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Correlation and path analysis study in F_3 generation of cowpea [*Vigna unguiculata* (L.) Walp.] genotypes

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Abstract
The present experiment entitled "Genetic variability and character association studies in F_3 generation of cowpea. (*Vigna unguiculata* (L.) Walp.)" was carried out for assessing the genetic variability, correlation and path analysis in F_3 population of forty five crosses of cowpea in Randomized Block Design with two replications. The character seed yield per plant had positive and highly significant correlation with number of pods per plant (0.8906), harvest index (0.8758), 100 seed weight (0.7123) and pod length (0.3114) at phenotypic level. Similarly at phenotypic level it showed negative nonsignificant correlation with days to 50% flowering (-0.0159) while, days to maturity (-0.3005) had negative significant correlation. Positive and highly significant correlation was reported between seed yield per plant and number of pods per plant (1.0080) followed by harvest index (0.8652), 100 seed weight (0.7685) at genotypic level. Genotypically negative highly significant correlation was reported with days to maturity (-0.4294) and negative nonsignificant correlation with days to 50% flowering (-0.0413).
Path coefficient analysis revealed positive direct effect of number of pods per plant, days to initiation of flowering and hundred seed weight at both genotypic and phenotypic level. Whereas, characters *viz*., days to maturity, number of clusters per plant, number of pods per cluster and plant height at genotypic level and characters *viz*., number of branches per plant and pod length at phenotypic level were having direct positive effect on seed yield per plant.

Keywords: Cowpea, PCV, GCV, correlation and path analysis, *Vigna unguiculata*

Introduction
Cowpea (*Vigna unguiculata* (L.). Walp) is an important leguminous crop mainly grown both in kharif and spring summer season crop in most parts of India. It is a self pollinated crop with a chromosome no. 2n=2x= 22. Cowpea belongs to the family Leguminaseae genus *vigna*, subfamily fabaceae and tribe phaseoleae it comprises five subspecies (Verdcourt, 1970) [25] *viz., unguiculata, cylindrical, sesquipedalis, dekindtiana* and *mensensis* in phaseolae. Out of these five subspecies first three are cultivated and next two are wild species. Its primary centre of origin is in Africa (Pasquet and Baudoin, 2001) [28], but Vavilov (1949) [23] recognized India and Africa as the primary centre of origin and China as secondary centre of Origin. The total area of beans in India is 37.54 million hectares with production of 1370.21 million tonnes (Anon., 2014) [1]. For carrying out genetic improvement programme in any crop it is must that one should conduct genetic variability study in respective crop for determining extent of variability present in crop species. Selection from quantitative characters is less efficient, if it is based on phenotypic expression, therefore, it is necessary to assess the relative extent of genetic and non genetic variability exhibited by individual characters. The correlation co-efficient gives us an idea of the nature as well as intensity of association between two or more quantitative characters between yield and yield contributing characters, correlation measures mutual relationship between yield and yield contributing characters. Thus, correlation helps in the selecting superior genotype from diverse genetic populations. Path analysis measures direct influence of one characters on other as well as permits the partitioning of given correlation coefficients into its components of direct and indirect effects. The path analysis provides information about magnitude and direction of direct and indirect effect of the yield components, which cannot provide by correlation.

Materials and Methods
The present investigation entitled "Genetic variability and character association studies in F_3 generation in cowpea (*Vigna unguiculata* (L.) Walp)" was accomplished in *Rabi*, 2018-2019 in randomized block design. The experimental material comprises of fourty-five genotypes of F_3 generation of cowpea obtained from Department of Agricultural Botany, College of

Agriculture, Dapoli. The total 24 crosses were made by using L x T mating design with 8 lines and 3 testers and the F_1 were evaluated during *Rabi* 2016–2017 along with parents (by Dr. U. B. Pethe). Out of 24 crosses, 21 were selected as F_2 population and evaluated during Rabi 2017-18 along with parents (by Tate. P. T. M. Sc. Student). Seeds from 45 individual plants performing superior over others selected from F_3 families were sown in Randomized Block Design with 2 replications. The seeds were dibbled at 20 cm distance between row to row and 15 cm distance between plant to plant. Each plot had 0.80 m x 2.1 m area with 4 rows for each population. Each row contain 15 plants thus there were 60 plants per F_3 population, constitute 120 plants per cross in two replications. The plot was selected on the basis of suitability of the land for cultivation of cowpea.

