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Character association and path coefficient analysis in vegetable cowpea [*Vigna unguiculata* (L.) Walp]

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Abstract

A field experiment was conducted during *kharif* season 2016 to determine correlation coefficient and path analysis among 27 genotypes for fifteen characters comprised of pod yield and its contributing characters. These genotypes were planted in Randomized Block Design with three replications during *Kharif*, 2016 -17 at Horticulture Farm, S.K.N. College of Agriculture, Jobner. The result revealed that at genotypic and phenotypic level maximum significant and positive correlation was shown by pod yield quintal per hectare with pod yield per plant, followed by pod length. The results of path coefficient analysis indicated that at the genotypic level, the effect was significant and positive on pod yield per plant of characters pod length, number of pods per plant, number of clusters per plant, nitrogen content in pod, protein content in pod, number of pickings and significant negative effects shown by plant height at 45 days, number of primary branches per plant and days to first picking. Maximum direct effect was shown by number of clusters per plant. Hence, these characters may be simultaneously selected for developing better quality high yielding varieties of vegetable cowpea.

Keywords: cowpea, correlation, pod yield, path analysis

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an annual, autogamous leguminous vegetable crop of India belongs to family leguminosae with a chromosome number of $2n=2x=22$. It is native to India but tropical and central Africa is also considered as secondary centre of origin where wild races are found. Its young leaves, pods and grains contain vitamins and minerals which have fuelled its usage for human consumption and animal feeding (Nielson *et al.*, 1997)^[8]. It is considered as one of the oldest legumes and referred as "Poor man's meat" because of its high protein (20-25 %) source for human and livestock (Steele, 1972)^[11]. In different parts of the world it is known as Lobia, Southern pea, Blackeye pea, Chawalie and Mulatto-Gelato. It has multipurpose use such as green pods for vegetable, seed as pulse and leaves and foliage for fodder purpose, that's why it is an important crop of the arid and humid tropics. It is a drought tolerant crop and thrives in warm weather (21- 35°C) and well adapted to the drier regions of the tropics, where other food legumes do not perform well. In India, vegetable cowpea is mainly grown in Uttar Pradesh, Punjab, Haryana, Rajasthan and Madhya Pradesh. In Rajasthan, cowpea is one of the importance vegetable legume crop because of its short duration, high yield potential and quick growing habit along with high protein content and as cover crop which help in conservation of soil. Correlation coefficients, although, very useful in quantifying the size and direction of trait associations can be misleading if the high correlation between two traits is a consequence of the indirect effect of other traits (Bizeti *et al.*, 2004)^[4].

Materials and Method

The present investigation was carried out at Horticultre Farm, S.K.N College of Agriculture, Sri Karan Narendra Agriculute University, Jobner, Rajasthan during the *Kharif* season of the year 2016-17. The experimental material for the present study consisted of 27 promising genotypes of vegetable cowpea collected from different State Agricultural Universities, ICAR Research Institutes and the collection was maintained for study at S.K.N. College of Agriculture, Jobner, (Jaipur). The experiment was laid out in Randomized Block Design with three replications of each genotype. Two rows of each genotype were sown at spacing of 45x 15 cm in a plot of size is 3.0 x 0.9 m².

Correlation coefficient analysis

Simple correlation coefficients between yield and yield components and intercorrelation

among the various components were calculated using the formula suggested by Panse and Sukhatme (1967) [7].

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right) \left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

Where,

r = Correlation coefficient

n = Number of treatments

X and Y = Characters under study

Path coefficient analysis

Path coefficient analysis was carried out as suggested by Dewey and Lu (1959) by partitioning the simple correlation coefficients into direct and indirect effects. The direct and indirect effects were ranked based on the scales of Lenka and Misra (1973) [5] as given below

Negligible	:	0.00 to 0.09
Low	:	0.10 to 0.19
Moderate	:	0.20 to 0.29
High	:	0.30 to 0.99
Very high	:	> 1.00

Result and Discussion

Correlation coefficient

Phenotypic and genotypic correlation coefficients among fifteen quantitative and qualitative characters are presented in Table 1.1a and 1.1b. At genotypic level maximum significant and positive correlation shown by pod yield quintal per hectare with pod yield per plant ($r_g = 0.999$), followed by pod length ($r_g = 0.963$), number of pods per plant ($r_g = 0.611$), number of clusters per plant ($r_g = 0.436$), nitrogen content in pod ($r_g = 0.337$), protein content in pod ($r_g = 0.337$) and number of pickings ($r_g = 0.229$). Similar findings are also reported by Kalaiyarasi and Palanisamy (2000) [3] and Belhekar *et al.* (2003) [1] for number of pods per plant. Kutty *et al.* (2003) [4] and Singh *et al.* (2004) [10] for pod length and number of pods per plant and by Xiao *et al.* (2004) for pod length. At genotypic level maximum significant and negative correlation shown by plant height at 45 days ($r_g = -0.280$), number of primary branches per plant ($r_g = -0.276$) and days to first picking ($r_g = -0.244$).

