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Trait association and contributing effect of various traits in different groups of cowpea (*Vigna unguiculata* L. walp) varieties

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Abstract
Understanding the nature and extent of association between yield and yield related traits is the prerequisite study for any underutilized crop improvements of sustainable genetic enhancement. However, there is a lack of sufficient information on seed yield and related trait correlation and path coefficient analysis of cowpea Thirty two cowpea genotypes were tested in randomized block design during *Kharif* 2015-16 & 2016-17 at student farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P). The magnitude of genotypic correlations was higher than phenotypic correlations in most traits at both year; this implies that the traits under consideration were genetically controlled. Seed yield was positively and highly significantly correlated with most of the traits at phenotypic and genotypic levels. The analysis of variance revealed that there was a significant difference among thirty two genotypes. The thirty two cowpea varieties were evaluated for eleven quantitative characters viz. days to flower initiation, days to maturity, plant height (cm), pod length (cm), number of pods per plant, number of branches per plant, leaf length (cm), leaf width (cm), leaf: stem ratio, stover of yield per plant (gm.) and seed yield per plant (gm.). Genotypic correlation coefficient were higher than the corresponding phenotypic correlation coefficient for all the character under study. Seed yield per plant showed highly positive association ship with days to flower initiation, days to maturity, plant height, number of pods per plant, leaf width, leaf: stem ratio and stover yield per plant. Almost all traits genotypic direct and indirect effects were higher than the phenotypic direct and indirect effects; this indicated that the other traits had a strong genetically inherited relationship with seed yield. The information obtained from this study can be used for genetic enhancement of cowpea thereby developing high yielding varieties.

Keywords: Direct effect, genotypic association, indirect effect, phenotypic association, seed yield

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] Is a diploid species with 2n=2x=22 chromosome. It is an autogamous crop, with natural cross pollination ranging from zero to four percent. Cowpea belongs to the class of Dicotyledonea, order Fabales, family Fabaceae, subfamily Faboideae, tribe Phaseoleae, sub tribe Phaseolinae, and genus Vigna by Kohli *et al*., (2002) [8]. Cowpea exhibits different morphological forms; some are prostrate, erect or climbing. The leaves are trifoliate; inflorescences are axillary with few crowded flowers near the tip in alternate pairs. Langyintuo *et al*., (2003) [11] stated that anthers bear sticky and heavy pollen grains. Cowpea is produced for household purposes and as a cash crop. It is a multipurpose crop, since it is cultivated for leaf and seed yield**.** It is a multifunctional crop, providing food for man and livestock and serving as a valuable and dependable revenue-generating commodity for farmers and grain traders by Manonmani, *et al*., 2000 [12], Jogdhande, *et al*., (2017). Cowpea contributes 30-125 Kg N/ha in the soil due to its nitrogen fixing properties and also serves as a residue, which benefits the succeeding crops. It is also a shade tolerant crop and, therefore, compatible as an intercrop with a number of cereals and root crops, as well as with cotton, sugarcane and several plantation crops**.** In fresh form, the young leaves and immature pods are used as vegetables, while the grain is used in the preparation of several dishes. It is also a cheap source of many other nutrients; it is known as vegetable meat. This drought tolerant crop is nutritious and highly palatable as the leaves, seeds, fresh pods and flowers are consumed. The mature legume contains 23-25% protein and 50-67% carbohydrate, 1.9% fats, 6.35% fiber and small percentage of the B-vitamins such as folic acid, thiamine, riboflavin and niacin as well as some micronutrients such as iron and zinc by Bressani R (1985) [2].

In addition to human consumption cowpea haulms and chaff are used as livestock feeds in all producing regions and are also beneficial in maintaining soil fertility thus making it an important component of any cropping system. In India cowpea is a very important crop and cultivated for food, vegetables and fodder purpose. Cowpea is a very popular vegetable crops and being cultivated in all over country except hilly regions. In India it mainly grown in Rajasthan, Gujarat, Maharashtra, Karnataka, Tamilnadu, Bihar and Uttar Pradesh. As a grain legume it has a great potential for sustainable agriculture in marginal land and semi-arid regions of country. It is estimated that about 6.5 lakh hectare is under different forms of Cowpea and the share of fodder cowpea is 3 lakh ha. Correlation helps in the selection of superior genotype from diverse genetic populations by Deway and Lu (1959). However, in correlation studies indirect associations become more complex and confusing but path analysis helps to avoid this complication. Bizeti, *et al*., (2004) [3] and Chaudhary, *et al*., (2005) [4] stated that path analysis provides information about magnitude and direction of direct and indirect effect of the yield components, which cannot be provided by correlation. Cowpea varietal improvement programme in country has resulted in the development many improved and high yielding varieties for grain, vegetable and fodder purpose. Maximum varieties has been released for vegetable purpose followed by fodder cowpea. Released varieties has been developed mostly by utilizing exotic lines as parent mainly introduced CG system Institute viz. IITA, Nigeria. Therefore, the objectives of present study were to determine the nature and extent of phenotypic and genotypic correlations among quantitative traits of 32 varieties and to identify the most important traits for indirect selection in future cowpea breeding programs.

