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Full Research Article

Correlation and Path Co-efficient Analysis for Yield and it's Attributing Traits in Diverse Genotypes of Cowpea (*Vigna unguiculata* L.)

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Abstract

The present investigation was conducted at Vegetable Research Farm, Collage of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), during *kharif* season of 2014-15. The experimental material consisting of 15 genotypes of cowpea laid out in Randomized Complete Block Design with three replications. The present study resulted that, significant positive phenotypic correlation of pod yield plant^{-1} was observed with pods plant^{-1} (0.589), days to first flowering (0.415), seeds pod^{-1} (0.395), number of flower cluster plant^{-1} (0.372) and pod length (0.304). Seed yield plant^{-1} was resulted significant and positive correlation with pod yield plant^{-1} (0.395) indicating that these characters are the primary yield determinant in cowpea. Path coefficient analysis of different characters contributing towards pod yield plant^{-1} resulted that number of pods plant^{-1} (2.108) had highest positive direct effect followed by pod weight (2.054), number of flower cluster^{-1} (0.347), pod width (0.298), number of branches at 90 DAS (0.256), number of flower cluster plant^{-1} (0.154), days to first picking (0.128), plant height at 90 DAS (0.081) and pod length (0.033). Whereas, days to first flowering (-0.061) had the maximum negative direct effect on pod yield plant^{-1} followed by days to 50% flowering (-0.121), number of seeds pod^{-1} (-0.563) and pods cluster^{-1} (-0.712). Hence, simultaneous selection for these characters can be made for the improvement of cowpea yield.

1. Introduction

Cowpea [*Vigna unguiculata* (L.) Walp](2n=22) belong to family Leguminosae also known as southern pea and black eye pea, is one of the most important vegetables. It is cultivated for its long, green or purplish pods to be cooked as vegetable or for dry seeds used as pulse. Its foliage is also used as fodder or green manure, producing 20-30 cm elongated kidney shaped, 8-12 mm long seeds. Cowpea is commonly cultivated as a nutritious and highly palatable food source in Asia and throughout the tropics and sub-tropics. Green pod of cowpea contains (85 g) moisture, (3.0 g) protein, (1.0 g) minerals, (2.0 g) fiber, (8.0 g) carbohydrates, (72 mg) calcium, (59 mg) phosphorus, (2.0 mg) iron, (0.09 mg) riboflavin and (0.07 mg) thiamin 100 g^{-1} of edible portion (Anonymous, 2011).

Phenotypic correlations of yield with growth attributes and path analysis become useful tools for crop improvement programmes to select the desirable traits (Ahmed and Kamaluddin, 2013). However, little information is available on these aspects in cowpea. Keeping in view, the present study was undertaken to quantify the correlation and path analysis of yield and yield attributing traits to facilitate desirable selection based on component traits in cowpea breeding program.

2. Materials and Methods

2.1. Study site

The present investigation was conducted at Vegetable Research Farm, Department of Horticulture, JNKVV, Jabalpur (M.P), during *Kharif* season of 2014-2015. Jabalpur is situated in Kymore plateau and Satpura Hills agro-climatic region of Madhya Pradesh. It falls on 23.9° N latitude and 79.58° E longitudes with an altitude of 411.8 m above mean sea level. The average annual rainfall is about 1375 mm and minimum and maximum temperature ranged from 6.8 to 46.6 °C.

2.2. Method of data collection

The experimental material consisting of 15 genotypes including 2 checks (2011/COPBVAR-7, 2012/COPBVAR-1, 2012/COPBVAR-2, 2012/COPBVAR-3, 2012/COPBVAR-5, 2012/

COPB VAR-6, 2014/COPBVAR-1, 2014/COPBVAR-2, 2014/COPBVAR-3, 2014/COPBVAR-4, 2014/COPBVAR-5, 2014/COPBVAR-6, Arka Gomti, Kashi Kanchan (Check)- IIVR Varanasi and Arka Garima (Check)-IIHR Bangalore) of Cowpea were sown on plot size of 3.0×2.4 m^2 in a Randomized Complete Block Design (RCBD) with 3 replications. The row and plant spacing was maintained at 60×30 cm^2 respectively and the objectives were to estimate the correlation and Path analysis of yield and it's attributing traits in Cowpea. The data recorded on various parameters viz., plant height (cm), number of branches $plant^{-1}$, days to first flowering, days to 50% flowering, number of flowers $cluster^{-1}$, number of flower clusters $plant^{-1}$, days to first picking, number of pods $plant^{-1}$, pod length (cm), pod width (cm), pod weight (g), number of seeds pod^{-1}, pod yield $plant^{-1}$ (g), pod yield $plot^{-1}$ (k), pod yield ha^{-1} (q), flower colour, (white/purple/light purple), pod shape (straight/slightly curved/curved), pod colour (dark green/Light green/Green), stringiness in pods (fiber present/fiber absent), flesh in pods (fleshy/non fleshy) and seed colour (light maroon/maroon/creamish).

