



Studies on Genetic Variability, Character Association and Path Co-efficient Analysis in Cowpea [*Vigna Unguiculata* (L.) Walp]

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ABSTRACT

Genetic variability, heritability, genetic advance, correlation and path coefficient analysis were carried out for forty genotypes of cowpea for 18 yield component and seed quality traits. Heritability in broad sense was high for number of clusters per plant and days to 50 per cent flowering indicate the presence of additive gene effects. Phenotypic and genotypic coefficients of variation were high for the seed yield per plant followed by pods per plant, length of main branch and number of clusters per plant. Positive correlation was found between seed yield and pods per plant, number of clusters per plant, number of seeds per pod, number of primary branches. Path analysis showed high positive direct effects on pods per plant, number of primary branches and number of seeds per pod. Pods per plant, number of clusters per plant, number of seeds per pod and number of primary branches were identified as selection criteria for improving yield and component characters in cowpea breeding programmes.

Key words : Correlation, Cowpea, Path analysis, Seed quality, Variability, Yield.

Cowpea [*Vigna unguiculata* (L.) Walp] is an important grain legume and important minor pulse crop in India. Its quick growth has made cowpea as an essential component of sustainable agriculture in marginal lands and dry regions of the tropics, where rainfall is scanty and soils are sandy with little organic matter. If early maturing varieties are grown as pure crop with required inputs, it has potential of yielding as high as cereals on productivity per day basis. In India, it occupies an area of 3.9 million hectares with production of 2.2 million tonnes and productivity of 564 kg ha⁻¹ (Kurer *et al.*, 2010). It is extensively grown in southern states of Andhra Pradesh, Karnataka and Tamil Nadu. In the context of yield enhancement, in order to have a good choice of character for selection of desirable genotypes under planned breeding programme, knowledge of the nature and magnitude of variation existing in available plant breeding materials, the association of component characters with yield and their exact contribution through direct and indirect effects are very important. Besides yield components, the contribution of seed quality parameters is essential for overall improvement of yield potential.

The basic information on the existence of genetic variability and diversity in a population and

the relationship between different traits is essential for any successful plant breeding program. The information on genetic variability can be of great help in formulating appropriate breeding strategy for genetic up-gradation of cowpea. Genetic studies regarding quantitative characters in cowpea are limited. Hence, the present investigation was undertaken to estimate the genetic variability and to study association of different characters and their direct and indirect effect on grain yield with a view to identify the accessions with best potentiality for upgrading grain yield and its component characters.

MATERIAL AND METHODS:

The experimental material for the present study comprised of 40 genotypes (36 accessions and four check varieties) of cowpea. The experiment was laid out in Randomized Block Design at National Bureau of Plant Genetic Resources (NBPGR) Regional Station, Hyderabad, Andhra Pradesh during kharif 2012 with two replications. It was carried out in one row of five meter length by adopting a spacing of 45 cm × 10 cm. In each genotype, observations were recorded on five randomly selected competitive plants per replication for 15 yield components and three seed quality parameters *viz.*, days to 50 per cent

Table 1. Analysis of variance for quantitative characters in cowpea.

S.No.	Character	Mean sum of squares		
		Replications (d.f=1)	Treatments (d.f=39)	Error (d.f=39)
1.	Days to 50% flowering	0.31	35.90**	0.15
2.	Leaf length(cm)	0.19	1.93**	0.10
3.	Leaf width(cm)	0.08	1.02**	0.11
4.	Plant height(cm)	96.47*	1016.88**	21.63
5.	No. of primary branches	0.02	1.13**	0.18
6.	Length of main branch (cm)	150.97	2394.79**	61.37
7.	No of clusters per plant	0.88*	67.89**	0.19
8.	Peduncle length(cm)	11.40	71.52**	3.18
9.	Pod length(cm)	0.15	15.09**	0.43
10.	Pods per plant	72.39*	133.53**	15.80
11.	Days to 80% flowering	5.00	24.04**	1.71
12.	No. of seeds per pod	0.71	13.54**	0.26
13.	Seed yield per plant(g)	150.70	1867.46**	39.88
14.	100 seed weight (g)	0.02	10.50**	0.04
15.	Germination (%)	1.25	180.59**	13.19
16.	Seedling vigour index-I	199500.30	352970.00**	57472.57
17.	Seedling vigour index-II	60610.05	1081688.00**	82047.18
18.	Protein content (%)	0.20	80.76**	1.30

