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Evaluation of correlation and path analysis in vegetable cowpea [*Vigna unguiculata* (L.) Walp.]

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Abstract
An investigation was carried out using 60 genotypes of vegetable cowpea to find out the correlation coefficients and path coefficients. The material was evaluated in a randomized block design with three replications at the Vegetable Research Station, J. A. U., Junagadh during summer 2018. The observations were recorded on 12 characters *viz*., days to 50% flowering, days to first green pod picking, number of primary branches per plant, plant height (cm), pod length (cm), pod width (cm), number of pods per plant, number of pods per cluster, ten pod weight (g), number of pods per plant, plant spread (cm) and green pod yield per plant (g). The values of genotypic correlations were higher than their corresponding phenotypic correlations. The pod yield per plant exhibited significant and positive correlations with number of primary branches per plant, plant height, pod length, number of pods per plant and number of seeds per pod at both genotypic and phenotypic levels. The path coefficient analysis showed the high positive direct influences on pod yield per plant through number of primary branches per plant and pod length and hence, due emphasis should be placed on these characters while selecting for high yielding types in vegetable cowpea.

Keywords: Correlation, direct and indirect effects, vegetable cowpea

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] is an ancient crop probably domesticated during the Neolithic period. In India, it is commonly known as lubia, black eye, roungi, kaffir pea, china pea and southern bean. It is grown throughout the tropics and subtropics as a grain legume. Vegetables play a vital role in the health and nutritional security of human beings. Their productivity per unit area is much higher than cereals. India ranked second in the production of vegetables with occupying 15.7% contribution in the world production (Anonymous, 2012) [2]. In India, the vegetable crops are grown in 102.59 lakh hectares with an annual production of 1843.94 lakh metric tonnes and the productivity of 17.97 tonnes/ha (Anonymous, 2018a) [3]. In Gujarat, it occupies an area of 6.50 lakh hectares with an annual production of 132.33 lakh metric tonnes and the productivity of 20.33 tonnes/ha (Anonymous, 2018b) [4]. In Gujarat, cowpea occupies an area of 27029 hectares with an annual production of 280818 metric tonnes and the productivity of 10.39 tonnes/ha (Anonymous, 2018b) [4]. Vegetable cowpea plays a key role in maintaining soil health and sustainability in the production from different cropping systems as they fix atmospheric nitrogen in their root nodules. Correlation studies provide better understanding of yield components, which helps the plant breeder during selection. Mass selection has been used to improve grain yield in several crops through indirect selection for highly heritable traits, which are associated with yield. A positive correlation between desirable characters is favorable to the plant breeder because, it helps in simultaneous improvement of both the characters. A negative correlation, on the other hand, will hinder the simultaneous expression of both the characters with high values. In such situations, some economic compromise has to be made. Path analysis has been widely applied to several crop species. The information obtained by this technique helps in direct and indirect selection for genetic improvement of yield (Dewey and Lu, 1959) [5].

Materials and Methods
The present investigation was carried-out to assess the correlation coefficients and path coefficient analysis in 60 genotypes of vegetable cowpea. The experiment was laid-out in a Randomized Block Design with three replications at the Vegetable Research Station, Junagadh Agricultural University, Junagadh (Gujarat) during summer of 2018.

The observations were recorded on five randomly selected plants in each entry and from each replication except days to 50% flowering, which was calculated on plot basis and their mean values were used for statistical analysis. The characters studied were; days to 50% flowering, days to first green pod picking, number of primary branches per plant, plant height (cm), pod length (cm), pod width (cm), number of pods per plant, number of pods per cluster, ten pod weight (g), number of pods per plant, plant spread (cm) and green pod yield per plant (g). Phenotypic and genotypic correlation coefficients for all the characters were worked out as per Al-Jibouri *et al.* (1958) [1]. Path coefficient analysis was carried out as per the procedure suggested by Dewey and Lu (1959) [5].

