leaf-stem ratio, green fodder yield and dry matter yield and branches per plant. The highest genetic advance was observed for leaf-stem ratio (79.20%) whereas moderate genetic advance was recorded for vine length (52.15%), dry matter yield (51.84%), green fodder yield (50.47) and number of leaves (49.25%). The low genetic advance was recorded for neutral detergent fibre (4.71%) and acid detergent fibre (7.38%). Khan *et al.* (2015) also reported similar results in their study for heritability and genetic advance. In the present study, high heritability combined with high genetic advance for

TABLE 2
Genotypic and Phenotypic correlations analysis for Green forage yield and its attributing traits in cowpea

Traits		GFY	DMY	CP	ADF	NDF	IVDMD	VL	NOL	LL	LB	B/P	SG	LSR
GFY	G	1	0.96**	0.07	-0.37*	-0.16	0.00	0.44**	-0.15	0.07	0.12	0.06	0.21	-0.17
	P	1	0.96**	0.06	-0.36*	-0.16	-0.002	0.42**	-0.14	0.06	0.10	0.05	0.17	-0.15
DMY	G		1	0.19	-0.38*	-0.25	0.02	0.39*	-0.02	0.13	0.32*	0.07	0.34*	-0.19
	P		1	0.17	-0.37*	-0.24	0.01	0.36*	-0.01	0.12	0.26	0.06	0.27	-0.17
CP	G			1	-0.64**	-0.71**	0.61**	0.05	0.50**	0.39**	0.40**	0.15	0.71**	-0.18
	P			1	-0.59*	-0.69**	0.59**	0.06	0.49**	0.35*	0.36*	0.16	0.60**	-0.17
ADF	G				1	0.37*	-0.29*	-0.30*	-0.49**	-0.19	-0.15	-0.51**	-0.67**	0.13
	P				1	0.34*	-0.28	-0.29	-0.47**	-0.17	-0.09	-0.13	-0.49**	0.11
NDF	G					1	-0.77**	-0.11	-0.42**	-0.07	-0.33*	-0.05	-0.43**	0.04
	P					1	-0.75**	-0.11	-0.41**	-0.06	-0.29*	-0.49	-0.34*	0.03
IVDMD	G						1	0.11	0.22	0.16	-0.03	0.22**	0.28	-0.14
	P						1	0.11	0.21	0.14	-0.02	0.20	0.14	-0.06
VL	G							1	0.19	-0.05	0.03	0.00	0.17	-0.07
	P							1	0.19	-0.05	0.02	0.20	0.14	-0.06
NOL	G								1	0.40**	0.37**	0.11	0.53**	0.05
	P								1	0.37*	0.33*	0.10	0.42**	0.05
LL	G									1	0.19	0.45**	0.47**	-0.03
	P									1	0.15	0.37**	0.35**	-0.03
LB	G										1	0.10	0.40**	-0.40**
	P										1	0.08	0.33*	-0.35*
B/P	G											1	0.24*	0.44**
	P											1	0.17	0.11
SG	G												1	0.14
	P												1	0.09
LSR	G													1
	P													1

vine length, number of leaves, leaf stem ratio, green fodder yield was observed, which important parameters for improvement in green fodder yield were. So, more focus should be directed towards the improvement of these traits so that green fodder yield can be ultimately increased. From these results, it can be concluded that there is low environmental influence on these traits and genes act additively in the expression of these traits. Moderate or low heritability combined with low genetic advance were recorded for acid detergent fibre and neutral detergent fibre which indicates that this trait is governed by non- additive gene action and there is a greater environmental influence on the expression of such traits.

Genotypic and phenotypic correlation

Green fodder yield is a complex trait affected by the number of other traits which might have positive as well as negative effects on this trait. So, for the improvement of green fodder yield and its components, knowledge of association among different traits, effects and cause of relationship will be helpful for the selection of appropriate breeding method for increasing green fodder yield. Correlation analysis clearly revealed that the magnitude of phenotypic correlation is lower than the genotypic correlation but they showed similar trend indirection. Low phenotypic correlation means that the expression of these traits is influenced by the environment. Correlation coefficient among various traits is presented in the Table 2. Green fodder yield had significantly high and positive correlation with dry matter yield (0.96) and vine length (0.44) which indicates that direct selection for these traits will be helpful for the improvement of green fodder yield in Cowpea. Similar results were obtained by Khan *et al*. (2015). Rohila *et al*. (2020), in sorghum, Moushtaq *et al*. (2013) in oats. It was also noted that traits like Acid Detergent Fibre content has negative correlation with green fodder yield and similar observations reported by Moushtaq *et al*. (2013). Dry matter yield showed positive correlation with vine length, leaf breadth and stem girth; crude protein showed positive correlation with *In-vitro d*ry matter digestibility, number of leaves, leaf length, leaf breadth and stem girth; acid detergent fiber showed positive correlation with neutral detergent fiber, *In-vitro d*ry matter digestibility showed positive correlation with