** Significant at 1 per cent level

*Significant at 5 per cent level

flowering, leaf length (cm), leaf width (cm), days to maturity, plant height (cm), number of primary branches per plant, length of main branch (cm), number of clusters per plant, peduncle length (cm), pod length (cm), number of pods per plant, days to 80 per cent flowering, number of seeds per pod, 100-seed weight (g), seed yield per plant (g), protein content (%), germination (%), seedling vigour index-I and seedling vigour index-II.

Analysis of variance was carried out with the mean data of each character. The components of variance were used to estimate genetic parameters like genotypic and phenotypic coefficients of variation (PCV and GCV) as given by Falconer (1981) and heritability (h^2) in the broad sense as given by Allard (1960).

Path coefficient analysis was also carried out at phenotypic as well as genotypic levels as described by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance for 40 genotypes of cowpea for eighteen quantitative traits are presented in Table 1. The analysis of variance showed that the mean sum of squares for the genotypes were highly significant for all traits measured. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were highest for seed yield per plant (59.31 and 58.06) followed by pods per plant (48.02 and 42.63), length of main branch (44.56 and 43.44), number of clusters per plant (40.68 and 40.56), 100-seed weight (32.50 and 29.89), plant height (32.10 and 31.42), protein content (28.04 and 27.59), peduncle length (25.58 and 24.46) and seedling vigour index-II (21.86 and 20.26). Moderate PCV and GCV were recorded for seedling vigour index-I (20.48 and 17.38), number of primary branches (19.69 and 16.46), pod length (19.04 and 18.51), number of

Table 2. Genetic parameters for quantitative traits among cowpea genotypes.

S.No	Trait	Mean	Range		Std. Error (\pm)	PCV (%)	GCV (%)	h^2 (b) (%)	GA (%)	GAM (%)
			Min.	Max.						
1	Days to 50% flowering	45.83	42.00	46.00	0.28	9.26	9.22	99.10	8.67	18.91
2	Leaf length(cm)	9.68	7.65	11.55	0.23	10.41	9.87	89.90	1.86	19.28
3	Leaf width(cm)	7.20	4.85	8.65	0.23	10.47	9.40	80.60	1.25	17.38
4	Plant height(cm)	70.88	33.50	136.15	3.14	32.10	31.42	95.80	44.98	63.37
5	No. of primary branches	4.13	2.20	5.30	0.30	19.69	16.46	71.50	1.19	28.98
6	Length of main branch(cm)	78.66	22.70	209.15	5.53	44.56	43.44	95.00	68.58	87.22
7	No. of clusters per plant	14.34	4.50	27.50	0.32	40.68	40.56	99.40	11.95	83.33
8	Peduncle length(cm)	23.89	4.70	38.50	1.25	25.58	24.46	91.50	11.51	48.20
9	Pod length(cm)	14.68	9.70	24.35	0.45	19.04	18.51	94.50	5.42	37.06
10	Pods per plant	17.52	4.20	35.75	3.84	48.02	42.63	78.80	14.03	77.98
11	Days to 80% flowering	62.95	57.00	74.50	0.80	5.71	5.31	86.70	6.40	10.19
12	No. of seeds per pod	14.88	9.85	19.50	0.36	17.66	17.31	96.10	5.20	34.97
13	Seed yield per plant(g)	52.06	6.53	118.00	4.46	59.31	58.06	95.80	60.95	117.07
14	100 seed weight (g)	8.77	4.30	15.20	0.15	32.50	29.89	07.10	1.63	16.35
15	Germination (%)	81.00	53.00	95.00	2.59	12.11	11.26	86.40	17.51	21.55
16	Seedling vigour index-I	2211	1351	3098	74.15	20.48	17.38	72.00	671.86	30.38
17	Seedling vigour index-II	3489	2173	4897	202.54	21.86	20.26	85.90	1349.79	38.68
18	Protein content (%)	22.84	10.76	33.70	0.80	28.04	27.59	96.80	12.77	55.93