Source of plant materials

The material for the present study comprised of F_3 population of forty five crosses of cowpea obtained from Department of Agricultural Botany, College of Agriculture, Dapoli. The crosses were made by using L x T mating design with 8 lines and 3 testers and the F_1 population was evaluated during *Rabi* 2016 – 2017, along with parents (Pethe. U. B. 2016-17), Out of 24 promising crossed families, 21 families were sown as F_2 population in Randomized Block Design with 3 replications, during *Rabi* 2017-18 along with parents (Tate. P. T. M. Sc. Student 2019). 45 individual plants performing superior to others selected from F_2 families were sown in Randomized Block Design with 2 replications.

Correlation analysis and Path coefficient analysis

Analysis of variance was performed using method described by Panse and Sukhatme (1967) [17]. Phenotypic coefficient of variance and genotypic coefficient of variability were calculated by the method explained by Singh and Chaudhary (1985). Heritability in broad sense and genetic advance were calculated by method given by (Burton and Devane, 1953) [4]. Correlation coefficient and path analysis was worked out as per the method suggested by Dewey and Lu (1959) [6].

The calculated value of 'r' was compared with table 'r' value with n-2 degrees of freedom at 5% and 1% level of significance, where, n refers to number of pairs of observation.

Path coefficient is rated based on the scales given below: (Lenka and Mishra, 1973) [11].

0.00 - 0.09 = Negligible
0.10 – 0.19 = Low
0.20 – 0.29 = Moderate
0.30 – 0.99 = High
> 1.00 = Very high

Results and Discussion

In order to find out the association between yield and yield contributing characters, the genotypic and phenotypic correlation coefficients were estimated and presented in Table 1.

Phenotypic and genotypic correlation coefficient

At phenotypic level, character seed yield per plant showed positive and highly significant
correlation with number of pods per plant (0.8906), harvest index (0.8758), 100 seed weight (0.7123) and pod length (0.3114). It showed positive nonsignificant correlation with plant height at maturity (0.0711), days to initiation of flowering (0.0846) number of branches per plant (0.1712), and number of seeds per pod (0.1894). The seed yield per plant showed negative nonsignificant correlation with days to 50% flowering (-0.0159) while, days to maturity (-0.3005) had negative significant correlation.

Genotypically, Positive and highly significant correlation was reported between seed yield per plant and number of pods per plant (1.0080) followed by harvest index (0.8652), 100 seed weight (0.7685). It showed positive nonsignificant correlation with days to initiation of flowering (0.0684) and plant height at maturity (0.0981) number of pods per cluster (0.2042). Negative highly significant correlation was reported with days to maturity (-0.4294). It had negative nonsignificant correlation with days to 50% flowering (-0.0413). Similar results were confirmed by Surpura and Sharma (2017) [21] for harvest index and number of clusters per plant, Nair *et al.* (2017) [16], Lal *et al.* (2014) [10], Mishra *et al.* (2013) [15], Manggoel *et al.* (2012) [13] for number of pods per plant.

Phenotypic Correlation Coefficient

Number of pods per plant had positive and highly significant correlation with harvest index (0.7883), 100 seed weight (0.6668) and pod length (0.3625). The character had negative highly significant correlation with days to maturity (-0.3633). Harvest index had positive and highly significant correlation with number of pods per plant (0.7883), 100 seed weight (0.6275) and number of pods per cluster (0.3068). Similar results were also reported by Surpura and Sharma (2017) [21] for harvest index at both levels. It showed negative significant correlation with days to maturity (-0.3099). It showed negative nonsignificant correlation with days to initiation of flowering (-0.0372) and days to 50% flowering (-0.1051). 100 seed weight showed positive and highly significant correlation with number of pods per plant (0.6668), harvest index (0.6275), number of clusters per plant (0.3682), number of seeds per pod (0.3554) and pod length (0.3512). Hundred seed weight had negative significant correlation with days to maturity (-0.2684). It showed negative nonsignificant correlation with days to initiation of flowering (-0.1534) and days to 50% flowering (-0.1566). Similar results were also in confirmation with results obtained by Lokesh and Niranjana (2018) for seed yield per plant. Pod length had positive and highly significant correlation with number of seeds per pod (0.7030), number of pods per plant (0.3625) and 100 seed weight (0.3512). It showed positive significant correlation with number of branches per plant (0.2073).