These characters are also showing significant correlation with each other. The character plant height at 45 days significantly and positively correlated with number of pickings ($r_g = 0.385$) and negatively with pod length ($r_g = -0.342$), pod yield per plant ($r_g = -0.280$) and pod yield per hectare ($r_g = -0.280$). Number of primary branches per plant negatively and significantly correlated with number of pods per plant ($r_g = -0.409$), pod length ($r_g = -0.305$), nitrogen content in pod ($r_g = -0.289$), protein content in pod ($r_g = -0.289$) pod yield per plant ($r_g = -0.276$) and pod yield ($r_g = -0.276$).

Days to 50 per cent flowering significantly and positively correlated with days to first picking ($r_g = 1.00$) and pod length ($r_g = -0.334$), number of pods per plant ($r_g = 0.225$) and negatively correlated with TSS content in pod ($r_g = -0.270$) and number of pickings ($r_g = -0.224$). Days to first picking significantly and negatively correlated with pod length ($r_g = -0.349$), pod yield per plant ($r_g = -0.244$), pod yield quintal per hectare ($r_g = -0.244$), TSS ($r_g = -0.239$), number of pickings ($r_g = -0.226$), and number of clusters per plant ($r_g = -0.222$). Number of pickings significantly and positively correlated with pod yield per plant ($r_g = 0.229$).

Number of cluster per plant significantly and positively correlated with pod yield per plant ($r_g = 0.436$), pod yield per hectare ($r_g = 0.436$), pod length ($r_g = 0.436$), protein content in pod ($r_g = 0.318$), pod yield per plant ($r_g = 0.318$), number of pickings ($r_g = 0.230$) and negatively with number of pods per cluster ($r_g = -0.933$) and TSS content in pod ($r_g = -0.449$). Number of pods per cluster significantly and positively correlated with number of pods per plant ($r_g = 0.355$), TSS content in pod ($r_g = 0.320$). Significantly and negatively correlated with pod length ($r_g = -0.223$ cm), nitrogen content in pod ($r_g = -0.260$) and protein content in pod ($r_g = -0.259$). Number of pods per plant significantly and positively correlated with pod yield per hectare ($r_g = 0.611$), pod yield per plant ($r_g = 0.611$) and pod length ($r_g = 0.359$) and negatively with TSS ($r_g = -0.367$). Pod length significantly and positively correlated with nitrogen content in pod ($r_g = 0.294$), protein content in pod ($r_g = 0.294$), pod yield per plant ($r_g = 0.963$).

Pod yield quintal per hectare significantly and positively correlated with pod yield per plant ($r_g = 0.999$) pod yield per hectare ($r_g = 0.963$), protein content in pod ($r_g = 0.337$), nitrogen content in pod ($r_g = 0.337$) and with number of pickings ($r_g = 0.229$). Nitrogen content per cent significantly and positively correlated with protein content in pod ($r_g = 0.999$) and pod yield per plant ($r_g = 0.337$). Protein content of pod ($r_g = 0.337$) significantly and positively correlated with pod yield per plant ($r_g = 0.337$).

At phenotypic level maximum significant and positive correlation reflected by pod yield per hectare ($r_p = 0.999$) followed by pod length ($r_p = 0.925$), number of pods per plant ($r_p = 0.416$), number of clusters per plant ($r_p = 0.396$), nitrogen content in pod ($r_p = 0.331$), protein content in pod ($r_p = 0.331$) and significant and negative association shown by plant height (cm) at 45 days ($r_p = -0.271$ cm), number of primary branches per plant ($r_p = -0.263$) and days to first picking ($r_p = -0.230$).

These characters are also showing significant correlation with each other's the character plant height at 45 days was significant and positively correlated with number of pickings ($r_p = 0.324$) and negatively with pod length ($r_p = -0.339$), pod yield ($r_p = -0.271$) and pod yield per plant ($r_p = -0.271$). Number of primary branches per plant significantly and negatively correlated with pod length ($r_p = -0.296$), nitrogen content in pod ($r_p = -0.280$), protein content in pod ($r_p = -0.280$), number of pods per plant ($r_p = -0.278$), pod yield ($r_p = -0.263$), and pod yield per plant ($r_p = -0.263$).

