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Research Note

Association analysis of morpho-physiological traits in vegetable cowpea (*Vigna unguiculata* L. Walp.)

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Abstract
Vegetables play a vital role in health and nutritional security of human beings. Cowpea is an annual herbaceous legume mostly grown in arid to semiarid parts, providing rich source of nutrition in diet. The genetics of traits and their relativeness in productivity was determined by studying thirteen morpho-physiological traits during summer 2018 at Sardarkrushinagar, Gujarat. Sufficient genetic variability for green pod yield and its attributes was observed among twelve advanced lines and cultivars. Maximum positive correlation depicted by pod yield per plant with harvest index followed by chlorophyll content, plant height and nitrogen content of pods at phenotypic level while, negative correlation was exerted with the number of leaves, primary branches, days to 50 per cent flowering and secondary branches. The path analysis depicted protein content of green pod having higher positive direct effect followed by harvest index and total dry weight whereas, nitrogen content of green pod had negative direct effect on green pod yield per plant followed by secondary branches, the number of leaves and nitrogen content in plant part.

Keywords
Cowpea, chlorophyll, green pod, leaf area.

Cowpea (*Vigna unguiculata* L. Walp.) is one of the most popular short duration vegetable crop. Being short duration crops, vegetables fit well in multiple cropping systems. Vegetables play a vital role in the health and nutritional security of human beings to improve the economy of the farming community. The productivity of vegetables per unit area is much higher than cereals. Vegetables farming because of its labour intensive nature offers more employment opportunities. India best owed with diverse climatic conditions is most suitable for growing tropical, subtropical and temperate types of vegetables. The vegetable improvement work in India, initiated nearly four decades ago, resulted in the development of a large number of varieties. There are still some vegetables, which have great potential and cowpea is one of them. It can be used at all stages of its growth as a vegetable crop. The tender green leaves constitute an important food source often prepared as pot herb, like spinach. The immature snapped pods are used in the same way as snap beans, often mixed with other foods. Green cowpea seeds are boiled as a fresh vegetable or may be canned or frozen. Dry matured seeds are also suitable for boiling and canning. Barret *et al*. (1997) reported that some varieties are suitable for harvesting as leaves, young pods and mature seeds each over a long period for human consumption as well as for feeding livestock. It can be grown in rainfed and irrigated conditions.

Nutritional content of cowpea seed comprises of protein (24.8%), fat (1.9%) and fiber (6.3%) while, tender pods are said to be good source of minerals, calcium (80 mg), phosphorus (74 mg), iron (2.5 mg), vitamins ('A', 'B' and 'C'), carbohydrates (8 g), proteins (4.3 g), fats (0.6 g) and fiber (2 g) per 100 g of edible portion (Davis *et al*., 2000 and Gopalakrishnan, 2007). It is also cultivated in Africa, Australia and Central Asia. In India, cowpea is grown almost in all states, but the largest cultivating states are Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Kerala and Orissa. In Gujarat, it is cultivated in 27,029 hectares area with an annual production of 2,80,818

MT leading to an average productivity of 10.39 MT per hectare during 2017-18 (Anonymous, 2018). Yield in crop plants is quantitative in nature and possess very complex genetic mechanisms for its control and affected by number of factors. Owing to this, direct selection for yield is tough job and many a time may or may not be reward to improve genetic makeup of plant. Khanpara *et al.,* 2015 suggested the most desirable method for improving green pod yield is concurrent selections based on associated traits. 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). Based on the estimation of genotypic and phenotypic correlation coefficients, it may be suggested to lay more emphasis on particular characters in the selection programs aiming to improve yield in cowpea. In the present study, the estimates of correlation coefficients and path analysis for determining the contribution of various traits to cowpea yield.

The investigation was carried out at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during the summer season of 2018. It is situated at 34˚ - 32' north latitude and 72˚ - 30' east longitude with an altitude of 154.52 meter above the mean sea level. This region falls under the North Gujarat agro-climatic zone. The experimental material for the present study consisted of twelve genotypes of vegetable cowpea. List of genotypes and their sources are given below in **Table 1**. The experiment was laid out in Randomized Block Design with three replications. Analysis of variance was calculated according the method suggested by Panse and Sukhatme (1978). Six rows of each genotype were sown at the spacing of 45 cm x 15 cm in a plot of size is 5.0 m × 2.7 m. The data were recorded for plant height, the number of leaves, leaf area per plant, days to 50% flowering, harvest index, primary branches per plant, secondary branches per plant, total dry weight, chlorophyll content, N-content in plant parts, N-content in pod and protein content. Estimation of chlorophyll content