Material and Methods

The experimental materials of the study comprised of 32 cowpea varieties from Indian origin. These varieties were procured from Department of Genetics and Plant Breeding, G.B.P.U.A & T. Pantnagar. A field experiment was conducted during *kharif* season 2015-16 and 2016-17 at the student Research Farm, CSAUAT, Kanpur. All the genotypes were sown in Randomized Complete Block Design with three replications. Each genotype was sown in four lines in 3.0 m long and 1.50 m broad plots and space planted at 75 cm between row to row and plant to plant distance respectively. The present investigation is based on eleven characters namely days to flower initiation, days to maturity, pod length, plant height, number of pods per plant, number of branches per plant, leaf length, leaf width, leaf: stem ratio, stover yield per plant, seed yield per plant was taken to obtain sufficient information related to 32 released varieties of cowpea and thereby to suggest strategy for significant improvement in yield. The experimental data collected were compiled by taking the mean values of selected plants in each plot and subjected for statistical analyses. As per the procedures given by Panse and Sukhatme (1961) for the randomized block design (RBD) accordingly statistical analysis of variance for all the traits were carried out. At possible correlation coefficient among 11 characters were calculated at genotypic and phenotypic levels following the procedure of Miller *et al.*, (1958). The analysis of path coefficient was undertaken with a view to understand the underlying causes of given effects and the relationship between a component character and dependent character as measured by genotypic and phenotypic correlation coefficient and was subdivided into direct effect of these characters. Path Coefficient Analysis was carried out by the method modified by Dewey and Lu (1959) [5] from the technique originally proposed by Wright (1921) [21]. Path coefficient were obtained by simultaneous equations which express basic relationship between correlation and path analysis.

Result and Discussion

Knowledge about magnitude and nature of variability present in population is a pre-requisite for any crop improvement program. Variability is a result of its genotype and genotype x environment interactions. Only heritable component of variation is of prime importance from breeding point of view. So it is necessary to divide total variability into its heritable and non-heritable component of variation.

Present study revealed highly significant differences among the tested genotype in respect of all characters. This indicated that these present days varieties can be utilize for future cowpea breeding program.

It is clear from the results that the genotypes were more variable for stover yield per plant, plant height, seed yield per plant and number of pods per plant. This indicated that due emphasis has been given for these characters while adopting selection for the development of these varieties.

The analysis of variance also showed highly significant differences between the treatments for all the characters under study. It basically represented presence of large variability in the materials which could be successfully exploited in future breeding programme for developing high yielding New Plant Type Varieties. Kumar and Mishra (2004) [10, 19] showed the similar observations.

Phenotypic and genotypic coefficient of variation (Table 1) was maximum for number of pods per plant followed by seed yield per plant, stover yield per plant, minimum phenotypic and genotypic coefficient of variation were recorded for leaf length, leaf width followed by days to maturity. Moderate GCV obtained for plant height followed by pod length, leaf: stem ratio, number of branches per plant, days to flower initiation and moderate PCV was observed for plant height, pod length leaf: stem ratio, number of branches per plant, days to flower initiation. The GCV and PCV values indicated that lot of variability exists among the genotypic and phenotypic level and better chances of improvement is possible by selection. These finding are in conformity to the finding of previous workers Nwosu *et al.,* (2013) [14], Pravin *et al.*, (2013), Vir and Singh (2014) [20], Kharde *et al*., (2014) [9]. Shahid *et al*., (2005) [16], Singh *et al*., (2002) [2, 17, 20] reported that high estimate genotypic and phenotypic coefficient of variability for seed yield per plant, while little variability was recorded for leaf length and leaf width. Its indicates that the selection based on seed yield per plant, may be advantageous as compared to other character under study.

