Character associations, path analysis and molecular characterization in Cowpea (*Vigna unguiculata* L.)

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Abstract

Fifty-six diverse cowpea genotypes were assessed for associations among various agronomic characters and also path analysis for pod yield per plant. The values of genotypic correlation were higher than their corresponding phenotypic correlations. The green pod yield per plant had highly significant and positive correlations at both genotypic and phenotypic levels with pod length, 10-pod weight and number of pods per plant whereas pod width, number of seeds per pod, number of pods per cluster and 100-seed weight had positive and non-significant association with green pod yield per plant. Days to first green pod picking and plant height had negative and highly significant correlations at both genotypic and phenotypic levels with green pod yield per plant. The number of primary branches per plant had negative and non-significant association with green pod yield per plant.

The path coefficient analysis indicated that the highest positive direct as well as appreciable indirect influences were exerted by number of pods per plant, pod length and ten pod weight. However, number of pods per cluster showed moderate positive direct effect on green pod yield per plant. These results suggested that characters such as number of pods/plants, pod length, 10 pod weight and number of pod/cluster may be considered as the most important yield contributing characters and due emphasis may be given on these components while selecting for high yielding types of vegetable cowpea. Molecular characterization revealed that genotype JCPL-4 and JCPL-51are highly diverse and can be used for creating variability.

Keywords: Vegetable cowpea, correlations, green pod yield, character association, path analysis.

Introduction

Vegetable cowpea (*Vigna uniguiculata* L.) commonly known as beans is an important, versatile food crop. It is the most ancient human food. It belongs to family of *fabaceae* (*Leguminoisae*) and subfamily of *papillnoideae*. Cowpea has been intercropped for long time with various other crops such as maize, wheat, millet, sorghum. It can be utilized in various ways ranging from the use of young green seedling as vegetables and also forage for livestock to its consumption as beans. It is an excellent source of protein which is enriched by amino acids, lysine and tryptophan. In a country like India where protein malnutrition is a problem, cowpea marks its position as a cheap and reliable source of protein.

The presence of ample variability in a crop species is a pre-requisite for a successful breeding programme. Thus, an assessment of variability and estimates of breeding parameters for various traits are essential for obtaining good yield. Yield is a complex character influenced by several genetic factors interacting with environment. In order to improve yield, it is important that effective selection of traits must be carried out. For a successful selection, it is necessary to study the nature and association of the character in question with other relevant traits and also the genetic variability available for these traits.

Correlation and path analysis would give a better idea of relationship between different pair of characters. Path coefficient provides a better index for selection rather than mere correlation coefficient by separating the correlation coefficients of yield and its components into direct and indirect effects. Along with this the molecular marker characterization will help to group genotypes based on the variability at DNA level.

Material and Methods

Fifty six diverse genotypes of vegetable cowpea were sown in a randomized block design with three replications during Kharif. Each genotype was accommodated in a single row of 3 m length with a spacing of 60 × 30cm. The recommended agronomical practices and plant protection measures were followed for the successful raising of the crop. The observations were recorded on five randomly selected plants in each genotype from each replication and their mean values were used for the statistical analysis. Data was recorded for 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 seeds per pod, number of pods per cluster,10-pod weight (g), hundred fresh seeds weight (g) and green pod yield per plant (g). The data for days to 50% flowering was recorded on plot basis and data for green pod yield per plant (g) was recorded by weighing the total green tender marketable pods for each picking and summed over pickings to get total green pod yield. The total green pod yield was averaged out to compute green pod yield per plant. The rest of the morphological traits were recorded on randomly selected five competitive plants from each accession in each replicate and average value was used for the statistical analysis. The data was subjected to Analysis of Variance for randomized block design[29]. The phenotypic and

genotypic correlation coefficients among all the characters were estimated[4] and path coefficient was also calculated[6].

DNA extraction: Two to three young leaves were collected in ice cooled condition for obtaining 100 mg sample to isolate total genomic DNA using modified Tomar et al[23] method. The quantification of DNA in individual sample was performed spectrophotometrically and the quality was checked on 1.0% agarose gel to store at 4 ^{0}C for further use.