Days to 50 per cent flowering significantly and positively correlated with days to first picking ($r_p = 0.946$) and negatively with pod length ($r_p = -0.310$). Days to first pickings significantly and negatively correlated with pod length ($r_p = -0.338$), pod yield per hectare ($r_p = -0.230$) and pod yield per plant ($r_p = -0.230$). Number of cluster per plant significantly and positively correlated with pod length ($r_p = 0.419$), pod yield per hectare ($r_p = 0.396$), pod yield per plant ($r_p = 0.396$), nitrogen content in pod ($r_p = 0.307$), protein content in pod ($r_p = 0.306$) and significantly negatively correlated with number of pods per cluster ($r_p = -0.896$) and TSS content in pod ($r_p = -0.330$). Number of pods per cluster significantly and positively correlated with number of pods per plant ($r_p = 0.332$), TSS content in pod ($r_p = 0.238$). Negatively and significantly correlated with pod length ($r_p = -0.227$ cm), nitrogen content in pod ($r_p = -0.258$) and protein content in pod ($r_p = -0.257$).

Pod length significantly and positively correlated with pod yield per plant ($r_p = 0.925$), nitrogen content in pod ($r_p = 0.294$).

and protein content in pod (0.293). Number of pods per plant significantly and positively correlated with pod yield quintal per hectare ($r_p = 0.416$), pod length ($r_p = 0.224$). Pod yield per hectare significantly and positively correlated with pod yield per plant ($r_p = 0.999$), pod length ($r_p = 0.925$), nitrogen content in pod ($r_p = 0.331$), protein content in pod ($r_p = 0.331$). Nitrogen content of pod was significant and positively correlated with protein content in pod (0.999) and pod yield per plant ($r_p = 0.331$). Protein content in pod significantly and positively correlated with pod yield per plant ($r_p = 0.331$).

Path analysis

The results of path coefficient analysis in table 1.2a and 1.2b indicated that at the genotypic level, the significant and positive effect on pod yield per plant through pod length (0.963), number of pods per plant (0.611), number of cluster per plant (0.436), nitrogen content in pod (0.337), protein content in pod (0.337) number of pickings (0.229) and significant negative effects shown by plant height at 45 days

(-0.280), number of primary branches per plant (-0.276) and days to first picking (-0.244). Maximum direct effect shown by number of clusters per plant because it was most important character as it was having maximum direct effect on pod yield per plant (2.578) followed by number of pods per cluster (1.389).

Results shows that at the phenotypic level, the significant and positive effect on pod yield per plant through pod length (0.925), number of pods per plant (0.416), number of cluster per plant (0.396), nitrogen content in pod (0.331) and protein content in pod (0.331). Similarly Lal *et al.* (2007) and Mehta *et al.* (2005) revealed that pod length exerted high direct effect on pod yield per plant. Whereas significant and negative effects shown by plant height at 45 days (-0.271), number of primary branches per plant (-0.263) and days to first picking (-0.230). Maximum direct effect shown by pod length (0.894) followed by protein content in pod (0.511) as its having maximum direct effect on pod yield per plant.

Table 1.1a: Genotypic correlation coefficients between different characters in vegetable cowpea

S.No	Characters	Plant height at 45 days	Number of primary branches/plant	Leaf area (cm ²)	Days to 50% flowering	Days to first picking	Number of picking	Number of clusters/plant	Number of pods/cluster	Number of pods/plant	Pod length (cm)	Pod yield/q/ha	TSS (%)	Nitrogen content in pod (%)	Protein content in pod (%)	Pod yield/plant (g)
1	Plant height (cm) at 45 days	1.000	0.134	0.144	0.014	0.011	0.385**	0.189	-0.212	-0.022	-0.342**	-0.280*	0.119	0.077	0.077	-0.280*
2	Number of primary branches/plant		1.000	0.113	0.149	0.159	-0.014	-0.096	-0.072	-0.409**	-0.305**	-0.276*	0.082	-0.289**	-0.289**	-0.276*
3	Leaf area (cm ²)			1.000	-0.081	-0.024	-0.058	0.13	-0.116	0.109	-0.07	0.061	0.124	0.071	-0.058	
4	Days to 50% flowering				1.000	1.00**	-0.224*	-0.213	0.171	0.225*	-0.334**	-0.214	-0.270*	0.097	0.097	-0.214
5	Days to first picking					1.000	-0.226*	-0.222*	0.168	0.188	-0.349**	-0.244*	-0.239*	0.069	0.070	-0.244*
6	Number of picking						1.000	0.230*	-0.158	0.131	0.229*	0.171	-0.125	0.153	0.152	0.229*
7	Number of clusters/plant							1.000	-0.933**	-0.112	0.436**	0.436**	-0.449**	0.318**	0.318**	0.436**
8	Number of pods/cluster								1.000	0.355**	-0.223*	-0.164	0.320**	-0.260*	-0.259*	-0.164
9	Number of pods/plant									1.000	0.359**	0.611**	-0.367**	0.178	0.178	0.611**
10	Pod length (cm)										1.000	0.963**	-0.057	0.294**	0.294**	0.963**
11	Pod yield (q/ha)											1.000	-0.190	0.337**	0.337**	0.999**
12	TSS(%)												1.000	-0.127	-0.127	-0.190
13	Nitrogen content in pod(%)													1.000	0.999**	0.337**
14	Protein content of pod (%)														1.000	0.337**

