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Interrelationship and path coefficient analysis of some growth and yield characteristics in cowpea (*Vigna unguiculata* L. Walp) genotypes

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Abstract: Field experiments were conducted during 2010/2011 to determine the interrelationship and path coefficient analysis of growth characters to seed yield. The experiment was laid out in 7 x 7 triple lattice designs at Haramaya University research farm, Dire Dawa. Seed yield exhibited positive and significant environmental correlation with number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, number of pods per plant, number of seeds per pod and plant height. Path analysis revealed that, yield per plant exerted the maximum positive direct effect on seed yield followed by number of pods per plant, while number of secondary branches per plant, days to flowering, days to maturity and number of seed per pod exhibited negative direct effect phenotypically. In addition, genotypic path analysis revealed that, maximum direct effect on seed yield was exerted by number of pods per plant and yield per plant. However, days to 50% flowering, days to maturity, number of secondary branches per plant and number of seed per pod exerted negative direct effect on seed yield. Thus, yield per plant and number of pods per plant could be used as a selection index for cowpea improvement.

Keywords: Correlation, Cowpea, Interrelationship, Path Analysis

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a diploid species with 2n=2x=22 chromosomes. It is a self pollinated crop, with natural cross-pollination of up to one percent. Cowpea belongs to the class of *Dicotyledonea*, order *Fabales*, family *Fabaceae*, subfamily *Faboideae*, tribe *Phaseoleae*, subtribe *Phaseolinae*, and genus *Vigna* [1]. The primary gene-pool is composed of the domesticated cowpea (*V. unguiculata* subsp. *unguiculata* var. *unguiculata*) and its wild progenitor (*V. unguiculata* subsp. *unguiculata* var. *spontanea*. The secondary gene-pool of cowpea includes nine perennial subspecies [2]. All cultivated cowpeas are grouped under the species *Vigna unguiculata*, which is subdivided into four cultivars group such as *unguiculata* (common cowpea used as food and fodder), *sesquipedalis* (the yard-long or asparagus bean used as vegetables), *biflora* (catjang) and *textilis* (used for fibers). The cultivar group of *unguiculata* is the most diverse of the four and is widely grown in Africa, Asia and Latin America. [3] mentioned that cowpea is the second most important pulse crop after groundnut, cultivated in Africa. It is grown primarily in the semiarid and humid tropical regions lying between 35 ˚N and 30 ˚S of the equator. It is estimated that cowpea is now cultivated on at least 12.5 million hectares with an annual production of over 3 million tons of grains worldwide [4]. Currently, Central and West Africa account for more than 64% of the total area under cowpea cultivation, followed by South America, Asia, East, and South Africa. In the United States, cowpea is a crop of minor significance, grown on just over 80,000 hectares [5]. Generally, cowpea is one of the most important food leguminous crop plant of great socio-economic, cultural, nutritional importance and a valuable component of the traditional cropping systems in the semi-arid tropics [6].

However, some cowpea accessions have short life cycles and mature early and are able to provide food while others have long life cycles and mature late and can provide fodder. But, when it planted in the dry season with irrigation, it matures within 60-90 days and gives poor fodder yields [7]. The choice of cowpea specific genotypes adaptable to this kind of unfavorable environmental condition should be determined by a careful breeding program [8].

Correlation analysis is an easy to use technique which provides information that selection for one character results in progress for other positively correlated characters. The importance of correlation studies in selection programmes is appreciable when highly heritable characters are associated with the important character like yield. Path coefficient is an excellent means of studying direct and indirect effects of interrelated components of a complex trait particularly if the high correlation between two traits is a consequence of the indirect effect of other traits [9]. Path-coefficient analysis measures the direct influence of one variable on another. By determining the inter-relationships among grain yield components, a better understanding of both the direct and indirect effects of the specific components can be attained [10]. Even though there has been limited research on cowpea cultivation in Ethiopia, several workers have estimated the correlation between different yield attributing characters and their direct and indirect effects on yield in cowpea [11, 12, 13], soyabean [14, 15], rice [16, 17] and bambara groundnut [18, 19]. Knowledge of the relationship that exists between yield and other characters and also interrelationships among various characters is necessary to be able to design appropriate selection criteria in cowpea breeding program. This research therefore, aimed at assessing the interrelationship and contribution of some growth characters to seed yield with the view of enhancing their agronomic performance and as well as serve as a basis for selection in cowpea improvement.