Table 1. List of genotypes and their sources

Sr. No.	Genotypes	Procured from
1.	JDNVC 15	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
2.	JDNVC 41	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
3.	JDNVC 51	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
4.	JDNVC 56	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
5.	JDNVC 63	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
6.	JDNVC 92	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
7.	GC 4	Pulse Research Station Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.
8.	GC 5	Pulse Research Station Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.
9.	GC 6	Pulse Research Station Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.
10.	Pusa Falguni	Vegetable Research Station, Anand Agricultural University, Anand.
11.	GDVC 2	Vegetable Research Scheme, Main Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan.
12.	AVCP 1	Vegetable Research Station, Anand Agricultural University, Anand.

was done using Yoshida *et al*. (1972) method in which fresh five leaves were randomly collected from upper, middle and lower part of the plant. 0.1 gm of selected leaf sample was used for chemical extraction and observed at 663 nm and 645 nm by spectronic 20 spectrophotometer. Micro Kjeldahl's method (Jackson, 1967) was used for nitrogen estimation using composite oven dried plant sample. Simple correlation coefficients between yield and yield components and inter correlation among the various components were calculated for all the possible pairs of phenotypic correlation was tested using the method suggested by Fisher and Yates (1963). The cause and effect, interrelationship between two variables cannot be estimated from simple correlation coefficient analysis. Therefore, the path coefficient analysis was carried-out according to the method suggested by Wright (1921) and used by Dewey and Lu (1959).

The analysis of variance revealed that the mean square values due to genotypes were significant for all thirteen traits indicating the presence of sufficient amount of genetic variability in the material studied. Phenotypic and genotypic correlation coefficients among thirteen quantitative and qualitative characters are presented in **Table 2.** At phenotypic level, maximum positive correlation was shown by pod yield per plant with harvest index followed by chlorophyll content, plant height, protein content of pod, nitrogen content of green pod and nitrogen content in plant parts. Whereas, negatively correlated with the number of leaves, primary branches, days to 50 percent flowering, secondary branches, total dry weight and leaf area per plant was observed. The strong associations between these traits might be due to linkage and/or pleiotropy or any other genetic reasons. For elucidating the reasons behind correlation, we need to study large segregating populations of the genotypes. Patel *et al*. (2016), Garg *et al.* (2017) and Nigude *et al.* (2004) reported similar results for plant height, days to 50 per cent flowering and harvest index and similar results were observed by Diwaker *et al.* (2018) for nitrogen content in pod and protein content in pod.

Plant height at 90 days after sowing (DAS) showed a highly significant and positive correlation with leaf area per plant followed by a significant and positive correlation with chlorophyll content. On other hand, it showed a positive correlation with the number of leaves, harvest index of green pod, nitrogen content of green pods, protein content of green pod and total dry weight of the plant. The results indicated that the number of leaves showed a highest significant and positive correlation with leaf area per plant followed by secondary branches and primary branches. Primary branches showed a highest significant and positive correlation with the secondary branches followed by leaf area. Secondary branches at 90 DAS showed a significant and negative correlation with nitrogen content of plant. The results indicated that the leaf area showed significant and negatively correlated with protein content in green pod, nitrogen content of green pod and nitrogen content in plant. Harvest index of green pod expressed a significant and positively correlated with chlorophyll content.

Table 2. Correlation coefficient of different growth characters, yield and its components and other parameters of vegetable cowpea at 90 days after sowing