The statistical analysis as correlation coefficients were calculated in all possible combinations taking all the characters into consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller et al. (1958) and the phenotypic correlations were tested for their significance by using *t* test. Path co-efficient analysis was worked out to show the cause and effect relationship between yield and various yield components and to partition the total correlation coefficient into direct and indirect effects. This procedure was developed by wright (1921) and as per consent used by Dewey and Lu (1959).

3. Results and Discussion

3.1. Correlation co-efficient

The magnitude of genotypic correlation was higher than the phenotypic correlation for all the traits that indicated inherent association between various characters (Table 1). The findings were in agreement to Pathak and Jamwal (2002); Venkatesan et al. (2003). In the present findings significant positive phenotypic correlation of pod yield $plant^{-1}$ was observed with pod $plant^{-1}$ (0.589), days to first flowering (0.415), seeds pod^{-1} (0.395), number of flower cluster $plant^{-1}$ (0.372), pod length (0.304) indicating that these characters are the primary yield determinant in cowpea. These findings corroborated the earlier findings of Pathak and Jamwal (2002); Kutty et al. (2003); Lal et al. (2007); Singh et al. (2011) for pod weight and number of pods $plant^{-1}$. Venkatesan et al. (2003) for number of pods $cluster^{-1}$ and number of pod $plant^{-1}$, Singh et al. (2004); Anbumalarmathi et al. (2005); Sharma et al. (2007); Manggoel et al. (2012) for number of pods $plant^{-1}$. Plant height at 30 DAS showed significant and positive correlation with plant height at 90 DAS (0.546), number of branches $plant^{-1}$ at 30 DAS (0.389), plant height at 60 DAS (0.350) and pod weight (0.304). Significant and negative association of this character was observed with number of flower cluster $plant^{-1}$ (-0.340) and pods $plant^{-1}$ (-0.372). Correlation coefficient of plant height at 60 DAS showed highly significant and positive with number of branches $plant^{-1}$ at 60 DAS (0.511), number of branches $plant^{-1}$ at 90 DAS (0.422), plant height at 90 DAS (0.406), number of branches $plant^{-1}$ at 30 DAS (0.314). Plant height at 90 DAS expressed a highly significant and positive correlation coefficient with number of branches $plant^{-1}$ at 90 DAS (0.537), number of branches $plant^{-1}$ at 60 DAS (0.458), number of branches $plant^{-1}$ at 30 DAS (0.443), pods $cluster^{-1}$ (0.391) and pod length (0.309). But it was exhibited significant and negative with number of flower cluster $plant^{-1}$ (-0.388) and pods $plant^{-1}$ (-0.361). Similar observations were documented by Pathak and Jamwal (2002); Alege and Singh (2007); Nehru et al. (2009) for plant height. Number of branches $plant^{-1}$ at 30 DAS expressed significant and positive correlation with number of branches $plant^{-1}$ at 60 DAS (0.501), number of branches $plant^{-1}$ at 90 DAS (0.501), pods $cluster^{-1}$ (0.500) and flower $cluster^{-1}$ (0.420), while, it was found significant and negative correlation with other traits like days to first flowering (-0.454) and days to 50% flowering (-0.423). Number of branches $plant^{-1}$ at 60 DAS expressed significantly and positively associated with number of branches $plant^{-1}$ at 90 DAS (0.732), pods $cluster^{-1}$ 0.416) and flower $cluster^{-1}$ (0.377), while, it was found significant and negative association with days to 50% flowering (-0.421) and pod weight (-0.296). Number of branches $plant^{-1}$ at 90 DAS expressed significantly and positively associated with pod length (0.387) and pods $cluster^{-1}$ (0.334), while, it was found significant and negative with days to 50% flowering (-0.429). The results are in propinquity with of Venkatesan et al. (2003); Singh et al. (2004); Alege (2007); Rani et al. (2011); Nath et al. (2014).