PCV: Phenotypic Coefficient of Variation GCV: Genotypic Coefficient of Variation

 h^2 (b): Heritability in broad sense

GA: Genetic Advance

GAM: Genetic Advance as per cent of mean

Table 3. Phenotypic correlation coefficient among seventeen yield and yield related attributes in 40 genotypes of cowpea.

Character	Days to 50% flowering (cm)	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	No. of primary branches	Length of main branch (cm)	No of clusters per plant	Peduncle length (cm)	Pod length (cm)	Pods per plant	Days to 80% flowering	No. of seeds per pod	100 seed weight (g)	Germination (%)	SVI- I	SVI- II	Protein (%)	Seed yield (g)
Days to 50% flowering	1.0000	0.0841	0.3414**	0.6300**	0.0040	0.7428**	-0.0422	0.0496	0.2329*	-0.0967	0.8206**	0.0943	-0.0479	-0.0575	-0.1462	-0.1102	-0.2924**	-0.1019
Leaf length (cm)	1.0000	1.0000	0.5665**	0.3061**	0.0758	0.1760	0.2382*	0.1029	0.5170**	0.3384**	0.0727	0.1750	-0.0166	0.0029	0.0786	0.1945	0.0988	0.3737**
Leaf width (cm)	1.0000	1.0000	1.0000	0.4480**	0.0423	0.3889**	0.2156	0.1027	0.3876**	0.1350	0.3973	0.2734*	0.0089	0.1043	0.0603	0.2880**	-0.1912	0.2641*
Plant height (cm)	1.0000	1.0000	1.0000	1.0000	0.1115	0.8227**	0.1055	0.2815*	0.2550*	0.1290	0.5957**	0.3593**	0.0110	0.0870	0.0731	0.1860	-0.1454	0.2220**
No. of primary branches	1.0000	1.0000	1.0000	1.0000	1.0000	0.1158	0.5196**	0.5364**	0.0242	0.4669**	0.0499	0.3942**	-0.0208	0.2236*	0.1143	0.0882	0.0959	0.6068**
Length of main branch (cm)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0667	0.1760	0.2889**	0.0348	0.6873**	0.2930**	0.0070	-0.1701	-0.1901	-0.0507	-0.1212	0.0884
No of clusters per plant	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.4300**	0.4367**	0.7085**	-0.0034	0.5118**	-0.1074	0.0832	0.0219	0.0807	0.3347**	0.6358**
Peduncle length (cm)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-0.0174	0.5065**	0.1659	0.5714**	-0.0313	0.1186	-0.0316	0.0945	-0.0092	0.5638**
Pod length (cm)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1294	1.0000	0.1294	0.1846	0.2457*	0.0098	-0.2094	-0.2240*	0.0938	0.1174	0.1683
Pods per plant	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-0.0422	0.5304**	-0.1146	0.0651	0.0871	0.0566	0.2555*	0.7357**
Days to 80% flowering	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1492	-0.2002	-0.0410	-0.1726	-0.0898	-0.4019**	-0.0772
No. of seeds per pod	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-0.1432	0.0712	0.0391	0.0249	-0.0369	0.6168**
100 seed weight (g)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-0.0147	-0.0310	0.1799	0.0555	-0.0201
Germination (%)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SVI- I	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SVI- II	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Protein (%)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Seed yield (g)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

* Significant at 5% level, ** Significant at 1% level.