		Plant height	Number of leaves	Primary branches	Secondary branches	Leaf area per plant	Total dry weight	Days to 50 % Flowering	Harvest index	Chloro-phyll content	N in plant sample	N in green pod	Protein in green pod	Total GPY per plant
Plant height	G	1.000	0.2797	-0.2442	-0.0836	0.5324	0.0327	-0.1057	0.2070	0.4477	-0.2408	0.1513	0.1547	0.3489
	P	1.000	0.2328	-0.1704	-0.0787	0.4485**	0.0243	-0.0180	0.1696	0.4148*	-0.2306	0.1513	0.1506	0.3092
Number of leaves	G		1.000	0.7407	0.6811	0.6772	-0.1577	0.1610	-0.3462	0.2647	-0.8089	-0.5468	-0.5479	-0.4031
	P		1.000	0.5296**	0.5579**	0.5787**	-0.1101	0.1464	-0.3427*	0.2285	-0.6907**	-0.5050**	-0.5095 **	-0.3813*
Primary branches	G			1.000	0.7207	0.6054	-0.2407	0.1196	-0.1376	-0.1882	-0.6095	-0.8102	-0.8098	-0.2349
	P			1.000	0.6703**	0.4856**	-0.1650	0.2226	-0.1115	-0.1588	-0.5304**	-0.6253**	-0.6313**	-0.1851
Secondary branches	G				1.000	0.2080	-0.2776	0.0065	0.0075	0.1223	-0.5448	-0.3360	-0.3361	-0.1711
	P				1.000	0.2115	-0.2421	0.0228	0.0098	0.1204	-0.5350**	-0.3093	-0.3118	-0.1540
Leaf area per plant	G					1.000	-0.0061	0.0067	-0.1914	0.0199	-0.5495	-0.6797	-0.6788	-0.0956
	P					1.000	0.0089	0.0291	-0.2077	0.0242	-0.4790**	-0.5932**	-0.5951**	-0.1032
Total dry weight	G						1.000	-0.1794	-0.5018	-0.4639	0.0717	0.0444	0.0497	-0.1711
	P						1.000	-0.0544	-0.4659**	-0.4450**	0.0419	0.0351	0.0374	-0.1458
Days to 50% Flowering	G							1.000	-0.1856	-0.2156	0.2408	-0.1051	-0.1042	-0.2999
	P							1.000	-0.1075	-0.1539	0.1495	-0.0639	-0.0744	-0.1580
Harvest index	G								1.000	0.4249	0.1005	0.3246	0.3251	0.9262
	P								1.000	0.4102*	0.0983	0.2888	0.2889	0.9195**
Chlorophyll content	G									1.000	-0.1949	0.0852	0.0857	0.3640
	P									1.000	-0.1833	0.0809	0.0807	0.3550*
Nitrogen in plant sample	G										1.000	0.5789	0.5786	0.0848
	P										1.000	0.5500**	0.5496**	0.0872
Nitrogen in Green pod	G											1.000	1.000	0.3038
	P											1.000	0.9995**	0.2829
Protein in Green pod	G												1.000	0.3063
	P												1.000	0.2847

Where, N- Nitrogen, GPY-Green pod yield

* & ** Significance at 5% & 1% probability level, respectively.

At genotypic level, maximum significant and positive correlation shown by pod yield per plant with harvest index followed by chlorophyll content and plant height. While, the number of leaves showed negative significant correlations. Plant height showed a highly positive correlated with leaf area per plant followed by chlorophyll content, the numbers of leaves and harvest index. Selvi *et. al.* (2016) reported the same results for correlations between pod yield and it component traits. Numbers of leaves per plant expressed a positive correlation with primary branches, secondary branches and leaf area per plant. The results indicated that the higher number of leaves per plant positively increase leaf area per plant. Primary branches showed a positive genotypic correlation with secondary branches, leaf area per plant and days to 50 per cent flowering. The results indicated that more number of secondary branches produce border leaves were positively correlated with chlorophyll content, harvest index and days to 50 per cent flowering. Chlorophyll content expressed positive correlation with nitrogen and protein content in green pod. The results indicated that the higher chlorophyll content in plant samples are also responsible for higher nitrogen and protein content in green pod.

Table 3. Phenotypic path analysis showing direct (diagonal and bold) and indirect effects of different characters on green pod yield per plant at 90 days after sowing.

Characters	Plant height	Number of leaves per plant	Primary branches/ plant	Secondary branches/ plant	Leaf area/ plant	Total dry weight	Days to 50 % Flowering	Harvest index	Chlorophyll content	Nitrogen in plant sample	Nitrogen in green pod	Protein in green pod
Plant height	**0.0421**	0.0098	-0.0072	-0.0033	0.0189	0.0010	-0.0008	0.0071	0.0175	-0.0097	0.0064	0.0063
Number of leaves/plant	-0.0063	**-0.0269**	-0.0143	-0.0150	-0.0156	0.0030	-0.0039	0.0092	-0.0062	0.0186	0.0136	0.0137
Primary branches	-0.0162	0.0505	**0.0953**	0.0639	0.0463	-0.0157	0.0212	-0.0106	-0.0151	-0.0506	-0.0596	-0.0602
Secondary branches	0.0122	-0.0866	-0.1040	**-0.1552**	-0.0328	0.0376	-0.0035	-0.0015	-0.0187	0.0830	0.0480	0.0484
Leaf area per plant	0.0443	0.0572	0.0480	0.0209	**0.0988**	0.0009	0.0029	-0.0205	0.0024	-0.0473	-0.0586	-0.0588
Total dry matter	0.0088	-0.0398	-0.0596	-0.0875	0.0032	**0.3612**	-0.0196	-0.1683	-0.1607	0.0151	0.0127	0.0135
Days to 50 % flowering	0.0002	-0.0016	-0.0025	-0.0003	-0.0003	0.0006	**-0.0111**	0.0012	0.0017	-0.0017	0.0007	0.0008
Harvest index	0.1799	-0.3637	-0.1183	0.0104	-0.2204	-0.4943	-0.1141	**1.0611**	0.4353	0.1043	0.3064	0.3066
Chlorophyll content	0.0395	0.0218	-0.0151	0.0115	0.0023	-0.0424	-0.0147	0.0391	0.0952	-0.0175	0.0077	0.0077
Nitrogen in plant sample	0.0033	0.0100	0.0077	0.0078	0.0069	-0.0006	-0.0022	-0.0014	0.0027	**-0.0145**	-0.0080	-0.0080
Nitrogen in Green pod	-0.1605	0.5358	0.6634	0.3281	0.6293	-0.0372	0.0678	-0.3064	-0.0858	-0.5835	**-1.0609**	-1.0604
Protein in green pod	0.1619	-0.5478	-0.6786	-0.3352	-0.6398	0.0402	-0.0800	0.3106	0.0867	0.5909	1.0745	**1.0750**
Green pod yield	0.3092	-0.3813*	-0.1851	-0.1540	-0.1032	-0.1458	-0.1580	0.9195**	0.3550*	0.0872	0.2829	0.2847

