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Character association studies and path coefficient analysis among yield attributing traits in cowpea (*Vigna unguiculata* L.)

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Abstract

The present investigation was carried out at Agricultural Research station Warangal, Telangana, to understand the correlation and path analysis for yield and yield attributing traits for 31 genotypes including 2 checks in Randomized Block Design replicated thrice during Rabi, 2022. Association studies revealed that genotypic correlation values were higher than that of phenotypic correlations. Important traits i.e., number of pods per plant (0.7075**/0.6700) followed by number of pods per cluster (0.6717**/0.6308) exhibited the highest positive significant association with single plant yield. Path coefficient analysis also revealed that the number of pods per plant and number of branches per plant had reported the highest positive direct effect of on single plant yield at both genotypic and phenotypic levels. Hence, these traits could be used as selection indices for cowpea hybrid development.

Keywords: Cowpea, correlation, path coefficient analysis, genotypic correlation, phenotypic correlation, selection indices

Introduction

Cowpea (*Vigna unguiculata* L.) is an important autogamous pulse crop. It belongs to the family *Leguminosae* with a chromosome number of $2n = 22$. Cowpea is critical to the survival of millions of people in developing countries. Its primary centre of origin is India and Ethiopia and secondary centre of origin is China. Cowpea contains more than 25% protein in its seeds and is a major source of protein, minerals and vitamins in the daily diet and is thus referred to as vegetable meat. It can fix atmospheric nitrogen via its nodules and grows well in soils containing 85 percent soil and less than 0.2 percent organic matter.

In India, the average yield of cowpea is quite low, with significant fluctuations in yield every year. There is an urgent need to increase vegetable cowpea output in order to satisfy minimal requirements while also safeguarding national security with rapidly increasing population. Although the research on genetic enhancement of vegetable crops has begun in India a few decades ago and has resulted in the production of several improved cultivars, there are still certain vegetables like cowpea, that are underutilised despite having enormous potential in the market. Their genetic advancement is only achievable when a diverse set of parents are made available for the breeding programme. The selection of parents is the fundamental rationale in any crop improvement programmes. Information on the interrelationships between different traits are required for a systematic breeding programme to develop high yielding hybrids. Nature and genetic divergence information would assist plant breeders in selecting the correct type parents for successful hybridization.

Yield is a complicated trait that is influenced by a number of factors. The major biometrical methodologies for determining the yield components are correlation and path coefficient analysis. Characters that are positively connected with yield are extremely significant to plant breeders when it comes to selection. Although the correlation coefficient reveals the nature of association between the various features, path analysis divides the correlation coefficients into measures of direct and indirect impacts, allowing for a better understanding of each character's direct and indirect contribution to yield. A thorough understanding of the direction and magnitude of the relationship between yield and yield-related traits will aid in the development of a successful breeding programme.

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In this view the current investigation aims to better understand the nature of associations between yield and yield attributing traits.

Materials and Methods

The experimental material consisted of 31 genotypes (20 hybrids, 5 lines, 4 testers along with 2 checks) was carried out at Regional Agricultural Research Station, Warangal situated at 18.013226°N latitude and 79.605726°E longitude during *Rabi*, 2022. The experimental material was planted with a spacing of 45 cm between the rows and 10 cm between the plants in randomized complete block design with three replications. Data was recorded on five randomly selected competitive plants per replication for 10 parameters viz., Days to 50% flowering, Days to maturity; plant height, number of branches per plant, number of pods per plant, number of seeds per pod, pod length; pods per cluster, 100 grain weight, seed yield per plant. Out of them, days to 50% flowering was measured on a plot basis. For the other traits, however, five plants were randomly chosen, and observations were made from each replication at the maturity stage, and for 100 grain weight, data was taken per replication for each genotype. All the agronomic practices and necessary plant protection measures were followed to raise a healthy crop.

The statistical analysis was performed by calculating correlation coefficients in all possible combinations at the genotypic, phenotypic, and environmental levels using the formula proposed by (Miller *et al.*, 1958), and the phenotypic correlations were tested for significance using the *t* test. The estimated values of correlation coefficients were then compared with table values of correlation coefficients (Fisher and Yates, 1963) at 5 percent and 1 percent levels of significance in order to test their significance. A path co-efficient analysis was performed to demonstrate the cause and effect relationship between yield and various yield components, as well as to divide the total correlation coefficient into direct and indirect effects. Wright (1921) developed this procedure, and as per consent used by Dewey and Lu (1959). INDOSTAT software was used to carry out each of the above mentioned analyses.