* & ** Significance at 5% & 1% respectively

Table 1.1b: Phenotypic correlation coefficients between different characters in vegetable cowpea

S.No	Characters	Plant height at 45 days(cm)	Number of primary branches/plant	Leaf area (cm ²)	Days to 50% flowering	Days to first picking	Number of picking	Number of clusters/plant	Number of pods/cluster	Number of pods/plant	Pod length (cm)	Pod yield/q/h	TSS (%)	Nitrogen content (%)	Protein content of pod (%)	Pod yield/plant (g)
1	Plant height at 45 days(cm)	1.000	0.131	0.132	0.012	0.015	0.324**	0.18	-0.206	-0.017	-0.339**	-0.271*	0.081	0.076	0.076	-0.271*
2	Number of primary branches/plant		1.000	0.097	0.145	0.145	-0.015	-0.096	-0.066	-0.278*	-0.296**	-0.263*	0.073	-0.280*	-0.280*	-0.263*
3	Leaf area			1.000	-0.063	-0.022	0.064	-0.1	0.097	0.036	-0.063	-0.079	0.078	0.065	0.065	-0.079

	(cm ²)															
4	Days to 50% flowering				1.000	0.946**	-0.162	-0.202	0.153	0.123	-	-0.208	-0.136	0.091	0.092	-0.208
5	Days to first picking					1.000	-0.208	-0.216	0.164	0.123	-	-0.230*	-0.156	0.068	0.068	-0.230*
6	Number of picking						1.000	0.207	-0.124	0.113	0.128	0.167	-0.074	0.117	0.116	0.167
7	Number of clusters/ plant							1.000	-0.896**	0.029	0.419**	0.396**	-	0.307**	0.306**	0.396**
8	Number of pods/ cluster								1.000	0.332**	-0.227*	-0.150	0.238*	-0.258*	-0.257*	-0.150
9	Number of pods/plant									1.000	0.224*	0.416**	-0.166	0.119	0.119	0.416**
10	Pod length (cm)										1.000	0.925**	-0.053	0.294**	0.293**	0.925**
11	Pod yield (g/ha)											1.000	-0.117	0.331**	0.331**	0.999**
12	TSS (%)												1.000	-0.103	-0.103	-0.117
13	Nitrogen content in pod (%)													1.000	0.999**	0.331**
14	Protein content of pod (%)														1.000	0.331**

*&** Significance at 5% & 1% respectively

Table 1.2a: Direct (diagonal) and indirect effect of different characters on pod yield per plant in vegetable cowpea at genotypic level