Association of days to first flowering was recorded significant and positive with days to 50% flowering (0.428), while, it was found significant and negative with number of flower $cluster^{-1}$ (-0.312) and number of pods $cluster^{-1}$ (-0.307). These results are in close harmony with the findings of Pathak and Jamwal (2002); Correa et al. (2010). Days to 50% flowering was recorded highly significant and positive with pods yield $plant^{-1}$ (0.415) and pod width (0.330). It was observed significant and negative with flower $cluster^{-1}$ (-0.447). These results are in close harmony with the findings of Singh et al. (2004). The correlation coefficient of number of flower $cluster^{-1}$ was found significant and positive correlation with number of pods $cluster^{-1}$ (0.785). Also, significant and negative association was exhibited with number of flower cluster $plant^{-1}$ (-0.506) and pod

Table 1: Estimates of genotypic and phenotypic correlation coefficients among yield and its contributing traits in cowpea

Character		PHT (cm)			NBPP			DFF	DFPF	FCL	NFCLPP	DFP	PCL	PPP	PL (cm)	PW (cm)	PWT	SPP	PYPP
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS												
PHT 30 DAS	G	1.000	0.474	0.766	0.796	0.424	0.532	-0.821	-0.304	0.203	-0.549	-0.287	0.494	-0.507	0.371	0.222	0.427	0.009	-0.160
	p	1.000	0.350*	0.546***	0.389**	0.214	0.170	-0.267	-0.012	0.004	-0.340*	-0.036	0.272	-0.372*	0.272	0.111	0.304*	-0.028	-0.153
PHT 60 DAS	G		1.000	0.634	0.718	0.784	0.765	-0.211	-0.230	0.114	-0.153	-0.143	0.450	0.040	0.320	-0.030	-0.092	-0.221	0.100
	P		1.000	0.402**	0.314*	0.511***	0.422**	0.016	-0.161	0.089	-0.056	-0.142	0.282	0.057	0.217	-0.044	-0.091	-0.203	0.120
PHT 90 DAS	G			1.000	0.656	0.572	0.6968	-0.208	-0.210	0.296	-0.446	-0.129	0.475	-0.381	0.334	0.255	0.251	0.037	-0.246
	P			1.000	0.443**	0.458**	0.537***	-0.155	-0.128	0.202	-0.388**	-0.097	0.391**	-0.361*	0.309*	0.226	0.252	0.067	-0.230
NBPP 30 DAS	G				1.000	1.040	0.661	-0.673	-0.715	0.902	-0.407	0.005	0.848	-0.089	-0.093	-0.083	-0.219	-0.310	-0.336
	P				1.000	0.501***	0.501*	-0.454**	-0.423**	0.420**	-0.265	-0.016	0.500***	-0.040	-0.040	0.021	-0.118	-0.260	-0.155
NBPP 60 DAS	G					1.000	0.880	-0.548	-0.737	0.448	-0.038	-0.021	0.472	0.169	0.193	-0.362	-0.299	-0.095	-0.003
	P					1.000	0.732***	-0.198	-0.421**	0.377*	-0.075	0.021	0.416**	0.125	0.125	-0.274	-0.296*	-0.135	-0.044
NBPP 90 DAS	G						1.000	-0.284	-0.574	0.326	-0.228	-0.275	0.380	-0.089	0.526	-0.273	0.046	0.026	-0.006
	P						1.000	-0.180	-0.429**	0.262	-0.201	-0.152	0.334*	-0.129	0.387**	-0.156	0.013	0.053	-0.145
DFF	G							1.000	0.812	-0.483	0.150	-0.223	-0.408	0.144	-0.072	0.215	-0.004	-0.010	0.234
	P							1.000	0.428**	-0.312*	0.163	-0.130	-0.307*	0.125	-0.049	0.121	0.007	-0.049	0.195
DFPF	G								1.000	-0.529	0.215	0.225	-0.310	0.135	-0.227	0.520	0.124	-0.194	0.564
	P								1.000	-0.447**	0.159	0.232	-0.214	0.136	-0.194	0.330*	0.086	-0.143	0.415**
FCL	G									1.000	-0.544	0.067	0.861	-0.129	-0.338	0.294	-0.068	-0.351	-0.281
	P									1.000	-0.506***	0.007	0.785***	-0.094	-0.310*	0.267	-0.085	-0.255	-0.171