Results and Discussion

Because phenotypic selection is always influenced by various biotic and abiotic factors, crop improvement programmes will benefit from selection based on a set of traits that have a true association with grain yield.

The phenotypic and genotypic correlation coefficients among yield and yield components i.e., days to 50 percent flowering, Days to maturity, number of branches per plant, number of pods per plant, number of seeds per pod, plant height, pod length, number of pods per cluster, 100 grain weight and seed yield per plant were assessed and the outcomes have been summarized in Table 1.

The findings showed that for all the characters under study the genotypic correlation coefficients were consistently greater than the phenotypic correlation coefficients, indicating that the relationship between yield and its component traits was primarily due to genetic factors.

Single plant yield was found to be positively and significantly correlated both at genotypic and phenotypic levels with plant height (0.2528**/0.3446), number of branches per plant (0.5710***/0.5444), number of pods per plant (0.7075***/0.6700), number of pods per cluster

0.6717**/0.6308), number of seeds per pod (0.5385***/0.5110) and 100 grain weight (0.5290***/0.5160).

Number of pods per plant (0.7075***/0.6700), number of pods per cluster 0.6717**/0.5308) also exhibited the similar trend of significant positive association with single plant yield. Similar results were recorded by (Nair *et al.*, 2017) ^[13].

Number of seeds per pod (0.5385***/0.5110) and 100 grain weight also registered a positive significant relationship with single plant yield, which will have a direct impact on the seed yield. These results are in accordance with the findings of (Thorat and Gadewar *et al.*, 2013) ^[22] for both 100 grain weight and number of seeds per pod.

Interrelationships among yield attributing traits revealed that days to 50% flowering was significantly and positively correlated with Days to maturity, number of branches per plant, number of seeds per pod and positive and non-significant correlation with number of pods per plant, number of pods per cluster, 100 grain weight and single plant yield, while negative and non-significant association was registered with plant height, pod length. Similar positive associations were found by (Mishra and Dash *et al.*, 2009) ^[12]. for days to 50% flowering, branches per plant and pod length.

Days to maturity has significant and positive correlation with Days to 50% flowering, number of branches per plant while positive and non-significant association with number of pods per plant, number of seeds per pod, number of pods per cluster, single plant yield and negative and non-significant association with plant height, pod length and 100 grain weight.

Number of branches per plant, number of pods per plant, number of seeds per pod, number of pods per cluster and single plant yield showed a significant positive association with plant height while a positive and non-significant correlation was observed with 100 grain weight and negative and non-significant correlation was observed with pod length, days to 50% flowering and days to maturity. These findings of substantial and positive relationship were in line with those (Sarvamangala *et al.*, 2012) ^[19] for number of pods per plant. (Ajayi *et al.*, 2014) ^[1] for number of seeds per plant.

Number of branches per plant was significantly and positively correlated with plant height, days to maturity, number of pods per plant, number of seeds per pod, number of pods per cluster, 100 grain weight and single plant yield and positive and non-significant correlation with pod length. This was similar with (Meena *et al.*, 2015) ^[11]. for number of branches per plant.

Number of pods per plant reported positive and significant association with plant height, Number of branches per plant, number of seeds per pod, number of pods per cluster, 100 grain weight & single plant yield. While, significant and negative association with pod length and positive and non-significant with days to maturity and days to 50% flowering. These findings were in agreement with (Ajibade and Morakinyo *et al.*, 2000; Kumari *et al.*, 2010; Nair *et al.*, 2017) ^[2, 7, 13] in case of number of pods per plant.

Path Coefficient Analysis

It is well known that simple correlation does not reveal the true association of the characteristics to yield, and thus does not explain the cause-and-effect relationship between the

various yield attributes and, ultimately, the yield. The path analysis technique divides correlation coefficients into direct and indirect effects to provide information on the true contribution of an independent attribute on yield.

