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Correlation and path analysis studies in F_2 generation of cowpea (*Vigna unguiculata* subsp. *unguiculata*)

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Abstract
An experiment was conducted with twenty three F_2 generation genotypes in randomized block design with three replication in *rabi* season of 2017-18 at Research and Education farm, Department of Agriculture Botany, College of Agriculture, Dapoli. The correlation study revealed that the characters viz., days to first flowering, days to maturity, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, hundred seed weight and harvest index showed highly significant positive correlation with seed yield per plant at phenotypic and genotypic level. The path coefficient analysis revealed that the characters viz., days to first flowering, days to maturity, number of clusters per plant, number of pods per plant, 100 seed weight and harvest index exhibited positive direct effect on seed yield per plant.

Keywords: Grain cowpea, correlation, path analysis

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] is an annual, autogamous leguminous crop belonging to family Leguminoseae with a diploid chromosome number of 2n=2x=22. It is native to India (Vavilov, 1949) [20] but tropical and central Africa is also considered as secondary centre of origin where wild races are found even now (Ng and Marechal, 1985) [12]. Cowpea is cultivated around the world not only as a pulse but also vegetable crop. It has many common names including Black-eyed pea, Southernpea and Lobia. Cultivated cowpea varieties are adapted to hot and dry condition. Cowpea is tropical grain legume which plays an important nutritional role in developing countries of the tropics and sub tropics, especially in Sub-Saharan Africa, Asia, Central and South America (Singh *et al*., 1997) [16]. Cowpea has been referred to as "Poor man's meat" because of its high protein content (20-25%). Cowpea young leaves, pods and beans contain vitamins and minerals which have fuelled its usage for human consumption and animal feeding (Nielson *et al*., 1997) and considered as one of agriculture's oldest legume used as protein source for humans and livestock (Steele, 1972) [17].
Yield is a complex character influenced by various components towards yield. Correlation and path coefficient analysis are the important biometrical techniques to determine the yield components. The characters that are positively correlated with yield are of considerably important to plant breeder for selection purpose. Although the correlation coefficient indicates the nature of association among the different traits, path analysis splits the correlation coefficients into measure of direct and indirect effects, thus provides understanding of the direct and indirect contribution of each characters towards yield. With this view, a study was made to understand the nature of correlations among yield and yield components in 23 F_2 generation genotypes of cowpea (*Vigna unguiculata* ssp. *unguiculata).*

Materials & Methods
The experiment was conducted in Randomized Block Design with 23 F_2 generation genotypes with three replications during *rabi* 2017-2018. The seed was dibbled at 30 cm distance between row to row and 20cm distance between plant to plant. Each plot had 1.8 m x 1m area with three rows for each population. Each row contain 10 plants thus there were 30 plants per population, constitute 90 plants per cross in three replications. All the recommended package of practices and plant protection measures were followed timely to raise a good crop. Observations were recorded on twelve characters *viz.*, days to first flowering, days to maturity, number of primary branches per plant, plant height (cm), number of clusters per plant, number of pods per plant, number of pods per cluster, pod length (cm), number of seeds per pod, 100 seed weight, harvest index and seed yield per plant.

The data were subjected to correlation coefficient (Burton and Devane, 1953) [4] and path analysis (Dewey and Lu, 1959) [6].

Results & Discussion

The correlation co-efficient and path analysis for seed yield per plant and its contributing characters for 23 F_2 generation genotypes at phenotypic and genotypic level are presented in Table 1, 2, 3 and 4 respectively.

Correlation

The character seed yield per plant had positive significant correlation with harvest index, number of clusters per plant, number of pods per cluster and number of pods per plant at both genotypic and phenotypic level. These results were in agreement with Ajibade and Morakinyo (2000) [1], Kumari *et al.* (2010) and Nair *et al.* (2017) [10] in case of number of pods per plant and Surpura and Sharma (2017) [19] for harvest index. Number of primary branches per plant showed positive and highly significant correlation with number of clusters per plant, number of pods per cluster, number of pods per plant and harvest index at both genotypic and phenotypic level. Similar findings were recorded by Surpura and Sharma (2017) [19] for number of pods per plant and harvest index in cowpea. The character number of clusters per plant exhibited positive significant correlation with number of pods per plant and harvest index. Sugunthi and Murugan (2008) observed positive highly significant correlation of number of cluster per plant with number of pods per plant. While it showed non-significant negative relation with number of seeds per pod at both genotypic and phenotypic level. Bhagawati *et al.* (2017) also reported negative non-significant correlation of number of clusters per plant with number seeds per pod in cowpea but only at genotypic level.