RAPD markers: RAPD primers were used for the molecular characterization of cowpea. A set of 5 primers from OPA to OPO (OPA 1, OPA 2, OPA 3, OPA 4, OPA 5, OPB 1…..to OPO4 and OPO 5) making a total of 75 primers were used.[24] PCR master mix contained 10 mM Tris HCl (pH 8.3), 1.5 mM $MgCl_2$, 10 pM primers, 10 mM dNTPs, 20 ng genomic DNA, 1 unit Taq DNA polymerase with sterile distilled water to make final volume of 20 µl. PCR condition was performed as described by Tomar et al[23] with modifications. RAPD protocol was as follows: initial denaturation at 94 ^{0}C for 7 min followed by 45 cycle of 94^{0}C for 30 sec for denaturation, annealing at Ta for 45 sec and extension at 72 ^{0}C for 2 min, final extension was done at 72^{0}C for 10 min.

Amplified products were loaded on 1.6% agarose gel containing ethidium bromide (0.5 µg/ml) and 50 bp DNA ladder which was run at 120V for 2 hrs to separate amplified products. Gel was visualized and documented using genesys gel documentation system (Syngene).

Data analysis: RAPD banding pattern was scored as present (1) and absent (0) to convert it into binary data format for analysis by PAST[7].

Results

Analysis of Variance: The data obtained for 12 characters were subjected to statistical analysis of variance which revealed highly significant differences among the genotypes for all the characters studied. The mean squares due to various sources of variation with regards to different traits *viz.* yield and component traits for cowpea are presented in table 1. Analysis of Variance revealed that highly significant differences among the genotypes were observed for all the traits. This indicates the presence of significant amount of genetic variability among the material studied.

Correlation Coefficients: The correlation coefficients were worked-out among 12 characters to find out association of pod yield per plant with its components at genotypic (rg) and phenotypic (rp) levels. The data given in table 2 revealed that in general, the phenotypic correlation coefficients were relatively higher than their corresponding genotypic correlations coefficients. The results on correlation coefficients between different pairs of characters are presented below:

The green pod yield per plant had highly significant and positive correlations at both genotypic and phenotypic levels with pod length (rg=0.3686, rp=0.3585), 10-pod weight (rg= 0.4745, rp= 0.4628) and number of pod per plant (rg=0.6333, rp= 0.6344) whereas, pod width (rg=0.2256, rp=0.2108), number of seeds per pod (rg=0.0544, rp=0.0473), number of pods per cluster (rg=0.0907, rp=0.0830) and 100-seed weight (rg=0.0542, rp=0.0539) had positive and non-significant association with green pod yield per plant.

Days to first green pod picking (rg=-0.4868, rp=-0.4652) and plant height (rg=-0.3552, rp=-0.3394) had negative and highly significant at both genotypic and phenotypic levels with green pod yield per plant while number of primary branches per plant (rg=-0.1426, rp=-0.1380) had negative and non-significant association with green pod yield per plant.

Table 1
Analysis of variance showing mean squares for 12 characters in 56 genotypes of cowpea

Source of variation	d. f.	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)
		1	2	3	4	5	6
Replications	02	13.6250*	18.0059	0.0380	50.1197*	1.8105*	0.0052*
Genotypes	55	83.1323**	110.6942**	2.6484**	135.9572**	9.9624**	0.0242**
Error	110	4.4128	7.3332	0.05116	4.9256	0.5253	0.0013

Source of variation	d. f.	Number of seeds per pod	Number of pods per cluster	10-pod weight (g)	100-seed weight (g)	Number of pods per plant	Green pod yield per plant (g)
		7	8	9	10	11	12
Replications	02	2.8191*	0.0728	2.2303	1.2457	30.0986	153.7185
Genotypes	55	4.6449**	1.6958**	390.5561**	122.1056**	392.0761**	5957.2137**
Error	110	0.2267	0.0610	5.8059	1.3837	11.2755	274.8938

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

Table 2
Genotypic (r_g) and phenotypic (r_p) correlation coefficients among 12 characters in vegetable cowpea