If the correlation coefficient is positive while the direct effect is negative, it is because of the indirect effects, which should be prioritised during the selection process. The restriction must be established to exclude the undesirable indirect effects so that the direct effects can be used if, on the other hand, the correlation coefficient is negative but the direct effect is positive.

Path coefficient analysis estimates for the yield and yield component qualities are shown in Table 2. According to the path analysis, the number of pods per plant (0.4772) had the most positive direct effect on single plant yield. The high positive direct effect of this trait has been nullified by the negative indirect effect of pod length (-0.1658), but indirect effects via days to 50% flowering, days to maturity, plant height, number of branches per plant, number of seeds per pod, number of pods per cluster, and 100 grain weight were very high, bringing the total correlation with yield to $r = 0.6329$. This results were in conformation with reports of (Nath *et al.*, 2009; Vishwanath *et al.*, 2009; Udensi *et al.*, 2012; Shanko *et al.*, 2014; Lal *et al.*, 2014; Lokesh and Niranjana *et al.*, 2018; Das *et al.*, 2020; Dinesh *et al.*, 2020; Nancee *et al.*, 2015; Yadav and Rajasekhar *et al.*, 2019) [15, 24, 23, 20, 5, 6, 14, 25].

Number of branches per plant was discovered to be the second most important character, with a positive direct effect of (0.3535) on single plant yield. It had a significant indirect effect on days to 50% flowering, days to maturity, plant height, number of pods per plant, number of seeds per pod, pod length, and number of pods per cluster. This findings were similar with the results of (Kumari *et al.*, 2010; Pandey *et al.*, 2014; Singh *et al.*, 2020) [7, 18, 21] for number of branches per plant.

Days to 50% flowering (0.3365) had a direct positive effect on single plant yield due to indirect positive effects from days to maturity, number of branches per plant, number of pods per cluster, number of seeds per pod, number of pods per cluster, and 100 grain weight. while it had a negative impact on plant height and pod length. The results are in line

with the findings of (Nancee *et al.*, 2015; Nigude *et al.*, 2004; Yadav and Rajasekhar *et al.*, 2019) [14, 16, 25] for days to fifty percent flowering.

The traits, 100 grain weight and number of pods per cluster showed a positive direct effect on single plant yield. This was in confirmation with (Vishwanath *et al.*, Dinesh *et al.*; 2017, Meena *et al.*, 2015) [24, 6, 11]; for hundred seed weight) for pods per cluster.

Though the correlation coefficient of plant height (0.2528) was positive, it had a negative direct effect on single plant yield, owing to the negative indirect effects of number of branches per plant, number of pods per plant, number of seeds per pod, number of pods per cluster, and 100 grain weight, while having a positive indirect effect through Days to 50% flowering, days to maturity, and pod length.

Pod length (0.0101) reported a positive direct effect on single plant yield, while it's correlation coefficient was negative (-0.1170) which was mainly due to negative indirect effects through Days to 50% flowering, days to maturity, plant height, number of pods per plant and number of pods per cluster while its effects with number of branches per plant, number of seeds per pod and 100 grain weight were positive. These findings were similar with (Nath *et al.* 2009; Paghadar *et al.*, 2019) [15, 17].

Days to maturity (0.0984) had a positive correlation coefficient, but it had a negative direct effect on single plant yield due to negative indirect effects of Days to 50% flowering, number of branches per plant, number of pods per plant, number of seeds per pod, number of pods per cluster, and number of pods per cluster, while it had a positive indirect effect through plant height and pod length. These results were similar to that of (Kumari *et al.*, 2010) [7]. Number of seeds per pod (-0.1026) reported a negative direct effect on single plant yield, while it's correlation coefficient was positive (0.5110) which was mainly due to negative indirect effects through Days to 50% flowering, days to maturity, plant height, number of pods per plant, number of branches per plant, number of pods per plant, pod length, number of pods per cluster and 100 grain weight. These results were similar to that of (Kumari *et al.*, 2010) [7] for number of seeds per pod.