Continue....

character		PHT (cm)			NBPP			DFF	DFPF	FCL	NFCLPP	DFP	PCL	PPP	PL (cm)	PW (cm)	PWT	SPP	PYPP
		30DAS	60DAS	90 DAS	30DAS	60 DAS	90 DAS												
NFCLPP	G										1.000	0.547	-0.600	0.841	-0.286	-0.580	-0.753	-0.186	0.481
	P										1.000	0.407**	-0.610***	0.763***	-0.263	-0.533***	-0.664***	-0.129	0.372*
DFP	G											1.000	-0.015	0.593	-0.496	0.018	-0.518	-0.110	0.391
	P											1.000	0.062	0.462**	-0.415**	0.009	-0.429**	-0.043	0.222
PCL	G												1.000	-0.098	-0.315	0.582	0.053	-0.459	0.012
	P												1.000	-0.087	-0.296*	0.502***	0.039	-0.351*	0.014
PPP	G													1.000	-0.641	-0.313	-0.918	-0.515	0.550
	P													1.000	-0.610***	-0.295*	-0.871***	-0.467**	0.589***
PL (cm)	G														1.000	-0.328	0.571	0.567	-0.371
	P														1.000	0.300*	0.554***	0.493***	0.304*
PW (cm)	G															1.000	0.500	-0.157	0.221
	P															1.000	0.472**	-0.099	0.145
PWT	G																1.000	0.519	-0.234
	P																1.000	0.464**	-0.232
SPP	G																	1.000	-0.414
	P																	1.000	0.395**
PYPP	G																		1.000
	P																		1.000

length (-0.310). The correlation coefficient of number of flower cluster plant^{1} was found significant and positive correlation with pods plant^{-1} (0.763), days to first picking (0.407), and pod yield plant^{-1} (0.372), while, it was exhibited significantly and negatively association with pod weight (-0.664), pods cluster^{-1} (-0.610) and pod length (-0.533). These results are in close harmony with the findings of Venkatesan et al. (2003); Lal et al. (2007); Prasad et al. (2013). Days to first picking was recorded highly significant and positive association with pods plant^{-1} (0.462), while, it was found significant and negative with pod weight (-0.429) and pod length (-0.415). Similar finding also published by Pathak and Jamwal (2002); Kutty et al. (2003); Venkatesan et al. (2003); Nath et al. (2014).

The correlation coefficient of number of pods cluster^{-1} was found significant and positive correlation with pod width (0.502). Also, significant and negative association was exhibited with number of seeds pod^{-1} (-0.351) and pod length (-0.296). The correlation coefficient of number of pods plant^{-1} was found significant and positive correlation with pod yield plant^{-1} (0.589). Also, significant and negative association was exhibited with pod weight (-0.871), pod length (-0.610), seeds pod^{-1} (-0.467) and pod width (-0.295) was previously reported by of Dahiya et al. (2007); Cholin et al. (2012). Pod length was recorded highly significant and positive association with pod weight (0.554), seeds pod^{-1} (0.493), pod yield plant^{-1} (0.304) and pods width (0.300). Pod width showed significant and positive correlation with pod weight (0.472). These results are in close harmony with the findings of Pathak and Jamwal (2002) for pod weight and length. Pod weight expressed highly significant and positive association with number of seeds pod^{-1} (0.464) was previously reported by Pathak and Jamwal (2002), Kutty et al. (2003); Lal et al. (2007); Dahiya et al. (2007); Baghizadeh et al. (2010). The correlation coefficient of seed yield plant^{-1} was found significant and positive correlation with pod yield plant^{-1} (0.395). The results are in propinquity with the findings of Pathak and Jamwal (2002); Alege et al. (2007); Sharma et al. (2007).

3.2. Path co-efficient analysis

Path coefficient analysis is a powerful tool, which enable portioning of the given relationships in its further components. It helps in understanding the causal system in a better way because it enables partitioning the total correlations coefficient into direct and indirect effects of various characters. In the present investigation, path co-efficient analysis (Table 2 and 3). was carried out for characters under study using genotypic and phenotypic correlation coefficient and taking pod yield plant^{-1} as dependable variable, in order to see the causal factor and so as to identify the components which are responsible for producing pod yield plant^{-1}. In general the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects.