2. Materials and Methods

2.1. Experimental Site and Materials

A field experiment was conducted at Haramaya University's research site located in Dire Dawa, Ethiopia. The experiment was conducted from March to June, 2011. The area is characterized by lowland humid tropical condition and has a bimodal rainfall pattern with a total mean annual rainfall of 520mm while the ambient temperature ranges between 21.6 to 34.6 ºC. The soil property of the experimental site is a sandy loam texture [20] having an average pH of 8.12 and organic matter, total nitrogen and an available phosphorus contents of 1.5%, 0.15% and 15.6 mg/kg respectively in the 0−30cm soil depth [21]. The experimental materials comprised of 49 cowpea accessions.

The experiment was laid out in a 7x7 triple lattice design with three replications. The net plot size was 2m x 2m with spacing between rows was 50cm, between plants within the row was 25cm and also spacing between block was 2m and within plot was 0.5m. There were 4 rows in each plot, which accommodates 8 seeds per row. The plots were weeded manually to keep weed pressure low.

2.2. Data Collection and Analysis

Data on 5 randomly selected plant from each plot to obtain 11 characters: plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, seed yield per plant, pod length, days to 50% flowering, days to 95% maturity, 100 seed weight and grain yield in kg/ha was collected. The correlation coefficients (r) were computed among all the measured traits using SPSS for Windows Version 16 (SPSS, Inc., Chicago, IL). Path coefficient analysis was done following the method suggested by [22].

3. Results and Discussion

3.1. Correlation Coefficient

The possibility of high yield through yield attributes as primary interest in crop improvement requires understanding the amount and the magnitude of correlations among various yield traits. Estimates of correlation coefficient at phenotypic and genotypic level are given in Table 1 and 2.

Table 1. *Phenotypic correlation coefficients (rp) of yield and yield related traits for the 49 Cowpea accessions.*

	NSB	PH	DF	DM	NPPP	PL	NSPP	YPP	HSW	SYLD
NPB	0.717**	0.079	0.172*	0.006	0.094*	0.003	-0.012	0.282**	-0.008	0.157*
NSB		0.068	0.077	-0.013	0.238**	0.044	-0.066	0.345**	-0.043	0.224**
PH			-0.078	0.084	0.239**	0.131*	0.145	0.104	-0.115	0.149
DF				0.309**	-0.119*	0.082	0.064	-0.109*	-0.074	0.003
DM					-0.003	-0.117	0.135*	-0.106	-0.193*	-0.180*
NPPP						0.073	0.001	0.391**	-0.166*	0.380**
PL							0.067*	0.125	-0.060	0.039
NSPP								0.105**	-0.074	-0.144
YPP									0.084	0.316**
HSW										-0.021

NPB= Number of primary branch, NSB= Number of secondary branch, PH= Plant height, DF= Days to 50%flowering, DM=Days to 95% maturity, NPPP= Number of pod per plant. PL= Pod length, NSPP= Number of seed per pod, YPP= Seed yield per plant, HSW= 100-seed weight, SYLD = Seed yield (kg/ha), *, ** = Significant a 5% and 1% probability

Table 2. Genotypic correlation coefficients (rg) of yield and yield related traits for the 49 Cowpea accessions.