S.No.	Characters	Plant height at 45 days (cm)	Number of primary branches/plant	Leaf area (cm ²)	Days to 50% flowering	Days to first picking	Number of pickings	Number of clusters / plant	Number of pods / cluster	Number of pods / plant	Pod length (cm)	TSS (%)	Nitrogen content in pod (%)	Protein content in pod (%)	Pod yield/plant (g)
C1	Plant height at 45 days	-0.858	0.061	-0.013	0.000	-0.001	0.092	0.487	-0.294	-0.023	0.142	0.119	0.047	-0.038	-0.280*
C2	Number of primary branches/ plant	-0.115	0.457	-0.011	0.003	-0.008	-0.003	-0.247	-0.100	-0.429	0.126	0.082	-0.175	0.143	-0.276*
C3	Leaf area (cm ²)	-0.124	0.052	-0.094	-0.002	0.001	0.031	-0.299	0.151	0.064	0.029	0.124	0.043	-0.035	-0.058
C4	Days to 50% flowering	-0.012	0.068	0.008	0.023	-0.051	-0.054	-0.549	0.237	0.236	0.138	-	0.059	-0.048	-0.214
C5	Days to first picking	-0.009	0.073	0.002	0.023	-0.050	-0.054	-0.572	0.233	0.197	0.145	-	0.042	-0.035	-0.244*
C6	Number of picking	-0.331	-0.006	-0.012	-0.005	0.011	0.239	0.593	-0.219	0.137	-0.071	-	0.092	-0.075	0.229*
C7	Number of clusters/ plant	-0.162	-0.044	0.011	-0.005	0.011	0.055	2.578	-1.296	-0.118	-0.181	-	0.192	-0.157	0.436**
C8	Number of pods/ cluster	0.182	-0.033	-0.010	0.004	-0.008	-0.038	-2.405	1.389	0.373	0.092	0.320	-0.157	0.128	-0.164
C9	Number of pods/plant	0.019	-0.187	-0.006	0.005	-0.009	0.031	-0.289	0.493	1.049	-0.149	-	0.108	-0.088	0.611**
C10	Pod length (cm)	0.294	-0.140	0.007	-0.008	0.017	0.041	1.124	-0.310	0.377	-0.414	-	0.178	-0.146	0.963**
C11	TSS (%)	-0.102	0.038	-0.012	-0.006	0.012	-0.030	-1.157	0.444	-0.385	0.024	0.999	-0.077	0.063	-0.190
C12	Nitrogen content in pod (%)	-0.066	-0.132	-0.007	0.002	-0.003	0.037	0.820	-0.361	0.187	-0.122	-	0.604	-0.495	0.337**
C13	Protein content in pod (%)	-0.066	-0.132	-0.007	0.002	-0.003	0.036	0.820	-0.360	0.187	-0.122	-	0.604	-0.495	0.337**

Table 1.2b: Direct (diagonal) and indirect effects of different characters on pod yield per plant in cowpea at phenotypic level

S.No.	Characters	Plant height at 45 days (cm)	Number of primary branches/plant	Leaf area (cm ²)	Days to 50% flowering	Days to first picking	Number of pickings	Number of clusters / plant	Number of pods / cluster	Number of pods / plant	Pod length (cm)	TSS (%)	Nitrogen content in pod (%)	Protein content in pod (%)	Pod yield plant (g)
C1	Plant height at 45 days (cm)	0.024	0.011	-0.006	-0.001	0.001	0.008	0.004	-0.008	-0.004	-0.303	-	-0.034	0.039	-0.271*
C2	Number of primary branches/ plant	0.003	0.083	-0.005	-0.008	0.012	0.000	-0.002	-0.003	-0.058	-0.265	-	0.125	-0.143	-0.263*
C3	Leaf area (cm ²)	0.003	0.008	-0.049	0.004	-0.002	0.002	-0.002	0.004	0.008	-0.056	-	-0.029	0.033	-0.079

C4	Days to 50% flowering	0.000	0.012	0.003	-0.056	0.076	-0.004	-0.005	0.006	0.026	-0.277	0.004	-0.041	0.047	-0.208
C5	Days to first picking	0.000	0.012	0.001	-0.053	0.081	-0.005	-0.005	0.007	0.026	-0.302	0.004	-0.030	0.035	-0.230*
C6	Number of Pickings	0.008	-0.001	-0.003	0.009	-0.017	0.024	0.005	-0.005	0.024	0.114	0.002	-0.052	0.059	0.167
C7	Number of clusters/ plant	0.004	-0.008	0.005	0.011	-0.017	0.005	0.023	-0.037	0.006	0.375	0.009	-0.137	0.156	0.396**
C8	Number of pods/ cluster	-0.005	-0.006	-0.005	-0.009	0.013	-0.003	-0.021	0.041	0.069	-0.203	-0.007	0.115	-0.131	-0.150
C9	Number of Pods/plant	0.000	-0.023	-0.002	-0.007	0.010	0.003	0.001	0.014	0.208	0.200	0.005	-0.053	0.061	0.416**
C10	Pod length (cm)	-0.008	-0.025	0.003	0.017	-0.027	0.003	0.010	-0.009	0.047	0.894	0.001	-0.131	0.150	0.925**
C11	TSS (%)	0.002	0.006	-0.004	0.008	-0.013	-0.002	-0.008	0.010	-0.035	-0.047	0.028	0.046	-0.053	-0.117
C12	Nitrogen Content in pod (%)	0.002	-0.023	-0.003	-0.005	0.005	0.003	0.007	-0.011	0.025	0.263	0.003	-0.445	0.511	0.331**
C13	Protein Content in Pod (%)	0.002	-0.023	-0.003	-0.005	0.005	0.003	0.007	-0.011	0.025	0.262	0.003	-0.445	0.511	0.331**

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