Path coefficient analysis of different characters contributing towards pod yield plant^{-1} showed that number of pods plant^{-1} (2.108) had highest positive direct effect followed by pod weight (2.054), number of flower cluster^{-1} (0.347), pod width (0.298), number of branches at 90 DAS (0.256), number of flower cluster plant^{-1} (0.154), days to first picking (0.128), plant height at 90 DAS (0.081) and pod length (0.033). Whereas, days to first flowering (-0.061) had the highest negative direct effect on pod yield plant^{-1} followed by days to 50% flowering (-0.121), number of seeds pod^{-1} (-0.563) and pods cluster^{-1} (-0.712). The results are in propinquity with for number of pods plant^{-1} and pod length, Mittal and singh (2005); Lal et al. (2007) for pod length, Sharma et al. (2007) for plant height, pods plant^{-1} and pod length, Nawab et al. (2008); Singh et al. (2011); Sapara et al. (2014) for number of pods plant^{-1} and pod length.

Plant height at 90 DAS imparted highest positive indirect effect on pod yield plant^{-1} through, number of branches at 90 DAS (0.056), pods cluster^{-1} (0.038), pod length (0.027), flower cluster^{-1} (0.024), pod width (0.020) and pod weight (0.020). Whereas, negative indirect effect was visible to be highest via days to first picking (-0.010), days to first flowering (-0.017), days to 50% flowering (-0.017), pods plant^{-1} (-0.031) and number of flower cluster plant $^{-1}$ (-0.036). Number of branches plant^{-1} at 90 DAS exhibited highest positive indirect effect pod yield plant^{-1} via plant height at 90 DAS (0.174), pod length (0.131), pods cluster^{-1} (0.095), and flower cluster^{-1} (0.081). Whereas, it was expressed high negative indirect effect via pods plant^{-1} (-0.022), number of flower cluster plant^{-1} (-0.057), pods width (-0.068), days to first picking (-0.069), days to first flowering (-0.071) and days to 50% flowering (-0.143). Similar results also reported by Venkatesan et al. (2003); Mittal (2007), Nawab et al. (2008); Singh et al. (2011); Sapara et al. (2014). Days to first flowering was reported to have highest positive indirect effect on pod yield plant^{-1} through, number of flower cluster^{-1} (0.029), pods cluster^{-1} (0.025), number of branches at 90 DAS (0.017), days to first picking (0.013) and plant height at 90 DAS (0.012). Whereas, it was expressed high negative indirect effect by remaining characters. Similar observations were documented by Pathak and Jamwal (2002); Alege and Singh (2007); Nehru et al. (2009); Prasad et al. (2013). Days to 50% flowering was reported to have highest positive indirect effect on pod yield plant^{-1} through, number of branches plant^{-1} at 90 DAS (0.069), followed by flower cluster^{-1} (0.064), pods cluster^{-1} (0.037), pod length (0.027), plant height at 90 DAS

Table 2: Phenotypic path coefficients showing direct and indirect effects of different characters on pod yield plant^{-1} (g)

Character	Plant height at 90 DAS	No. of branch at 90 DAS	Days to first flowering	Days to 50% flowering	Flowers cluster^{-1}	Clusters plant^{-1}	Days to first picking	Pods cluster^{-1}	Pods plant^{-1}	Pod length (cm)	Pod width (cm)	Pod weight (g)	Seeds pod^{-1}
Plant height at 90 DAS	-0.040	-0.022	0.006	0.005	-0.008	0.015	0.004	-0.016	0.014	-0.012	-0.009	-0.010	-0.002
No. of branch at 90 DAS	0.002	0.003	-0.000	-0.001	0.001	-0.000	-0.000	0.001	-0.000	0.001	-0.0006	0.000	0.0002
Days to first flowering	0.012	0.015	-0.082	-0.035	0.025	-0.013	0.010	0.025	-0.010	0.004	-0.010	-0.000	0.004
Days to 50% flowering	-0.026	-0.088	0.088	0.206	-0.092	0.032	0.047	-0.044	0.028	-0.040	0.068	0.017	-0.029
Flowers cluster^{-1}	0.041	0.054	-0.064	-0.092	0.207	-0.104	0.001	0.162	-0.019	-0.064	0.055	-0.017	-0.053
Clusters plant^{-1}	0.018	0.009	-0.007	-0.007	0.024	-0.047	-0.019	0.029	-0.036	0.012	0.025	0.031	0.006
Days to first picking	0.001	0.001	0.001	-0.002	-0.000	-0.004	-0.010	-0.000	-0.004	0.004	-0.000	0.004	0.0004
Pods cluster^{-1}	-0.031	-0.027	0.024	0.017	-0.063	0.049	-0.005	-0.081	0.007	0.024	-0.040	-0.003	0.028
Pods plant^{-1}	-0.606	-0.217	0.211	0.228	-0.158	1.282	0.776	-0.146	1.679	-1.024	-0.496	-1.463	-0.785
Pod length (cm)	0.118	0.148	-0.018	-0.074	-0.118	-0.100	-0.159	-0.113	-0.233	0.383	-0.115	0.212	0.189
Pod width (cm)	0.038	-0.026	0.020	0.056	0.045	-0.090	0.001	0.085	-0.050	-0.051	0.170	0.080	-0.017
Pod weight (g)	0.255	0.014	0.007	0.087	-0.086	-0.671	-0.434	0.040	-0.880	0.560	0.477	1.010	0.468
Seeds Pod^{-1}	-0.013	-0.011	0.010	0.029	0.052	0.026	0.008	0.072	0.09	-0.101	0.020	-0.095	-0.205
Pod yield plant^{-1} (g)	-0.230	-0.145	0.195	0.415	-0.171	0.372	0.222	0.014	0.589	-0.304	0.145	-0.232	-0.395