Table 4. Direct and indirect effects of component characters on seed yield in 40 genotypes of cowpea

Character	Days to 50% flowering	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	No. of primary branches	Length of main branch (cm)	No of clusters per plant	Peduncle length (cm)	Pod length (cm)	Pods per plant	Days to 80% flowering	No. of seeds per pod	100 seed weight (g)	Germination (%)	SVI- I	SVI- II	Protein Correlation values for Seed yield (g/plant)	
Days to 50% flowering	0.0367	0.0146	0.0198	0.0747	0.0011	-0.0489	-0.0058	0.0010	-0.0328	-0.0290	-0.1673	0.0252	-0.0003	0.0034	0.0129	-0.0189	0.0119	-0.1019
Leaf length (cm)	0.0031	0.1738	0.0329	0.0363	0.0215	-0.0116	0.0330	0.0020	-0.0729	0.1016	-0.0148	0.0467	-0.0001	-0.0002	-0.0069	0.0333	-0.004	0.3737**
Leaf width (cm)	0.0125	0.0984	0.0580	0.0531	0.0120	-0.0256	0.0299	0.0020	-0.0546	0.0405	-0.0810	0.0730	0.0000	-0.0061	-0.0053	0.0494	0.0078	0.2641*
Plant height(cm)	0.0231	0.0532	0.0260	0.1186	0.0316	-0.0541	0.0146	0.0055	-0.0359	0.0387	-0.1215	0.0960	0.0001	-0.0051	-0.0064	0.0319	0.0059	0.2220*
No. of primary branches	0.0001	0.0132	0.0025	0.0132	0.2832	-0.0076	0.0719	0.0104	-0.0034	0.1402	-0.0102	0.1053	-0.0001	-0.0131	-0.0101	0.0151	-0.0039	0.6068**
Length of main branch (cm)	0.0272	0.0306	0.0226	0.0976	0.0328	-0.0658	0.0092	0.0034	-0.0407	0.0104	-0.1401	0.0783	0.0000	0.0099	0.0167	-0.0087	0.0049	0.0884
No of clusters per plant	-0.0015	0.0414	0.0125	0.0125	0.1471	-0.0044	0.1384	0.0083	-0.0615	0.2127	0.0007	0.1367	-0.0006	-0.0049	-0.0019	0.0138	-0.0136	0.6358**
Peduncle length (cm)	0.0018	0.0179	0.0060	0.0334	0.1519	-0.0116	0.0595	0.0194	0.0025	0.1521	-0.0338	0.1526	-0.0002	-0.0069	0.0028	0.0162	0.0004	0.5638**
Pod length (cm)	0.0085	0.0899	0.0225	0.0302	0.0069	-0.0190	0.0605	-0.0003	-0.1409	0.0388	-0.0376	0.0656	0.0001	0.0122	0.0197	0.0161	-0.0048	0.1683
Pods per plant	-0.0035	0.0588	0.0078	0.0153	0.1322	-0.0023	0.0981	0.0098	-0.0182	0.3002	0.0086	0.1417	-0.0006	-0.0038	-0.0077	0.0097	-0.0104	0.7357**
Days to 80% flowering	0.0301	0.0126	0.0231	0.0706	0.0141	-0.0452	-0.0005	0.0032	-0.0260	-0.0127	-0.2039	0.0399	-0.0011	0.0024	0.0152	-0.0154	0.0163	-0.0772
No. of seeds per pod	0.0035	0.0304	0.0159	0.0426	0.1116	-0.0193	0.0708	0.0111	-0.0346	0.1592	-0.0304	0.2671	-0.0008	-0.0042	-0.0034	-0.0043	0.0015	0.6168**
100 seed weight (g)	-0.0018	0.0029	0.0005	0.0013	-0.0059	-0.0005	-0.0149	-0.0006	-0.0014	-0.0344	0.0408	-0.0382	0.0056	0.0009	0.0027	0.0308	-0.0023	-0.0201
Germination (%)	-0.0021	0.0005	0.0061	0.0103	0.0633	0.0112	0.0115	0.0023	0.0295	0.0195	0.0084	0.0190	-0.0001	-0.0584	-0.0714	0.0908	-0.0052	0.1352
SVI- I	-0.0054	0.0137	0.0035	0.0087	0.0324	0.0125	0.0030	-0.0006	0.0316	0.0262	0.0352	0.0104	-0.0002	-0.0474	-0.0879	0.0794	-0.0080	0.1070
SVI- II	-0.0040	0.0338	0.0167	0.0221	0.0250	0.0033	0.0112	0.0018	-0.0132	0.0170	0.0183	-0.0066	0.0010	-0.0309	-0.0407	0.1715	-0.0043	0.2218*
Protein (%)	-0.0107	0.0172	-0.0111	-0.0172	0.0271	0.0080	0.0463	-0.0002	-0.0165	0.0767	0.0819	-0.0098	0.0003	-0.0752	-0.0174	0.0179	-0.0407	0.1444