Genotypic Correlation Coefficient

Number of pods per plant showed positive and highly significant correlation with harvest index (0.8932), 100 seed weight (0.7114) and pod length (0.4275). It showed negative significant correlation with days to maturity (-0.4417). Similar results were obtained by Surpura and Sharma (2017) [21] and Bhadru and Navale (2012) [3] in cowpea. Pod length had positive and highly significant correlation with number of seeds per pod (0.7043), number of pods per plant (0.4275), 100 seed weight (0.3815) while positive significant correlation with number of branches per plant (0.2621), number of clusters per plant (0.2374) and plant height at maturity (0.2333). 100 seed weight had positive and highly significant correlation with number of pods per plant (0.7114), harvest index (0.6773), number of clusters per plant (0.0.4242), number of seeds per pod (0.4047), pod length (0.3815) while, it showed positive significant correlation with

number of branches per plant (0.2797), number of pods per cluster (0.2212) and negative significant correlation with days to maturity (-0.3071). The character harvest index had positive and highly significant correlation with number of pods per plant (0.8932) followed by 100 seed weight (0.6773), number of pods per cluster (0.3554) and number of clusters per plant (0.3061). The negative significant correlation was observed with days to maturity (-0.4315).

Path co-efficient analyses

The path coefficient analysis is statistical device developed by Wright takes into account the cause
and effect relationship between the dependent and independent variables and partitions it into direct and indirect effects. Path coefficient analysis revealed positive direct effect of number of pods per plant, days to initiation of flowering and hundred seed weight at both genotypic and phenotypic level. Whereas, characters *viz*., days to maturity, number of clusters per plant, number of pods per cluster and plant height at genotypic level and characters *viz*., number of branches per plant and pod length at phenotypic level were having direct positive effect on seed yield per plant.

Phenotypic correlation coefficient partitioned for path coefficient analysis

Number of branches per plant showed low positive direct effect (0.1066) on seed yield per plant. The indirect effect through days to initiation of flowering, days to 50% flowering, days to maturity, number of pods per plant, number of clusters per plant, pod length, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index was positive while through number of pods per cluster it was negative. Number of pods per plant showed high positive direct effect (0.3839) on seed yield. The results were in conformation with findings of Walle *et al.* (2018) [27] at Miesso (Location) and Kumar *et al.* (2010) [9] for positive direct effect of number of pods on seed yield. It had positive indirect effect through days to initiation of flowering, number of branches per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index. Pod length had low positive direct effect (0.1041) on seed yield. The indirect effect through days to initiation of flowering, days to 50% flowering, number of branches per plant, number of pods per plant, number of clusters per plant, number of pods per cluster, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index was positive. 100 seed weight had low positive direct effect (0.1579) on seed yield. It had positive indirect effect through number of branches per plant, number of pods per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, plant height at maturity and harvest index. Harvest index showed high positive direct effect (0.5017) on seed yield. It had positive indirect effect through number of branches per plant, number of pods per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, plant height at maturity and 100 seed weight. The residual effect for path analysis at phenotypic level was 0.3018

Genotypic correlation coefficient partitioned for path coefficient analysis

Days to maturity had moderate positive direct effect (0.2508) on seed yield per plant. Its indirect effect through days to initiation of flowering, days to 50% flowering, number of branches per plant, pod length and number of seeds per pod was positive. Number of pods per plant had very high positive direct effect (1.6407) on seed yield per plant. The results were in conformation with findings of Walle *et al.* (2018) [27] at Miesso (Location) and Kumar *et al.* (2010) [9] for positive direct effect of number of pods on seed yield. While, it had positive indirect effect through days to initiation of flowering, number of branches per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index. Number of clusters per plant showed low positive direct effect (0.1915) on seeds yield per plant. It's positive indirect effect was observed through number of branches per plant, number of pods per plant, pod length, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index. It had negative indirect effect through days to initiation of flowering, days to 50% flowering, days to maturity and number of pods per cluster. The character number of pods per cluster showed negligible positive direct effect (0.0692) on seed yield per plant. It's positive indirect effect was observed through days to initiation of flowering, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, plant height at maturity, 100 seed weight and harvest index. The similar findings of direct effect of number of pods per cluster on seed yield per plant were also reported by Das *et al*. (2018). The character plant height at maturity had negligible positive direct effect (0.0919) on seed yield per plant. It had positive indirect effect through number of branches per plant, number of pods per plant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, 100 seed weight and harvest index. The character 100 seed weight had moderate positive direct (0.2319) effect on seed yield per plant. The similar results of having positive direct of test weight on seed yield per plant were also confirmed by Meena *et al.* (2015) [14] and Manggoel *et al.* (2012) [13]. The indirect effect through number of branches per plant, number of pods per pant, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, plant height at maturity, harvest index. It showed negative indirect effect through days to initiation of flowering, days to 50% flowering and days to maturity.