Number of pods per cluster showed positive significant correlation with seed yield per plant, number of pods per plant and harvest index. Similar results were recorded by Sugunthi and Murugan (2008) and Nair *et al.* (2017) [10] in cowpea. As the number of pods in cluster increases, automatically number of pods in a plant increases thus yield also, while it was negatively and non-significantly correlated with number of seeds per pod.

Table 1: Estimates of phenotypic correlation coefficient between different characters studied in F_2 generation of cowpea.

Character	Days to first flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Hundred seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to first flowering	1.0000	0.5072**	0.0328	0.2575*	0.4197**	0.3883**	0.5132**	-0.0008	-0.3338**	0.2104	0.4133**	0.4795**
Days to maturity		1.0000	0.3214**	0.2945*	0.3593**	0.3122**	0.4670**	0.0200	-0.2629*	0.2045	0.4100**	0.4266**
Plant height (cm)			1.0000	0.6543**	0.3534**	0.2768*	0.3069*	0.3533**	0.1088	0.0771	0.2170	0.1887
Number of primary branches per plant				1.0000	0.6634**	0.5004**	0.5765**	0.4923**	0.0635	0.2819*	0.5180**	0.4719**
Number of clusters per plant					1.0000	0.5995**	0.8857**	0.5824**	-0.1091	0.5238**	0.7510**	0.8241**
Number of pods per cluster						1.0000	0.6236**	0.2668*	-0.0371	0.3568**	0.4746**	0.5517**
Number of pods per plant							1.0000	0.4519**	-0.2794*	0.5552**	0.7971**	0.8676**
Pod length (cm)								1.0000	0.3806**	0.4790**	0.5415**	0.5119**
Number of seeds per pod									1.0000	0.3228**	0.0415	0.0331
Hundred seed weight (g)										1.0000	0.8003**	0.7624**
Harvest index (%)											1.0000	0.8740**

*Significant at 5 per cent level; ** Significant at 1 per cent level

Table 2: Estimates of genotypic correlation coefficient between different characters studied in F_2 generation of cowpea.

Character	Days to first flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Hundred seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to first flowering	1.0000	1.0845**	0.1736	0.4178**	0.7460**	0.7968**	0.9754**	0.1045	-0.6615**	0.3395**	0.8299**	0.8818**
Days to maturity		1.0000	0.4667**	0.6030**	0.5809**	0.8898**	0.8175**	0.0254	-0.4845**	0.3892**	0.6529**	0.6263**
Plant height (cm)			1.0000	0.7258**	0.4005**	0.4239**	0.3315**	0.4672**	0.1012	0.0920	0.2321	0.1970
Number of primary branches per plant				1.0000	0.7490**	0.6702**	0.6167**	0.6649**	0.0574	0.2950*	0.6084**	0.4991**
Number of clusters per plant					1.0000	0.9942**	0.9356**	0.7265**	-0.1387	0.5478**	0.8533**	0.8704**
Number of pods per cluster						1.0000	0.9695**	0.7648**	-0.0950	0.5752**	0.8453**	0.8529**

Number of pods per plant							1.0000	0.5304**	-0.2962*	0.5717**	0.8776**	0.9090**
Pod length (cm)								1.0000	0.4492**	0.6124**	0.7191**	0.6121**
Number of seeds per pod									1.0000	0.3548**	0.0402	0.0250
Hundred seed weight (g)										1.0000	0.8850**	0.7960**
Harvest index (%)											1.0000	0.9572**

*Significant at 5 per cent level; ** Significant at 1 per cent level

Table 3: Path analysis for different characters at phenotypic level in F_2 generation of cowpea.

Character	Days to first flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Hundred seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to first flowering	0.0788	0.0505	-0.0026	0.0115	0.0831	0.0706	0.0648	-0.0001	-0.0263	0.0766	0.0726	0.4795**
Days to maturity	0.0632	0.0654	0.0610	0.0592	0.0835	0.0204	0.0305	0.0263	-0.0172	-0.0134	0.0476	0.4266**
Plant height (cm)	-0.0021	0.0633	-0.0650	0.0426	0.0530	-0.0180	0.0600	0.0230	-0.0071	-0.0050	0.0441	0.1887
Number of primary branches per plant	0.0871	-0.0311	0.0690	-0.1054	0.1300	0.0814	0.0608	0.0519	-0.0067	-0.0297	0.1046	0.4719**
Number of clusters per plant	-0.0946	0.1010	0.0997	0.1496	0.2255	0.1352	-0.1997	0.1313	-0.0246	0.1314	0.1693	0.8241**
Number of pods per cluster	-0.0096	-0.0077	-0.0069	0.1124	0.1149	-0.0248	0.1155	0.0263	0.0209	0.0989	0.1118	0.5517**
Number of pods per plant	0.2793	0.2542	-0.1670	0.3137	0.4820	-0.3394	0.5442	0.2459	-0.1521	0.3021	0.4338	0.8676**
Pod length	0.0000	-0.0009	0.0983	-0.0210	-0.0248	-0.0114	-0.0192	-0.0426	0.3162	0.2204	-0.0231	0.5119**
Number of seeds per pod	-0.0739	-0.0582	0.0241	0.0141	-0.0893	-0.1082	-0.0619	0.0843	0.2214	0.0715	0.0092	0.0331
Hundred seed weight (g)	0.1351	0.1341	0.1129	-0.0470	0.0874	-0.0595	-0.0926	0.0799	0.1118	0.1668	0.1335	0.7624**
Harvest index (%)	-0.0713	0.1078	-0.0374	0.1293	0.1295	0.0818	0.1375	0.0934	-0.0071	0.1380	0.1725	0.8740**