Table 3: Genotypic path coefficient showing direct and indirect effect of different character on pod yield plant^{-1} (g)

Character	Plant height at 90 DAS	No. of branch at 90 DAS	Days to first flowering	Days to 50% flowering	Flowers cluster^{-1}	Clusters plant^{-1}	Days to first picking	Pods cluster^{-1}	Pods plant^{-1}	Pod length (cm)	Pod width (cm)	Pod weight (g)	Seeds pod^{-1}	Pod yield plant^{-1} (g)
Plant height at 90 DAS	0.081	0.056	-0.017	-0.017	0.024	-0.036	-0.010	0.038	-0.031	0.027	0.020	0.020	0.003	-0.246
Branch at 90 DAS	0.174	0.250	-0.071	-0.143	0.081	-0.057	-0.069	0.095	-0.022	0.131	-0.068	0.011	0.006	-0.006
Days to first flowering	0.012	0.017	-0.061	-0.050	0.029	-0.009	0.013	0.025	-0.008	0.004	-0.013	0.000	0.000	0.234
Days to 50 %flowering	0.025	0.069	-0.098	-0.121	0.064	-0.026	-0.027	0.037	-0.016	0.027	-0.063	-0.015	0.023	0.564
Flowers cluster^{-1}	0.102	0.113	-0.167	-0.183	0.347	-0.188	0.023	0.298	-0.045	-0.117	0.102	-0.023	-0.122	-0.281
Clusters plant^{-1}	-0.069	-0.035	0.023	0.033	-0.084	0.154	0.084	-0.092	0.130	-0.044	-0.089	-0.116	-0.028	0.481
Days to first picking	-0.016	-0.035	-0.028	0.029	0.008	0.070	0.128	-0.002	0.076	-0.063	0.002	-0.066	-0.014	0.391
Pods cluster^{-1}	-0.338	-0.271	0.291	0.221	-0.613	0.427	0.011	-0.712	0.070	0.224	-0.414	-0.038	0.327	0.012
Pods plant^{-1}	-0.803	-0.188	0.304	0.284	-0.273	1.774	1.251	-0.208	2.108	-1.353	-0.660	-1.936	-1.087	0.550
Pod length (cm)	0.011	0.017	-0.002	-0.007	-0.011	-0.009	-0.016	-0.010	-0.021	0.033	-0.011	0.019	0.019	-0.371
Pod width (cm)	0.076	-0.081	0.064	0.155	0.088	-0.173	0.005	0.174	-0.093	-0.098	0.298	0.149	-0.046	0.221
Pod weight (g)	0.517	0.094	-0.008	0.254	-0.141	-1.548	-1.065	0.110	-1.886	1.174	1.029	2.054	1.067	-0.234
Seeds pod^{-1}	-0.021	-0.014	0.006	0.109	0.198	0.104	0.062	0.258	0.290	-0.319	0.088	-0.292	-0.563	-0.414