The residual effect for path analysis at genotypic level was 0.1968

Likewise, correlation and path analysis study provides basis for selection of characters *viz*. number of pods per plant, number of clusters per plant, pod length, 100 seed weight for genetic improvement in cowpea genotypes.

Table.1 Phenotypic (P) and genotypic (G) correlation coefficients for different characters in 30 genotypes of cowpea

Characters		Days to nitiation of flowering	Days to 50% flowering	Days to maturity	Number of branches per plant	Number of pods per plant	Number of clusters per plant	Number of pods per cluster	Pod length (cm)	Number of seeds per pod	Plant height at maturity (cm)	100 seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to nitiation of flowering	P	1.0000	0.8096***	0.4261***	0.0857	0.0713	-0.3462***	0.1196	0.0891	0.0616	-0.2687*	-0.1534	-0.0372	0.0846
	G	1.0000	0.9494***	0.3973***	0.1579	0.0612	-0.3938**	0.0898	0.1071	0.0797	-0.3164**	-0.1516	-0.0616	0.0684
Days to 50% flowering	P		1.0000	0.4256***	0.0307	-0.0200	-0.2958**	0.0556	0.1033	0.0784	-0.3715***	-0.1566	-0.1051	-0.0159
	G		1.0000	0.6302***	0.0657	-0.0370	-0.3379**	-0.0019	0.1739	0.1928	-0.4275**	-0.1805	-0.1454	-0.413
Days to maturity	P			1.0000	0.0828	-0.3633***	-0.1496	-0.0946	-0.0054	0.1122	-0.0961	-0.2684*	-0.3099**	-0.30005
	G			1.0000	0.1571	-0.4417**	-0.2214	-0.1870	0.0063	0.1698	-0.1159	-0.3091**	-0.4315**	-0.4294**
Number of branches per plant	P				1.0000	0.1076	0.3679***	-0.0042	0.2073*	0.2959**	0.4015***	0.2532*	0.0128	0.1712
	G				1.0000	0.1601	0.3733**	0.1183	0.2621	0.3341*	0.4380**	0.2797**	0.0382	0.2265*
Number of pods per plant	P					1.0000	0.2149*	0.2130*	0.3625***	0.2508	0.753	0.6668***	0.7883***	0.8906
	G					1.0000	0.2772**	0.2374*	04275***	0.3233**	0.0888	0.7114**	0.8932**	1.0080
Number of clusters per plant	P						1.0000	-0.1957	0.1867	0.3098***	0.1923	0.3682***	0.2491*	0.2358
	G						1.0000	-0.0457	0.2374*	0.3693**	0.2093*	0.4242**	0.3061**	0.2946**
Number of pods per cluster	P							1.0000	0.0042	-0.150	0.0396	0.1697	0.3068***	0.2092
	G							1.0000	0.0248	0.0290	0.0225	0.2212*	0.3554**	0.2042
Pod length (cm	P								1.0000	0.7030***	0.2018	0.3512**	0.1522	0.3114
	G								1.0000	0.7043***	0.2333*	0.3815**	0.1753	0.3605**
Number of seeds per pod	P									1.0000	0.2275*	0.3554***	0.1178	0.1894
	G									1.0000	0.2691	0.4047**	0.1329	0.2173*
Plant height at maturity (cm)	P										1.0000	0.1573	0.0382	0.0711
	G										1.0000	0.1609	0.0670	0.0981
100 seed weight (g	P											1.0000	0.6275***	0.7123***
	G											1.0000	0.6773***	0.7685**
Harvest index (%)	P												1.0000	0.8758**
	G												1.0000	0.8652**

Table 2: Phenotypic (P) and genotypic (G) path coefficient analysis indicating direct and indirect effects of components characters on green pod yield per plant in cowpea genotypes of cowpea