(Residual Effect = 0.1321)

* & ** Significance at 5% & 1% probability level, respectively.

The results of phenotypic path coefficient analysis given in **Table 3** indicated that the protein content of green pod had the highest positive direct effect followed by harvest index of green pod, total dry weight, leaf area per plant, primary branches, chlorophyll content and plant height on pod yield per plant. Sardana *et al.* (2007) observed similar result for primary branches per plant in pea. The average nitrogen content of proteins was found to be about 16 per cent which leads to higher protein synthesis may be the possible reason behind negative direct effect on green pod yield.

Plant height imparted a higher positive indirect effect on green pod yield per plant *via* harvest index of green pod followed by protein content in green pod, leaf area per plant, chlorophyll content, secondary branches, total dry weight, nitrogen content in plant part and days to 50 per cent flowering. Number of leaves per plant exhibited a significant and negative indirect effect on green pod yield per plant *via* protein content in green pod and harvest index of green pod. Number of leaves per plant exhibited a higher significant and positive indirect effect on nitrogen content in pod and positive indirect effect by leaf area per

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plant, primary branches per plant and chlorophyll content. Primary branches per plant was reported the highest significant and positive indirect effect via nitrogen content in green pod. Whereas, the significant and negative indirect effect of this character via protein content in green pod. Secondary branches per plant imparted significant and negative indirect effect was visible to be highest via protein content in green pod.

Leaf area per plant exhibited a significant and positive indirect effect on total green pod yield per plant was observed through nitrogen content in green pod. Whereas, the significant and negative indirect effect on green pod yield per plant via Protein content in green pod. Total dry weight imparted positive indirect effect on green pod yield per plant *via* protein content in green pod, secondary branches, the numbers of leaves, plant height, leaf area and days to 50 per cent flowering. Days to 50 per cent flowering exhibited a positive indirect effect *via,* nitrogen content in green pod, primary branches per plant leaf area per plant. While, it showed indirect low and negative indirect effects *via,* harvest index of green pod, total dry weight, plant height, protein content in green pod, chlorophyll content, the number of leaves, secondary branches and nitrogen content in plant part. Harvest index imparted high positive indirect effect on green pod yield per plant *via* protein content in green pod, chlorophyll content, the numbers of leaves, plant height and days to 50 per cent flowering. The results are in accordance with Sharma *et al.* (2009) and Patel *et al*. (2016) for plant height, Nawab *et al.* (2008) and Patel *et al*. (2018) for days to 50 per cent flowering. The low magnitude of residual effect suggests the chosen traits are sufficient for the path analysis on yield. Selvakumar and Ushakumari (2013) also observed a low magnitude of residual effect for path analysis in cowpea.

It can be concluded that the presence of genetic variability among cowpea genotypes could be used to broaden the genetic base for better use of its genetic potential for green pod yield and quality improvement in future for the number of branches, seeds per pod, nitrogen content and crude protein content etc. Primary branches, leaf area and chlorophyll content had a positive indirect effect on green pod yield. The traits that correlated in desired directions along with high direct effect such as harvest index, chlorophyll content, plant height and nitrogen content of pods, protein content of green pod, total dry weight could effectively utilized for future breeding strategies in vegetable cowpea.

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