(0.025) and seeds pod^{-1} (0.023). Whereas, it was expressed high negative indirect effect by remaining characters. Number of flower cluster^{-1} was reported to have highest positive indirect effect on pod yield plant^{-1} through, pods cluster^{-1} (0.298), number of branches at 90 DAS (0.113), plant height at 90 DAS (0.102), pod width (0.102) and days to first picking (0.035). Whereas, it was expressed high negative indirect effect via pod weight (-0.023), pods plant^{-1} (-0.045), pod length (-0.117), seeds pod^{-1} (-0.122), days to first flowering (-0.167), days to 50% flowering (-0.183) and number of flower cluster plant^{-1} (-0.188). Number of flower cluster plant^{-1} was reported to have highest positive indirect effect on pod yield plant^{-1} through, pods plant^{-1} (0.130), days to first picking (0.084), days to 50% flowering (0.033) and days to first flowering (0.023). Whereas, it was expressed high negative indirect effect through remaining characters under study. Days to first picking expressed highest positive indirect effect through, pods plant^{-1} (0.076), number of flower cluster plant^{-1} (0.070), days to 50% flowering (0.029). Similar observations were also noticed by Pathak Alege and Singh (2007); Nehru et al. (2009).

Highest positive indirect effect of number of pods cluster^{-1} on pod yield plant^{-1} was recorded through, cluster plant^{-1} (0.427), seed pod^{-1} (0.327), pod length (0.224), days to first flowering (0.291), days to 50% flowering (0.221), pods plant^{-1} (0.070), and days to first picking (0.011). Its negative indirect effect was high through remaining traits. Highest positive indirect effect of number of pods plant^{-1} on pod yield plant^{-1} was recorded through number of flower cluster plant^{-1} (1.773), days to first picking (1.251), days to first flowering (0.304), days to 50% flowering (0.284). Its indirect negative effect was high via pod width (-0.660), plant height at 90 DAS (-0.803), branches at 90 DAS (-0.188), pods cluster^{-1} (-0.208), flower cluster^{-1} (-0.273), seeds pod^{-1} (-1.087), pod length (-1.353) and pod weight (-1.936). Pod length revealed high values of positive indirect on pod yield plant^{-1} through pod weight (0.019), seeds pod^{-1} (0.019), branches at 90 DAS (0.017) and plant height at 90 DAS (0.011). While, the remaining characters showed high negative indirect was previously reported by of Dahiya et al. (2007); Baghizadeh et al. (2010); Cholin et al. (2012). Pod width revealed high values of positive indirect on pod yield plant^{-1} through pods cluster^{-1} (0.174), pod weight (0.149), days to 50% flowering (0.155), flowers cluster^{-1} (0.088), plant height at 90 DAS (0.076) and days to first flowering (0.064). Indirect effect i.e. seeds pod^{-1} (-0.046), branches plant^{-1} at 90 DAS (-0.081), pods plant^{-1} (-0.093) pod length (-0.098) and number of flower cluster plant^{-1} (-0.173). The results corroborated the findings of Vinieta et al. (2003); Mittal and Singh (2005). Highest positive indirect effect of pod weight on pod yield plant^{-1} was recorded through pod length (1.174), seeds pod^{-1} (1.067), pod width (1.029), plant height at 90 DAS (0.517), days to 50% flowering (0.254) pods cluster^{-1} (0.110), and number of branches at 90 DAS (0.094). It showed negative indirect effect through remaining traits. Number of seeds pod^{-1} manifested positive indirect effect through pods cluster^{-1} (0.258), pods plant^{-1} (0.290), flower cluster^{-1} (0.198), days to 50% flowering (0.109), number of flower cluster plant^{-1} (0.104), pod width (0.088) and days to first picking (0.062). Whereas, it was expressed high negative indirect effect its negative indirect effect was high through remaining traits. The results corroborated the findings of Vinieta et al. (2003); Mittal and Singh (2005) for number of seed pod^{-1}.