* Significant at 5% level*** Significant at 1% level Residual effect = 0.49; Diagonal values are direct effects; above and below are diagonal are indirect effects

seeds per pod (17.66 and 17.31) and germination (12.11 and 11.26). Low PCV and GCV were recorded for the rest of characters.

Heritability in broad sense was high (Table 2) for number of clusters per plant (99.40 %), days to 50 per cent flowering (99.10), protein content (96.80 %), number of seeds per pod (96.10 %), plant height (95.80 %) and seed yield per plant (95.80 %).

The estimates of phenotypic and genotypic coefficient of variation, heritability and genetic advance as per cent of mean were high for plant height, length of main branch, number of clusters per plant, peduncle length, pods per plant, seed yield per plant, seedling vigour index and protein content indicate the existence of high degree of variability and additive gene action in the material under study, offering ample scope for selection.

The minimum magnitudinal differences in PCV and GCV for all the traits studied implied that the traits are mostly governed by genetic factors with little role of environment in the phenotypic expression of these characters. Thus, selection of these traits on the basis of the phenotypic value may be effective. Similar results were earlier reported for heritability in cowpea by Kumar *et al.*, 2009, Sangwan *et al.* 2005, Siddique and Gupta 1991, Tyagi *et al.*, 2000 and Thiyagarajan, 1990.

Simple correlation coefficients were worked out for eighteen characters in forty cowpea genotypes among seed yield and its components and the results are presented in Table 3. Significantly positive correlations were found between seed yield and pods per plant (0.7357**), number of clusters per plant (0.6358**), number of seeds per pod (0.6168**), number of primary branches (0.6068**). Seed yield was negatively correlated with days to 50 per cent flowering (-0.1019), days to 80 per cent flowering (-0.0772) and 100-seed weight (-0.0201). The positive association between seed yield and yield attribute is also in accord with an earlier study on character association in cowpea by Uguru, 1996.

The estimates of direct and indirect contributions with yield were presented in Table 4. The path analysis showed the highest positive direct of pods per plant (0.3002), number of primary branches (0.2832), and number of seeds per pod

(0.2671). Length of main branch (-0.6058), pod length (-0.1409), days to 80 per cent flowering (-0.2039), germination (-0.0584), seedling vigour index-I (-0.0879) and protein content (-0.0407) showed the negative direct effect on seed yield per plant.

The high direct effects of number of pods per plant, number of primary branches, number of seeds per pod on seed yield in this study suggests that these traits are good yield enhancing indices. However, the indirect effects of these traits on seed yield via length of main branch, pod length, days to 80 per cent flowering, germination, seedling vigour index-I and protein content were negative. According to Izge *et al.*, 2006, higher indirect values could most likely be neutralized in most cases by negative indirect effects via other characters and this can lead to their low and non-significant genotypic correlations with total yield. In this regard, selection for such characters may not enhance yield improvement.

Substantial genetic variability, heritability with genetic advance as per cent of mean was recorded for important yield components to warrant selection in the cowpea accessions for improvement. The level of genetic variability observed for different traits would be useful for breeding varieties of cowpea for high yield. As high genetic variance and heritability estimates coupled with significantly positive correlations and high direct effects of number of pods per plant, number of primary branches, number of seeds per pod on seed yield were recorded for these traits could be listed in selection criteria for cowpea breeding programme.

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