Characters		Days to 50% flowering	Days to first green pod picking	No. of primary branches/ plant	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds /pod	No. of pods/ cluster	10-pod weight (g)	Hundred fresh seeds weight (g)	No. of pods/ plant
Green pod yield/plant (g)	r_g	-0.2583	-0.4868**	-0.1426	-0.3552**	0.3686**	0.2256	0.0544	0.0907	0.4745**	0.0542	0.6333**
	r_p	-0.2508	-0.4652**	-0.1380	-0.3394*	0.3585**	0.2108	0.0473	0.0830	0.4628**	0.0539	0.6344**
Days to 50% flowering	r_g		0.7853**	0.0866	0.1379	0.0937	-0.3045*	0.2890*	0.0504	-0.0068	0.3765**	-0.3006*
	r_p		0.7578**	0.0899	0.1276	0.0860	-0.2850*	0.2702*	0.0508	-0.0076	0.3628**	-0.2859*
Days to first green pod picking	r_g			0.2643*	0.2570	-0.0195	-0.2728*	0.2142	-0.0365	-0.0748	0.3090*	-0.4336**
	r_p			0.2488	0.2388	-0.0207	-0.2540	0.1999	-0.0335	-0.0689	0.2971*	-0.4154**
No. of primary branches /plant	r_g				0.7215**	-0.0442	-0.0217	0.2096	0.3617**	-0.0209	-0.0407	-0.1768
	r_p				0.7114**	-0.0415	-0.0207	0.2073	0.3544**	-0.0205	-0.0409	-0.1725
Plant height (cm)	r_g					-0.1683	-0.0761	-0.0198	0.2777*	-0.2008	-0.0262	-0.4195**
	r_p					-0.1621	-0.0775	-0.0150	0.2703*	-0.1953	-0.0270	-0.4039**
Pod length (cm)	r_g						0.3552**	0.2511	-0.0985	0.4676**	0.1744	-0.0660
	r_p						0.3459**	0.2495	-0.0920	0.4528**	0.1713	-0.0536
Pod width (cm)	r_g							0.2723*	-0.2267	0.1842	-0.0513	0.0815
	r_p							0.2644*	-0.2165	0.1741	-0.0492	0.0750
No. of seeds/pod	r_g								0.2162	0.1788	0.0144	0.0826
	r_p								0.2051	0.1744	0.0161	0.0747
No. of pods/cluster	r_g									-0.0422	-0.0472	0.0031
	r_p									-0.0403	-0.0466	0.0004
10-pod weight (g)	r_g										0.4079	0.2975*
	r_p										0.4025	0.2912*
Hundred fresh seeds weight (g)	r_g											0.0280
	r_p											0.0267

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

The days to 50% flowering had highly significant and positive correlations at both genotypic and phenotypic levels with days to first green pod picking (rg=0.7853, rp=0.7578) and 100- seed weight (rg=0.3765, rp=0.3628). The days to 50% flowering exhibited significant and positive correlation at genotypic and phenotypic levels with number of seeds per pod. The days to 50% flowering exhibited significant but negative correlation at both genotypic and phenotypic levels with pod width (rg =-0.3045, rp=-0.2850) and number of pods per plant (rg=-0.3006, rp=-0.2859).

The days to first green pod picking had positive and significant correlations at both genotypic and phenotypic levels with 100-seed weight (rg=0.3090, rp=0.2971) and significant and positive at genotypic level with number of primary branches per plant (rg=0.2643). The days to first green pod picking showed significant negative association with number of pods per plant (rg=-0.4336, rp=-0.4154) at both genotypic and phenotypic levels while with pod width (rg=-0.1718) only at genotypic level.

The number of primary branches per plant exhibited highly significant and positive correlation with plant height (rg=0.7215, rp=0.7114) and number of pods per cluster (rg=0.3617, rp=0.3544) at the genotypic and phenotypic levels. The plant height exhibited significant and positive association with number of pods per cluster (rg=0.2777, rp=0.2703) at genotypic and phenotypic levels. While number of pods per plant (rg=-0.4195, rp=-0.4039) had highly significant and negative correlation at genotypic and phenotypic levels with plant height.