3.3. Quality parameters

Qualitative characters viz., colour of flowers, shape of pod, colour of pod, seed colours, stringiness in pods and fleshy or non fleshy pods are summarized in (Table 4). Genotypes 2011/COPBVAR-7, 2012/COPBVAR-1, 2012/COPBVAR-2, 2014/COPBVAR-3 and Arka Garima exhibited purple colour flower. While, white colour flowers were observed in genotype 2012/COPBVAR-6, 2014/COPBVAR-1, 2014/COPBVAR-4 and Gomti, whereas genotypes 2012/COPBVAR-3, 2012/COPBVAR-5, 2014/COPBVAR-2, Kasha Kanchan, 2014/COPBVAR-5 and 2014/COPBVAR-6 were observed light purple flowers. Genotypes 2012/COPBVAR-2 and 2014/COPBVAR-6 exhibited dark green pods. Whereas, genotypes 2011/COPBVAR-7, 2012/COPBVAR-1, 2012/COPBVAR-3, 2012/COPBVAR-5, 2012/COPBVAR-6, 2014/COPBVAR2, 2014/COPBVAR-4 and Kashi Kanchan were observed green pods, remaining genotypes exhibited light green pods. Genotypes 2012/COPBVAR-2 and 2014/COPBVAR-4 exhibited light maroon seeds. Whereas, genotypes 2012/COPBVAR-1, 2011/COPBVAR-6 was observed maroon seeds. Genotypes 2011/COPBVAR-7, 2012/COPBVAR-3, 2012/COPBVAR-5 and Kashi Kanchan were observed dark maroon colour. Genotype 2014/COPBVAR-6 observed black colour, remaining genotypes exhibited creamish seeds.

Significant variation was observed among the genotypes for shape of pods i.e., straight, slightly curved and curved (Table 4). Shape of pods was observed to straight in genotypes 2012/COPBVAR-1, 2012/COPBVAR-2, 2014/COPBVAR-1, 2014/COPBVAR-2 and Arka Garima. Genotypes 2011/COPBVAR-7, 2014/COPBVAR-3, Gomti and 2014/COPBVAR-6 was produced curved pod, the remaining genotypes produced slightly curved pods. Significant variation was observed among the genotypes for Stringiness in pods i.e., fiber present or absent, fiber was present in genotypes 2012/COPBVAR-2, 2012/COPBVAR-3, 2014/COPBVAR-3, 2014/COPBVAR-6, 2014/COPBVAR -5 and Arka Garima, fiber was absent in the remaining genotypes. Wide variation was observed among the genotypes for fleshy or non fleshy

Table 4: Qualitative characters in cowpea genotypes

Genotypes	Genotypes	Pod colour	Shape of pod	Stringiness in pods	Fleshy or non fleshy green pods	Seed colour
2011/COPBVAR-7	Purple	Green	Curved	Fiber present	Fleshy	Dark maroon
2012/COPBVAR-1	Purple	Green	Straight	Fiber absent	Less fleshy	Maroon
2012/COPBVAR-2	Purple	Dark green	Straight	Fiber present	Fleshy	Light maroon
2012/COPBVAR-3	Light purple	Green	Slightly curved	Fiber present	non fleshy	Dark maroon
2012/COPBVAR-5	Light purple	Green	Slightly curved	Fiber absent	Fleshy	Dark maroon
2012/C0PBVAR-6	White	Green	Curved	Fiber absent	Non fleshy	Creamish
2014/COPBVAR-1	White	Light green	Straight	Fiber absent	Fleshy	Dark creamish
2014/COPBVAR-2	Light purple	Green	Straight	Fiber absent	Fleshy	Dark creamish
2014/COPBVAR-3	Purple	Light green	curved	Fiber present	Less fleshy	Dark creamish
2014/COPBVAR-4	White	Green	Slightly curved	Fiber absent	Less fleshy	Light maroon
2014/COPBVAR-5	Light purple	Light green	Slightly curved	Fiber present	Fleshy	Dark creamish
2014/COPBVR-6	Light purple	Dark green	Curved	Fiber present	Non fleshy	Black
Gomti	White	Light green	curved	Fiber absent	Fleshy	Creamish
Arka Garima (C)	Purple	Light green	Straight	Fiber present	Fleshy	Cream and maroon
Kashi Kanchan (C)	Light purple	Green	Slightly curved	Fiber absent	Less fleshy	Dark maroon

pods. Non fleshy pods were observed in genotypes 2012/COPBVAR-3, 2012/COPBVAR-6 and 2014/COPBVAR-6. Whereas, genotype 2014/COPBVAR -3, 2014/COPBVAR-4 and Arka Garima produced less fleshy pods, the remaining genotypes produced fleshy pods.

4. Conclusion

More emphasis should be given to selecting genotypes with number of pod plant^{-1}, days to 50% flowering, number of flower cluster plant^{-1} and number of seed pod^{-1} as exhibited higher association with pod yield of cowpea. The above findings further suggested that for getting higher yield, selection should be practiced for yield and yield related traits giving equal importance.

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