Results and Discussion

The study of genotypic correlation gives an idea of the extent of relationship between different variables. This relationship among yield contributing characters as well as their association with pod yield provides information for exercising selection pressure for bringing genetic improvement in pod yield. In general, the values of genotypic correlations were higher than their corresponding phenotypic correlations. This indicated that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. In the present study, green pod yield per plant was found to be significantly and positively correlated with number of primary branches per plant, plant height, pod length, number of pods per plant and number of seeds per pod at both genotypic and phenotypic levels. Such positive interrelationship between green pod yield per plant and these attributes has also been earlier reported in vegetable cowpea by several researchers. The positive genotypic association has been reported between green pod yield per plant and pod length (Shrama *et al.*, 2016 [10] and Jogdhande *et al*., 2017) [6]; number of pods per plant (Patil, 2006 [9] and Kumari *et al*., 2010) [7]; plant height, number of primary branches per plant and number of seeds per pod (Shrama *et al.*, 2016 [10] and Jogdhande *et al*., 2017) [6]. Thus, on the basis of correlations number of primary branches per plant, plant height, pod length, number of pods per plant and number of seeds per pod were proved to be the outstanding characters influencing green pod yield in vegetable cowpea and needs to be given importance in selection to achieve higher green pod yield.

Green pod yield, a polygenic trait, is influenced by its various components directly as well as indirectly *via* other traits, which create a complex situation before a breeder for making selection. Therefore, path coefficient analysis could provide a more realistic picture of the interrelationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficient. In the present study, the path coefficient analysis revealed that number of primary branches per plant and pod length exhibited high and positive direct effects on green pod yield per plant. Whereas, number of pods per plant showed moderate and positive direct effects on green pod yield per plant. Thus, these characters turned-out to be the major components of green pod yield and direct selection for these traits will be rewarding for yield improvement. Similar results were reported by Shrama *et al.* (2016) [10], Jogdhande *et al.* (2017) [6], Lokesh and Niranjana *et al.* (2018) [8] for number of primary branches per plant and pod length; Shrama *et al.* (2016) [10] and Jogdhande *et al.* (2017) [6] for number of pods per plant. Whereas, number of pods per plant showed moderate and positive direct effects as well as indirect effects on green pod yield per plant. These characters also exhibited significant and positive associations with green pod yield per plant and hence, they may be considered as the most important yield contributing characters and due emphasis should be placed on these components while selecting for high yielding types in vegetable cowpea.

Table 1: Genotypic (r_g) and phenotypic (r_p) correlation coefficients among 12 characters in 60 genotypes of vegetable cowpea

Characters	Corr.	Days to 50% flowering	Days to first green pod picking	No. of primary branches per plant	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of pods per plant	No. of seeds per pod	No. of pods per cluster	Ten pod weight (g)	Plant spread (cm)	Green pod yield per plant (g)
Days to 50% flowering	r_g	1.0000	0.8335**	0.0395	0.2527	0.1021	0.0270	0.0560	0.0461	-0.0928	0.1055	-0.3030*	0.1312
	r_p	1.0000	0.8173**	0.0469	0.2451	0.0920	0.0284	0.0570	0.0525	-0.0914	0.1013	-0.2474	0.1301
Days to first green pod picking	r_g		1.0000	0.1158	0.0307	0.0425	-0.1143	0.1334	0.0290	0.0500	0.0448	-0.1518	0.1343
	r_p		1.0000	0.1068	0.0339	0.0296	-0.1083	0.1262	0.0379	0.0508	0.0413	-0.1184	0.1339
No. of primary branches per plant	r_g			1.0000	0.5951**	0.8897**	-0.0181	0.7923**	0.7743**	0.0069	0.1914	-0.0713	0.9662**
	r_p			1.0000	0.5584**	0.7974**	-0.0231	0.7369**	0.6436**	-0.0066	0.1803	-0.0530	0.9007**
Plant height (cm)	r_g				1.0000	0.7175**	0.1220	0.5523**	0.6205**	-0.0369	0.1483	-0.1613	0.6863**
	r_p				1.0000	0.6827**	0.1105	0.5392**	0.5202**	-0.0360	0.1458	-0.1230	0.6674**
Pod length (cm)	r_g					1.0000	0.0505	0.6869**	0.7072**	-0.0084	0.1787	-0.2962*	0.9358**
	r_p					1.0000	0.0518	0.6537**	0.5928**	-0.0097	0.1637	-0.2326	0.8945**
Pod width (cm)	r_g						1.0000	-0.0065	-0.1499	0.0685	0.3838**	-0.0713	0.0353
	r_p						1.0000	-0.0040	-0.1250	0.0743	0.3660**	-0.0529	0.0317
No. of pods per plant	r_g							1.0000	0.6218**	-0.1135	0.1832	0.0063	0.8303**
	r_p							1.0000	0.5412**	-0.1101	0.1780	0.0024	0.8173**
No. of seeds per pod	r_g								1.0000	0.0423	0.1034	0.0083	0.8138**
	r_p								1.0000	0.0189	0.0930	-0.0194	0.6962**
No. of pods per cluster	r_g									1.0000	-0.0269	0.2509	0.0301
	r_p									1.0000	-0.0241	0.1978	0.0268
Ten pod weight (g)	r_g										1.0000	0.1813	0.2203
	r_p										1.0000	0.1546	0.2149
Plant spread (cm)	r_g											1.000	-0.1412
	r_p											1.000	-0.1226
Green pod yield per plant (g)	r_g												1.000
	r_p												1.000