Table 1: Phenotypic and genotypic coefficient of variation among thirty two genotype for eleven characters in cowpea

S. No.	Character	PCV	GCV
1	Days to flower initiation	19.09	18.66
2	Days to maturity	18.95	18.81
3	Pod length(cm)	26.23	25.42
4	Plant height(cm)	30.80	30.70
5	Number of pods per plant	39.94	39.81
6	Number of branches per plant	20.38	18.85
7	Leaf length(cm)	10.05	9.91
8	Leaf width(cm)	16.01	15.69
9	L:S ratio	25.14	24.97
10	Stover yield per plant(gm.)	33.06	32.76
11	Seed yield per plant(gm.)	39.32	37.45

The phenotypic and genotypic coefficients of correlation (Table 2) were determined among yield components in all possible character combination. In most of the characters exhibited higher genotypic correlation than the phenotypic correlation. The economic product i.e. seed yield in cowpea, is the complex characters which manifest from multiplicative interactions of several other characters that is termed as yield components. Falconer (1960) [6] while studying genetic mechanism of association between two characters, suggested that the linear association may be due to complete linkage or pleiotropy. Correlation resulting from linkage or pleiotropy is the overall effect of those genes that affect both the characters Some genes increase both characters (positive correlation) whereas some may increase one character and decrease another (negative correlation). The correlation coefficient is the measure of degree of symmetrical association between two variables or characters which helps us in understanding the nature and magnitude of association among yield and yield components and provides opportunity for indirect selection. The improvement normally depends upon the efficiency and accuracy of selection which is only possible when the selection is made not only on the basis of single characters but several other contributing characters are taken in consideration. It is therefore necessary to study the nature and magnitude of association of particular traits with the other traits.

Table 2: Phenotypic (P) and genotypic (G) correlation coefficient among the eleven characters on thirty two cowpea genotype

Character		Days to flower initiation	Days to maturity	Pod length (cm)	Plant height (cm)	Number of pod per plant	Number of branches per plant	Leaf length (cm)	Leaf width (cm)	L:S ratio	Stover yield per plant (gm.)	Seed yield per plant (gm.)
Days to flower initiation	P	1.000	0.944**	0.161	0.347**	0.456**	0.110	-0.533**	-0.113	0.443**	0.308**	0.151
	G	1.000	0.975**	0.178	0.359**	0.468**	0.141	-0.550**	-0.121	0.458**	0.315**	0.156
Days to maturity	P		1.000	0.070	0.455**	0.404**	0.555	-0.497**	-0.058	0.531**	0.396**	0.275**
	G		1.000	0.080	0.461**	0.407**	0.053	-0.506**	-0.062	0.535**	0.406**	0.307**
Pod length (cm)	P			1.000	0.041	0.132	0.283**	-0.130	0.047	0.075	0.088	-0.086
	G			1.000	0.043	0.136	0.325**	-0.137	0.046	0.082	0.086	-0.105
Plant height (cm)	P				1.000	0.392	-0.433**	-0.086	0.605**	0.882**	0.909**	0.443**
	G				1.000	0.396	-0.472**	-0.086	0.619**	0.893**	0.922**	0.469**
Number of Pod per plant	P					1.000	-0.201*	-0.331**	0.227*	0.473**	0.432**	0.085
	G					1.000	-0.220*	-0.337**	0.232*	0.478**	0.437**	0.094
Number of Branches per plant	P						1.000	0.259*	-0.521**	-0.250*	-0.360**	-0.196
	G						1.000	-0.282	-0.558**	-0.269**	-0.386**	-0.209*
Leaf length(cm)	P							1.000	0.302**	-0.158	-0.080	-0.052
	G							1.000	0.318**	-0.160	-0.082	-0.065
Leaf width (cm)	P								1.000	0.552**	0.620**	0.214*
	G								1.000	0.567**	0.636**	0.235*
L:S ratio	P									1.000	0.847**	0.389**
	G									1.000	0.856**	0.413**
Stover yield per plant (gm.)	P										1.000	0.359**
	G										1.000	0.367**

Significant level 5%*, 1%**, If correlation => 0.200, 0.2617

Study of correlation provide us information about relationship of traits which are not easily observable or have low heritability and provide us idea about the suitability of various character for indirect selection, because selection for one or more than one traits results in formulation of correlation response for several other traits (Searle 1965) [18]. Obtaining the real relationship of the characters, the estimation of genotypic correlation is essential.