Pod length exhibited highly significant and positive correlations with pod width (rg=0.3552, rp=0.3459) and 10-pod weight (rg=0.4676, rp=0.4528) at both genotypic and phenotypic levels. The pod width was significantly and

positively correlated with the number of seeds per pod (rg=0.2723, rp=0.2644) at both genotypic and phenotypic levels.

The number of seeds per pod was non-significantly and positively correlated with the number of pods per cluster, 10-pod weight, 100-seed weight and number of pods per plant at both the genotypic and phenotypic levels. Number of pods per cluster showed non-significantly correlations with 10-pod weight, 100-seed weight and number of pods per plant at both genotypic and phenotypic levels.

The 10-pod weight showed highly significant and positive correlations with 100-seed weight (rg=0.4079, rp=0.4025) at both genotypic and phenotypic levels and significant and positive correlation with number of pods per plant (rg=0.4079, rp=0.4025). The interrelationship between 100-seed weight and number of pods per plant was found to be positive and non-significant at both genotypic and phenotypic levels.

Path Coefficient Analysis: The genotypic correlation coefficients calculated for different pairs of character were subjected to path coefficient analysis for partitioning these values into the direct and indirect effects. The character which had shown significant genotypic correlation with pod yield per plant was considered for path coefficient analysis. The results obtained for direct and indirect effects of different characters on pod yield are presented in table 3.

Days to first picking had negative and significant correlation with pod yield per plant (rg= -0.4868) and its direct effect was negative and high in magnitude (-0.3472). This character showed low and positive indirect effects via number of pods per plant (0.1506). This trait showed low and positive indirect effects via pod length (0.0068), pod width (0.0947), number of pods per cluster (0.0.0127) and 10-pod weight (0.0260) while number of primary branches per plant (-0.0918), plant height (-0.0892) and number of seeds per pod (-0.0744) showed low and negative indirect effects.

This character showed moderate and negative indirect effects via days to 50% flowering (-0.2727) and low with 100-seed weight (-0.1073). The correlation coefficient between plant height and pod yield per plant was negative (rg= -0.3552) and its direct effect was negative and low in magnitude (-0.1072).

Table 3
Genotypic path coefficient analysis showing direct (diagonal) and indirect effects of different characters on total green pod yield per pod in vegetable cowpea

Characters	Days to 50% flowering	Days to first green pod picking	No. of primary branches/ plant	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds /pod	No. of pods /cluster	10-pod weight (g)	Hundred fresh seeds weight (g)	No. of pods /plant	Green pod yield /plant (g)
Days to 50% flowering	**0.2298**	0.1804	0.0199	0.0317	0.0215	-0.0700	0.0664	0.0116	-0.0016	0.0865	-0.0691	-0.2583
Days to first green pod picking	-0.2727	**-0.3472**	-0.0918	-0.0892	0.0068	0.0947	-0.0744	0.0127	0.0260	-0.1073	0.1506	-0.4868**
No. of primary branches/ plant	0.0079	0.0241	**0.0913**	0.0659	-0.0040	-0.0020	0.0191	0.0330	-0.0019	-0.0037	-0.0161	-0.1426
Plant height (cm)	-0.0148	-0.0276	-0.0774	**-0.1072**	0.0180	0.0082	0.0021	-0.0298	0.0215	0.0028	0.0450	-0.3552**
Pod length (cm)	0.0290	-0.0060	-0.0137	-0.0522	**0.3099**	0.1101	0.0778	-0.0305	0.1449	0.0541	-0.0205	0.3686**
Pod width (cm)	-0.0273	-0.0245	-0.0019	-0.0068	0.0319	**0.0897**	0.0244	-0.0203	0.0165	-0.0046	0.0073	0.2265
No. of seeds/pod	-0.0481	-0.0357	-0.0349	0.0033	-0.0418	-0.0453	**-0.1665**	-0.0360	-0.0298	-0.0024	-0.0138	0.0544
No. of pods/cluster	0.0077	-0.0056	0.0556	0.0427	-0.0151	-0.0348	0.0322	**0.1536**	-0.0065	-0.0073	0.0005	0.0907
10-pod weight (g)	-0.0012	-0.0133	-0.0037	-0.0357	0.0831	0.0327	0.0318	-0.0075	**0.1777**	0.0725	0.0529	0.4745**
Hundred fresh seeds weight (g)	-0.0190	-0.0156	0.0021	0.0013	-0.0088	0.0026	-0.0007	0.0024	-0.0205	**-0.0504**	-0.0014	0.0542
No. of pods/plant	-0.1497	-0.2159	-0.0880	-0.2089	-0.0329	0.0406	0.0411	0.0016	0.1481	0.0140	**0.4979**	0.6333**