Table 1: Correlation coefficients of yield and yield attributing traits in cowpea genotypes

Character		DFE	DM	PH	BPP	PPP	SPP	PL	PPC	100 GW	SYP
DFE	P	1.000	0.9598***	-0.0137	0.2493*	0.1846	0.2205*	-0.0536	0.1526	0.0330	0.1518
	G	1.000	0.9660	-0.0068	0.2544	0.1888	0.2275	-0.0537	0.1563	0.0301	0.1573
DM	P		1.000	-0.0490	0.2286*	0.1816	0.1654	-0.1623	0.0598	-0.0553	0.0984
	G		1.000	-0.0478	0.2351	0.1820	0.1707	-0.1718	0.0576	-0.0629	0.1050
PH	P			1.000	0.3248**	0.3261**	0.4273***	-0.0659	0.4114***	0.1866	0.2528***
	G			1.000	0.3992	0.3721	0.5396	-0.0680	0.4886	0.2400	0.3446***
BPP	P				1.000	0.3856***	0.6525***	0.0162	0.6426***	0.2411*	0.5444***
	G				1.000	0.4071	0.6776	0.0144	0.6781	0.2521	0.5710***
PPP	P					1.000	0.5449***	-0.3474***	0.6342***	0.5063***	0.6700***
	G					1.000	0.5867	-0.3701	0.6624	0.5231	0.7075***
SPP	P						1.000	0.1188	0.6477***	0.4611***	0.5110***
	G						1.000	0.1127	0.7185	0.4762	0.5385
PL	P							1.000	-0.0947	0.0385	-0.1170
	G							1.000	-0.0966	0.0380	-0.1205
PPC	P								1.000	0.4792***	0.6308***
	G								1.000	0.5158	0.6717***
100 GW	P									1.000	0.5160***
	G									1.000	0.5290***
SYP	P										1.000
	G										1.000

DFE-Days to 50 percent flowering, DM-Days to maturity, PH-Plant height(cm), BPP-Number of branches per plant, PPP-Number of pods per plant, SPP-Number of seeds per pod, PL-Pod length, PPC-Number of pods per cluster, TW-100 seed weight (g) and SYP-Seed yield per plant (g).

Table 2: Path coefficients for cowpea genotypes

Character		DFE	DM	PHT	BPP	PPP	SPP	PL	PPC	100 GW	SYP
DFE	P	0.3365	0.3230	-0.0046	0.0839	0.0621	0.0742	-0.0810	0.0513	0.0111	0.1518
	G	0.3051	0.2947	-0.0021	0.0776	0.0576	0.0694	-0.0164	0.0477	0.0092	0.1573
DM	P	-0.3557	-0.3705	0.0182	-0.0847	-0.0673	-0.0613	0.0601	-0.0222	0.0205	0.0984
	G	-0.3170	-0.3281	0.0157	-0.0771	-0.0597	-0.0560	0.0564	-0.0189	0.0207	0.1050
PHT	P	0.0007	0.0025	-0.0507	-0.0165	-0.0165	-0.0217	0.0033	-0.0209	-0.0095	0.2528
	G	-0.0001	-0.0005	0.0097	0.0039	0.0036	0.0052	-0.0007	0.0047	0.0023	0.3446
BPP	P	0.0881	0.0808	0.1148	0.3535	0.1363	0.2307	0.0057	0.2272	0.0852	0.5444
	G	0.0984	0.0910	0.1545	0.3870	0.1575	0.2622	0.0056	0.2624	0.0975	0.5710
PPP	P	0.0881	0.0867	0.1556	0.1840	0.4772	0.2600	-0.1658	0.3026	0.2416	0.6700
	G	0.1057	0.1019	0.2084	0.2280	0.5600	0.3285	-0.2072	0.3710	0.2929	0.7075
SPP	P	-0.0226	-0.0170	-0.0439	-0.0670	-0.0559	-0.1026	-0.0122	-0.0665	-0.0473	0.5110
	G	-0.0489	-0.0367	-0.1160	-0.1457	-0.1261	-0.2150	-0.0242	-0.1544	-0.1024	0.5385
PL	P	-0.0005	-0.0016	-0.0007	0.0002	-0.0035	0.0012	0.0101	-0.0010	0.0004	-0.1170
	G	-0.0036	-0.0116	-0.0046	0.0010	-0.0250	0.0076	0.0676	-0.0065	0.0026	-0.1205
PPC	P	0.0114	0.0045	0.0308	0.0481	0.0474	0.0484	-0.0071	0.0748	0.0358	0.6308
	G	0.0127	0.0047	0.0396	0.0550	0.0537	0.0582	-0.0078	0.0811	0.0418	0.6717
100 GW	P	0.0059	-0.0098	0.0332	0.0429	0.0902	0.0821	0.0069	0.0854	0.1781	0.5160
	G	0.0049	-0.0103	0.0394	0.0414	0.0860	0.0783	0.0062	0.0848	0.1644	0.5290