(Residual value = 0.2978)

Table 4: Path analysis for different characters at genotypic level in F_2 generation of cowpea.

Character	Days to first flowering	Days to maturity	Plant height (cm)	Number of primary branches	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Hundred seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to first flowering	0.4476	0.0854	-0.0777	0.1870	0.1492	0.1366	0.0468	-0.2961	-0.1520	0.2476	0.1074	0.8818**
Days to maturity	0.0411	0.0379	0.0177	0.0229	0.0220	0.0310	0.1038	0.0684	-0.0148	-0.0411	0.3374	0.6263**
Plant Height (cm)	-0.0169	0.0456	-0.0976	0.0709	0.0391	-0.0624	0.0456	0.0099	-0.0400	-0.0169	.2197	0.1970
Number of primary branches	0.0462	-0.0091	0.0803	-0.1106	0.1328	0.0682	0.1735	0.1063	-0.0326	-0.0462	0.0903	0.4991**
Number of clusters per plant	-0.0453	0.0119	0.0082	0.0154	0.0205	0.0192	-0.0149	0.0028	-0.0644	0.0153	0.9017	0.8704**
Number of pods per cluster	-0.0274	-0.2801	-0.0192	0.0658	0.1650	-0.5659	0.2306	0.3076	0.0952	0.5274	0.3539	0.8529**
Number of pods per plant	0.0306	0.0074	-0.0868	0.1946	0.2127	-0.1053	0.2927	0.1315	-0.1664	0.0306	0.3674	0.9090**
Pod length (cm)	-0.2072	0.1517	0.0317	-0.0780	-0.0712	-0.1428	0.1407	-0.3132	0.1111	0.2072	0.7821	0.6121**
Number of seeds per pod	-0.0464	-0.0532	0.0526	0.0876	-0.0748	-0.0781	-0.0837	0.1985	-0.1366	0.0464	0.1127	0.0250
Hundred seed weight (g)	0.0476	0.0854	0.0777	-0.1870	0.1339	-0.4366	-0.0468	0.1961	0.1008	0.4476	0.3773	0.7960**
Harvest index (%)	-0.0314	0.1100	-0.0401	0.0759	0.0856	-0.1671	-0.0422	0.6735	-0.0936	0.0595	0.3271	0.9572**

(Residual value = 0.2583)

Path Analysis

Path co-efficient analysis further provide an insight into the inter relationship of various characters with yield.

The characters number of clusters per plant and number of pods per plant had positive direct effect on seed yield per plant at genotypic and phenotypic level. This was in conformation with reports of Kumari *et al.* (2010), Shanko *et al.* (2014) [15], Lal *et al.* (2014) [8], Lokesh and Niranjana (2018) [9] and Das *et al.* (2018) [5]. Harvest index had high positive direct effect on seed yield per plant at both genotypic and phenotypic level. This result was similar with the observation of Sharma *et al.* (2016) [14] at both genotypic and phenotypic level for seed yield per plant. Hundred seed weight had positive direct effect on seed yield per plant at the genotypic and phenotypic level. It showed negative indirect effect on seed yield through number of pods per plant, number of pods per cluster and number of primary branches per plant. Anamika and Tajane (2014) [11] and Dinesh *et al.* (2017) [7] reported high positive direct effect of hundred seed weight on seed yield per plant and Almeida *et al.* (2014) [2] also confirmed negative indirect effect of hundred seed weight through number of pods per plant.

Conclusion

On the basis of correlation and path analysis for seed yield per plant simultaneous selection on the basis of number of pods per plant, number of clusters per plant, hundred seed weight could help in genetic improvement in cowpea.

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