*,** Significant at 5% and 1% levels, respectively

Table 2: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on green pod yield per plant in 60 genotypes of vegetable cowpea

Characters	Days to 50% flowering	Days to first green pod picking	No. of primary branches per plant	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of pods per plant	No. of seeds per pod	No. of pods per cluster	Ten pod weight (g)	Plant spread (cm)	Phenotypic correlation with green pod yield (g)
Days to 50% flowering	0.0548	0.0004	0.0145	0.0021	0.0352	0.0004	0.0156	0.0059	-0.0063	0.0030	0.0046	0.1301
Days to first green pod picking	0.0448	0.0005	0.033	0.0003	0.0113	-0.0016	0.0345	0.0043	0.0035	0.0012	0.0022	0.1339
No. of primary branches per plant	0.0026	0.0001	0.3086*	0.0047	0.3052*	-0.0003	0.2014	0.0727	-0.0005	0.0054	0.0010	0.9007**
Plant height (cm)	0.0134	0.0001	0.1723	0.0084	0.2613	0.0016	0.1474	0.0588	-0.0025	0.0043	0.0023	0.6674**
Pod length (cm)	0.005	0.0001	0.2461	0.0058	0.3827**	0.0008	0.1787	0.067	-0.0007	0.0049	0.0043	0.8945**
Pod width (cm)	0.0016	-0.0001	-0.0071	0.0009	0.0198	0.0148	-0.0011	-0.0141	0.0051	0.0109	0.0010	0.0317
No. of pods per plant	0.0031	0.0001	0.2274	0.0045	0.2502	-0.0001	0.2733*	0.0611	-0.0076	0.0053	0.0001	0.8173**
No. of seeds per pod	0.0029	0.0001	0.1986	0.0044	0.2269	-0.0018	0.1479	0.113	0.0013	0.0028	0.0004	0.6962**
No. of pods per cluster	-0.0050	0.0001	-0.0020	-0.0003	-0.0037	0.0011	-0.0301	0.0021	0.0691	-0.0007	-0.0037	0.0268
Ten pod weight (g)	0.0056	0.0001	0.0556	0.0012	0.0627	0.0054	0.0487	0.0105	-0.0017	0.0298	-0.0029	0.2149
Plant spread (cm)	-0.0136	-0.0001	-0.0164	-0.0010	-0.0890	-0.0008	0.0007	-0.0022	0.0137	0.0046	-0.0186	-0.0023

*, ** Significant at 5 % and 1% levels, respectively

Residual effect, R = 0.2321, R^2 = 0.9461

Conclusion

Correlation study revealed that number of primary branches per plant, plant height, pod length, number of pods per plant and number of seeds per pod were correlated with green pod yield per plant. Path coefficient analysis also revealed high direct effects of number of primary branches per plant and pod length on pod yield, therefore, due weightage should be given to these traits for selection in vegetable cowpea.

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