DFE-Days to 50 percent flowering, DM-Days to maturity, PH-Plant height(cm), BPP-Number of branches per plant, PPP-Number of pods per plant, SPP-Number of seeds per pod, PL-Pod length, PPC-Number of pods per cluster, TW-100 Seed weight (g)and SYP-Seed yield per plant(g).

Residual effect (Phenotype) = 0.6329 Residual effect (Genotype) = 0.5903

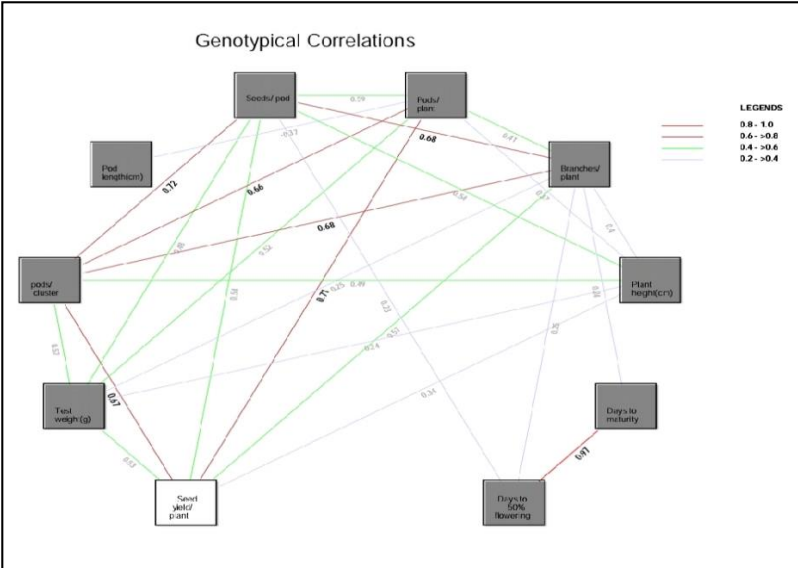


Fig 1: Phenotypic correlation coefficients among different traits in cowpea

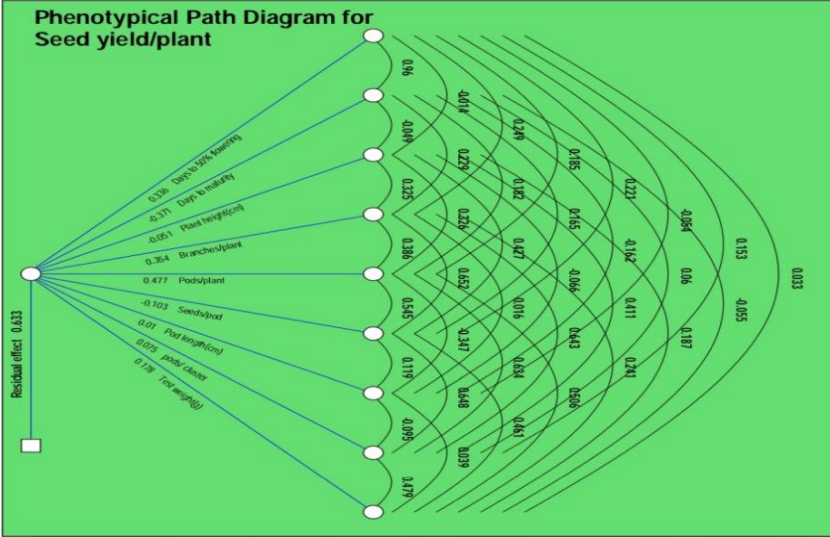


Fig 2: Phenotypological path diagram of various traits with seed yield per plot in cowpea

Conclusion

It can be concluded based on the results of variability studies, correlation and path coefficient analysis, that the characters number of pods per plant, pod length and number of seeds per pod, 100 seed weight largely define the seed yield of cowpea and hence should be prioritized in selection programmes in order to develop high yielding varieties and hybrids.

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