*, ** Significant at 5 % and 1% levels respectively
Residual effect, R = 0.5735
N.B.: Values at diagonal indicate direct effects of respective characters

The plant height exerted low and negative indirect effects on pod yield via days to 50% flowering (-0.0148), days to first picking (-0.0276), number of primary branches per plant (-0.0774) and number of pods per cluster (-0.0298). Plant height contributed towards pod yield per plant through low but positive indirect effects via pod length (0.0180), pod width (0.0082), number of seeds per pod (0.0021), 10-pod weight (0.0215), 100-seed weight (0.0028) and number of pods per plant (0.0450).

In spite of positive correlation coefficient between pod length and pod yield per plant (rg= 0.3686), its direct effect on pod yield per plant was also positive and high (0.3099). The pod length had low and positive indirect effect on pod yield via pod width (0.1101) and 10-pod weight (0.1449) while days to 50% flowering (0.0290), number of seeds per plant (0.0778) and 100-seed weight (0.0541) had low and positive indirect effect indirect effects on pod yield. This character showed low and negative indirect effect via days to first picking (-0.0060), number of primary branches per plant (-0.0137), plant height (-0.0522), number of pods per cluster (-0.0305) and number of pods per plant (-0.0205).

The correlation coefficient between 10-pod weight positively and highly significantly correlated with pod yield per plant (rg=0.4745) and also manifested low and positive direct effect (0.1777) on pod yield per plant. This trait exhibited low and negative indirect effects via days to 50% flowering (-0.0012), days to first picking (-0.0133), number of primary branches per plant (-0.0037), plant height (-0.0357) and number of pods per cluster (-0.0075) while pod length (0.0831), pod width (0.0327), number of seeds per plant (0.0318), 100-seed weight (0.0725) and number of pods per plant (0.0529) showed low and positive indirect effects.

The number of pods per plant vs pod yield per plant exhibited positive and significant genotypic correlation (rg=0.6333) and also exerted high and positive direct effect (0.4979) on pod yield per plant. This character contributed positive indirect effect towards the pod yield mainly through 10-pod weight (0.1481), pod width (0.0406), number of seeds per pod (0.0411), number of pods per cluster (0.0016) and 100-seed weight (0.0140). This character showed low and negative indirect effect via days to 50% flowering (-0.1497), days to first picking (-0.2159) and plant height (-0.2089) while number of primary branches per plant (-0.0880) and pod length (-0.0329) low and negative indirect effect on pod yield per plant.

Molecular Characterization: Dendrogram construction based upon molecular marker showed Jaccard's similarity range from 10.00% to 85.00% and bifurcated into five main clusters (Figure 1). Out of fifty six genotypes under study, three genotypes JCPL-1, JCPL-2 and JCPL-3 formed a single cluster while JCPL-4 and JCPL-51 were alone and diverse from all other genotype. Rest of the 51 genotype were clustered into two groups. The genotypes JCPL-4 and JCPL-51 were diverse and can be used in the breeding programme for creating variability.