Characters		Days to nitiation of flowering	Days to 50% flowering	Days to maturity	Number of branches per plant	Number of pods per plant	Number of clusters per plant	Number of pods per cluster	Pod length (cm)	Number of seeds per pod	Plant height at maturity (cm)	100 seed weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to nitiation of flowering	P	0.1137	0.0920	0.0484	0.0097	0.0081	-0.0393	0.0136	0.0101	0.0070	-0.0305	-0.0174	-0.0025	0.00846
	G	0.1978	0.01878	0.0786	0.0312	0.0121	-0.0779	0.0178	0.0212	0.0158	-0.0626	0.0300	-0.0122	0.0684
Days to 50% flowering	P	-0.0300	-0.0370	-0.0157	-0.0011	0.0007	0.0109	-0.0021	-0.0038	-0.0029	0.0137	0.0058	0.00.39	-0.0159
	G	-0.1825	-0.1922	-0.1211	-0.0126	0.0071	0.0650	0.0004	-0.0334	-0.0371	0.0822	0.0347	0.0279	-0.0413
Days to maturity	P	-0.0019	-0.0019	-0.0045	-0.0004	0.0016	0.0007	0.0004	0.0000	-0.0005	0.0004	0.0012	0.0014	-0.3005
	G	0.0996	0.1580	0.2508	0.0394	-0.1107	-0.0555	-0.0469	0.0016	0.0426	-0.0291	-0.0770	-0.1082	-0.4294
Number of branches per plant	P	0.0091	0.0033	0.0088	0.1066	0.0115	0.0392	-0.0005	0.0221	0.0315	0.0428	0.0270	0.0014	0.1712
	G	-0.0186	-0.0077	-0.0185	-0.1176	-0.0188	-0.0439	-0.0139	-0.0308	-0.0393	-0.0515	-0.0329	-0.0045	0.2265
Number of pods per plant	P	0.0274	-0.0077	-0.1395	0.0413	0.3839	0.0825	0.0818	0.1392	0.0963	0.0289	0.2560	0.3027	0.8906
	G	0.1004	-0.0606	-0.7246	0.2627	1.6407	0.4549	0.3894	0.7014	0.5304	0.1456	1.1672	1.4654	1.0080
Number of clusters per plant	P	0.0126	0.0107	0.0054	-0.0134	-0.0078	-0.036.	0.0071	-0.0068	-0.0113	-0.0070	-0.0134	-0.0090	0.2358
	G	-0.0754	-0.0647	-0.0424	0.0715	0.0531	0.1915	-0.0087	0.0455	0.0707	0.0401	0.0812	0.0586	0.2946
Number of pods per cluster	P	-0.0088	-0.0041	0.0070	0.0003	-0.0157	0.0144	-0.0736	-0.0003	0.0011	-0.0029	-0.0125	-0.0226	0.2092
	G	0.0062	-0.0001	-0.0129	0.0082	0.0164	-0.0032	0.0692	0.0017	0.0020	0.0016	0.0153	0.0246	0.2042
Pod length (cm	P	0.0093	0.0108	-0.0006	0.0216	0.0378	0.0194	0.0004	0.1041	0.0732	0.0210	0.0366	0.0158	0.3114
	G	-0.0123	-0.0199	-0.0007	-0.0300	-0.0489	-0.0272	-0.0028	-0.1145	-0.0806	-0.0267	-0.0437	-0.0201	0.3605
Number of seeds per pod	P	-0.0072	-0.0092	-0.0132	-0.0347	-0.0294	-0.0364	0.0018	-0.0825	-0.1174	-0.0267	-0.0417	-0.0138	0.1894
	G	-0.0251	-0.0606	-0.0534	-0.1050	-0.1016	-0.1161	-0.0091	0.2214	-0.3144	-0.0846	-0.1272	-0.0418	0.2173
Plant height at maturity (cm)	P	0.0034	0.0047	0.0012	-0.0051	-0.0010	-0.0024	-0.0005	-0.0026	-0.0029	-0.0127	-0.0020	-0.0005	0.0711
	G	-0.0291	-0.0393	-0.0107	0.0403	0.0082	0.0192	0.0021	0.0214	0.0247	0.0919	0.0148	0.0062	0.0981
100 seed weight (g	P	-0.0242	-0.0247	-0.0424	0.0400	0.1053	0.0581	0.0268	0.0555	0.0561	0.0284	0.1579	0.0991	0.7123
	G	-0.0351	-0.0419	-0.0712	0.0649	-0.1650	0.0984	0.0513	0.0885	0.0939	0.0373	0.2319	0.1571	0.7685
Harvest index (%)	P	-0.0187	-0.0527	-0.1555	0.0064	0.3955	0.1250	0.1539	0.0764	0.0591	0.0191	0.3148	0.5017	0.8758
	G	0.0424	0.1000	0.2968	-0.0263	-0.6144	-0.2106	-0.2445	-0.1206	-0.0914	-0.0461	-0.4659	-0.6879	0.8652

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