All possible genotypic and phenotypic correlation was worked out for eleven characters under study. Some studied characters among themselves indicated strong positive correlation viz. days to flower initiation with days to maturity, plant height, number of pod per plant, leaf: stem ratio, stover yield per plant both at phenotypic and genotypic level. Days to maturity with days to flower initiation, plant height, number of pod per plant, leaf: stem ratio, stover yield per plant, seed yield per plant. Stover yield per plant showed positive and highly significant relationship with days to flower initiation, days to maturity, plant height, number of pods per plant, leaf width, leaf: stem ratio, seed yield per plant at both phenotypic and genotypic level. Seed yield per plant was positively correlated with days to flower initiation, days to maturity, plant height, number of pods per plant, leaf width, leaf: stem ratio, Stover yield per plant at phenotypic and genotypic level. Positive correlation indicates that when one character increases other character increases automatically. This indicated an opportunity to improve seed yield and stover yield simultaneously. Manonmani *et al.*, (2000) [12], Kohli *et al*., (2002) [8], Mary *et al*., (2006) [13] and Bhandari *et al*., (2007) [1] also reported similar findings of positive and significant correlation of above mentioned characters with fodder yield. Mary and Gopalan (2006) [13] also reported highly significant positive significant phenotypic and genotypic correlation for plant height, number of branches, leaf length leaf width with seed yield per plant. Romanus *et al*., (2007) [15] also reported that the significant positive phenotype correlation between seed yield with pod length, number of pod per plant, and number of seeds per pod and suggested to use pod length, number of pods per plant, and pod yield were identified as the best selection criteria that could be used in cowpea breeding programs. By improving the characters which are directly and positively associated with seed yield will ultimately improve yield and also by elimination the negative correlated characters with grain yield.

Path coefficient analysis is a tool of partitioning the observed correlation into direct and indirect effects of different yield components on seed yield. Path analysis provides clear

picture of character association for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that it points out the causes and their relative importance whereas; the later measure simply the mutual association ignoring the causation. The concept of path coefficient was developed by Sewell Wright (1921) [21]. Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contribution of different characters to economic yield in crop plants so that the relative importance of various yields contributing character can be assessed.

Correlation provides relationship between two characters but in path analysis direct and indirect of independent trait on dependent trait will be known. Path coefficient analysis (Table 3) was done to determine direct and indirect influence of days to flower initiation, days to maturity, pod length, plant height, number of pod per plant, number of branches per plant, leaf length, leaf width, leaf: stem ratio, stover yield per plant on seed yield per plant. A large number of characters contributed to total seed yield per plant via several agronomic and yield related traits. So improving these characters will finally improve grain yield. Tyagi, and Agarwal (2012) [19] from their study on cowpea concluded higher seed weight per pod, number of pods/plant are important for effecting selection.

Table 3: Direct (bold) and indirect effects of eleven components traits on seed yield of cowpea as independent variable at genotypic level

S. No.	Character	Days to flower initiation	Days to maturity	Pod length (cm)	Plant height (cm)	Number of pods per plant	Number of branches per plant	Leaf length cm	Leaf width cm	L:S ratio	Stover yield per plant (gm.)	Seed yield per plant
1.	Days to flower initiation	-4.780	-4.659	-0.850	-1.719	-2.241	-0.674	2.634	0.579	-2.190	-1.506	0.156
2.	Days to maturity	4.721	4.844	0.392	2.234	1.973	0.256	-2.451	-0.304	2.596	1.970	0.307
3.	Pod length (cm)	0.036	0.016	0.207	0.009	0.028	0.067	0.028	0.009	0.017	0.017	-0.105
4.	Plant height (cm)	0.285	0.362	0.035	0.791	0.318	-0.375	-0.060	0.492	0.709	0.732	0.469
5.	Number of pods/ plant	0.248	0.215	0.075	0.212	0.532	-0.116	-0.171	0.123	0.253	0.231	0.094
6.	Number of branches/ plant	0.049	0.018	0.112	-0.165	-0.074	0.351	-0.090	-0.195	-0.094	-0.135	-0.209
7.	Leaf length cm	0.046	0.043	0.017	0.007	0.027	0.024	-0.080	-0.027	0.013	0.007	-0.065
8.	Leaf width cm	-0.034	-0.018	0.013	0.178	0.067	-0.160	0.094	0.287	0.163	0.183	0.235
9.	L:S ratio	-0.144	-0.169	-0.025	-0.282	-0.151	0.085	0.056	-0.17	-0.316	-0.270	0.413
10.	Stover yield/ plant (g)	-0.271	-0.350	-0.074	-0.795	-0.378	0.333	0.078	-0.549	-0.738	-0.862	0.367

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