Discussion

The data obtained for 12 characters subjected to Analysis of Variance revealed highly significant differences among the genotypes for all the characters studied. The mean squares due to various sources of variation with regards to different traits *viz.* yield and component traits for cowpea. The correlation coefficients were worked out among 12 characters to find out association of pod yield per plant with its components at genotypic (rg) and phenotypic (rp) levels (Table 2). The phenotypic correlation coefficients were relatively higher than their corresponding genotypic correlations coefficients. In the present study, green pod yield per plant was found to be significantly and positively correlated with pod length, ten pod weight and number of pods per plant at both genotypic and phenotypic levels. Such positive interrelationship between green pod yield per plant and these attributes has also been reported in vegetable cowpea by several researchers.

The positive genotypic association has been reported between green pod yield per plant and pod length[16,17]; ten pod weight[12] and number of pods per plant[17,18]. Thus, on the basis of correlations pod length, ten pod weight and number of pods per plant were proved to be the outstanding characters influencing green pod yield in vegetable cowpea and need to be given importance in selection to achieve higher green pod yield.

In the present study, green pod yield per plant was found to be significantly and negatively correlated with plant height and first green pod picking. The negative genotypic association has been reported between green pod yield per plant and days to first picking[16] and plant height[3]. It means that green pod yield per plant can be improved by selecting genotype which has moderate height and gives pickings early so that produce can be marketed as soon as possible. Remaining characters viz. days to 50% flowering, pod width, number of pods per cluster, number of primary branches per plant, number of seeds per pod and hundred seed weight did not show any significant relationship with green pod yield per plant.

Characters like days to 50% flowering had significant and positive correlation with days to first green pod picking, number of seeds per pod and hundred seed weight. The character of days to 50% flowering has negative and significant correlation with pod width and number of pods per plant. The negative and significant relation between days to 50% flowering and number of pods per plant was reported[1,25]; days to first picking had negative and significant correlation at both genotypic and phenotypic levels with green pod yield per plant and numbers of pods per plant.