TABLE 3
Path coefficient analysis for direct (diagonal and bold) and indirect effects on Green fodder yield in cowpea

Traits	DMY	CP	ADF	NDF	IVDMD	VL	NOL	LL	LB	B/P	SG	LSR	GCV with GFY
DMY	**0.844**	-0.059	0.105	-0.032	0.003	0.060	0.006	0.025	0.039	-0.018	0.014	-0.029	0.96**
CP(%)	0.168	**-0.297**	0.180	-090	0.167	0.009	-0.145	0.072	0.049	-0.036	0.030	-0.028	0.07
ADF (%)	-0.319	0.192	**-0.278**	0.046	-0.080	-0.047	0.141	-0.035	-0.018	0.036	-0.029	0.021	-0.37*
NDF (%)	-0.216	0.213	-0.102	**0.126**	-0.211	-0.018	0.122	-0.014	-0.041	-0.012	-0.018	0.006	-0.16
IVDMD (%)	0.0100	-0.183	0.082	-0.097	**0.273**	0.018	-0.063	0.030	-0.004	-0.054	0.012	-0.021	0.00
VL	0.328	-0.017	0.084	-0.014	0.032	**0.156**	-0.057	-0.010	0.003	-0.053	0.007	-0.011	0.44**
NOL	-0.017	-0.150	0.137	-0.053	0.060	0.031	**-0.288**	0.074	0.045	-0.028	0.023	0.009	-0.15
LL	0.114	-0.117	0.053	-0.009	0.044	-0.008	-0.116	**0.184**	0.023	-0.108	0.020	-0.004	0.07
LB	0.275	-0.120	0.041	-0.042	-0.009	0.004	-0.108	0.035	**0.122**	-0.025	0.017	-0.062	0.12
B/P	0.063	-0.045	0.041	0.006	0.062	0.034	-0.034	0.083	0.012	**-0.240**	0.0259	0.047	-0.55**
SG	0.283	-0.212	0.187	-0.055	0.078	0.027	-0.154	0.087	0.049	-0.144	**0.043**	0.021	0.21
LSR	-0.160	0.055	-0.038	0.005	-0.038	-0.011	-0.017	-0.005	-0.049	-0.073	0.006	**0.154**	-0.17

GFY=Green Fodder Yield/plot; DMY=Dry matter yield/plot; CP (%) =Crude Protein (%); ADF (%) = Acid Detergent Fibre (%); NDF (%) = Neutral Detergent Fibre (%); IVDMD (%) = In vitro dry matter digestibility (%); VL=Vine length/plant; NOL= Number of leaves/plant; LL= Leaf length per plant; LB=Leaf breadth per plant; B/P= Branches per plant; SG= Stem girth; LSR= Leaf Stem ratio.

crude protein and branches per plant, ,number of leaves showed positive correlation with leaf length, leaf breadth and stem girth,leaf breadth correlated positively with stem girth and branches per plant. Navaselvak kumaran *et al.,* 2019 also reported similar results. Some other traits such had negative and non-significant correlation among each other. Above results indicates that selection for higher green fodder yield should be focused on vine length, as it would result in higher biomass production in cowpea.

Path coefficient analysis

Correlation coefficient analysis provides knowledge about the relationship among the traits but does not tell about the extent of their relationship. So, path coefficient analysis was carried out to determine the extent of relationship among traits by taking green fodder yield as dependent variable and other traits as independent variable. At genotypic level (Table 3) highest direct effect on green fodder yield was exerted by dry matter yield (0.844) followed by leaf length (0.184),vine length (0.156) followed by leaf-stem ratio (0.154) and leaf breadth (0.122). The results of the present study are similar to the results obtained by Amandeep *et al.* 2021 for traits like leaf length, leaf breadth, number of leaves, acid detergent fibre and crude protein in oats. Indirect positive effects on green fodder yield were revealed by vine length (0.328), followed by stem girth (0.283), leaf breadth (0.275), crude protein (0.168), leaf length (0.114) via dry matter yield (0.844). So, selection criteria for the improvement of green fodder yield will focus on vine length, leaf length, leaf breadth and stem girth in future breeding programme.

CONCLUSION

Selection criteria for vine length, leaf length, leaf breadth and stem girth will be significant for the improvement of green fodder yield in the material under study. At the same time, selection for quality traits such as crude protein and acid detergent fibre will adversely affects the green fodder yield due to their strong negative correlation with green fodder yield.

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