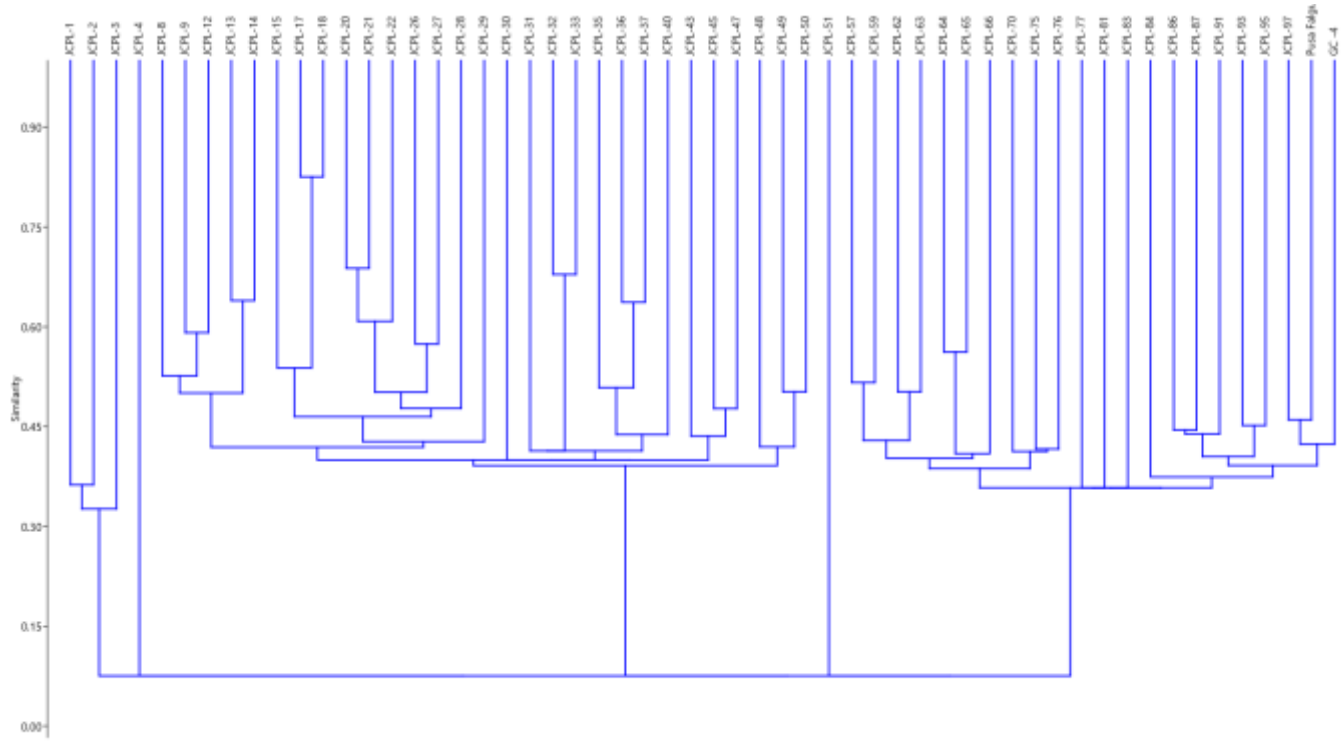

Figure 1: Dedogram based on RAPD characterization of cowpea

The negative genotypic association has been reported between days to first picking and green pod yield per plant and number of pods per plant [9,15].

The character number of primary branches per plant had positive and significant relation with plant height. The positive and significant association has been reported for plant height and number of primary branches per plant[3.] Plant height had negative and significant correlation with number of pods per plant. Similar results had been reported,[3] however contrary result has been reported[18]. The character pod length had been found positively and significantly correlated with pod width and ten pod weight similar results had been obtained[3,25].

The character pod width had positive and significant relation with number of seed per pod; similar results have been reported in literature[3] but a negative relationship has also been reported[25]. The character ten pod weight had a positive and significant relation with number of pods per plant, similar results have been reported [3,12].

The present results on correlation coefficient thus revealed that the number of pods per plant, ten pod weight and pod length were the most important attributes and may contribute considerably towards higher green pod yield. The interrelationship among yield components would help in increasing the yield levels and therefore, more emphasis should be given to these components while selecting better types in vegetable cowpea. In the present study, the path coefficient analysis revealed that number of pods per plant, pod length and ten pod weight exhibited high and positive direct effects on green pod yield per plant (Table 3). 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[9,14,21,22,27] for number of pods per plant[2,8,28] for pod length[25] for ten pod weight.

Days to first picking had negative and significant correlation with pod yield per plant and its direct effect was negative and high in magnitude. This character showed low and positive indirect effects via number of pods per plant. This trait showed low and positive indirect effects via pod length, pod width, number of pods per cluster and 10-pod weight while number of primary branches per plant, plant height and number of seeds per pod showed low and negative indirect effects. This character showed moderate and negative indirect effects via days to 50% flowering and low with 100-seed weight.

Similarly, correlation coefficient between plant height and pod yield per plant was negative and its direct effect was negative and low in magnitude. The plant height exerted low and negative indirect effects on pod yield via days to 50% flowering, days to first picking, number of primary branches per plant and number of pods per cluster.

Pod length had high and positive correlation with pod yield per plant and its direct effect on pod yield per plant was also positive and high. The pod length had low and positive indirect effect on pod yield via pod width and 10-pod weight while days to 50% flowering, number of seeds per plant and

100-seed weight had low and positive indirect effect indirect effects on pod yield.

Conclusion

The correlation coefficient between 10-pod weight was positively and highly significantly correlated with pod yield per plant and also manifested low and positive direct effect on pod yield per plant.

The number of pods per plant vs. pod yield per plant exhibited positive and significant genotypic correlation and also exerted high and positive direct effect on pod yield per plant. This character contributed positive indirect effect towards the pod yield mainly through 10-pod weight, pod width, number of seeds per pod, number of pods per cluster and 100-seed weight. This character showed low and negative indirect effect via days to 50% flowering, days to first picking and plant height while number of primary branches per plant and pod length low and negative indirect effect on pod yield per plant.

Thus, we can conclude from path analysis that characters with maximum direct and indirect effects are pod length, ten pod weight and number of pods per plant. These characters also exhibited significant and positive association 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.

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(Received 02nd March 2020, accepted 10th May 2020)