	NSB	PH	DF	DM	NPPP	PL	NSPP	YPP	HSW	SYLD
NPB	0.499**	0.059	0.211	-0.088	0.107	0.126	-0.051	0.143	-0.061	0.025
NSB		0.166	-0.142	-0.186	0.371**	0.196	-0.121	0.185*	-0.170	0.102
PH			-0.122	0.151*	0.422**	0.182	0.225	0.217	-0.193	0.271*
DF				0.347*	-0.261*	0.096	0.044*	-0.281*	-0.111	-0.124
DM					-0.072	-0.133	0.195	-0.247	-0.234*	-0.258
NPPP						0.103	0.086	0.470**	-0.263*	0.439**
PL							0.079	0.187	-0.052	0.098
NSPP								-0.073	-0.073	-0.266
YPP									0.159	0.438**
HSW										0.019

NPB= Number of primary branch, NSB= Number of secondary branch, PH= Plant height, DF= Days to 50%flowering, DM=Days to 95% maturity, NPPP= Number of pod per plant. PL= Pod length, NSPP= Number of seed per pod, YPP= Seed yield per plant, HSW= 100-seed weight, SYLD = Seed yield (kg/ha), *, ** = Significant a 5% and 1% probability

Seed yield per ha showed positive and highly significant association with seed yield per plant (r=0.316**), number of pod per plant (r=0.380**) and number of secondary branch (r=0.224**) at a phenotypic level whereas number of pod per plant (r=0.439**) and seed yield per plant (r=0.438**) showed a positive and highly significant association at a genotypic level. High significance of seed yield per plant, number of pod per plant and number of secondary branch shows that any improvement of these traits may result in an increment of seed yield. The current finding agrees with an earlier study on cowpea by [4, 23, 24] who reported a positive correlation of grain yield with pods per plant. The positive association between grain yield and yield attribute is also in accord with an earlier study on character association in cowpea by [12, 25]. Conversely, grain yield was negatively correlated with days to maturity (r= -0.180*). Similar result was reported by [26] who found negative genotypic and phenotypic correlation of days to maturity with seed yield. This may be related to the fact that when days to maturity increases, the phenology of the crop enters into the dry spell, which in turn leads to loss in yield. Number of primary branches and plant height also showed a significant correlation with seed yield at phenotypic and genotypic level respectively. Number of pods per plant however, had a significant positive correlation with seed yield per plant (r = 0.470**) at a genotypic level. This trait also recorded a positive relationship with seed yield per plant (r = 0.391**) at a phenotypic level.

Hundred (100) seed weight had significant and negative phenotypic correlation with number of pods per plant (r = -0.166*), number of seeds per pod (r = - 0.074) and days to maturity (r = -0.193*). Similar to the present finding [27] reported that the correlation of 100 seed weight with number of pods per plant and number of seeds per pod was significant and negative. Negative association between 100 seed weight and number of seeds per pod indicates a compensatory relationship between them. More seeds per pod could result in the reduction of the average seed size because of competition among seeds for limited food reserves [28]. Yield per plant exhibited a negative and significant phenotypic correlation with days to 50% flowering. This implies, long period of flowering in these cowpea accessions would greatly reduced yield. Similar to the current finding, [29] also reported a significant and negative correlation of days to 50% flowering with yield in green gram.

3.2. Path Coefficient Analysis

The phenotypic direct and indirect effect of different traits on seed yield is presented in Table 3. Yield per plant followed by number of pod per plant had exerted positive direct effect on seed yield at phenotypic level. However days to maturity, days to flowering, number of secondary branches per plant and number of seed per pod had negative direct effect on seed yield. The positive direct effect of plant yield on seed yield is in accordance with the previous report by [30, 33] in chickpea. [31] also found that number of pod per plant had positive direct effect on seed yield in cowpea. Traits like yield per plant and number of pods per plant which ultimately affects seed yield were the components that exerted a substantial direct effect on seed yield. Days to maturity and number of seed per pod contributed to seed yield mainly via their high and positive indirect effect with yield per plant. The positive direct effect of yield per plant on seed yield was counterbalanced by its indirect effect via days to flowering which finally resulted in positive and low phenotypic correlation with seed yield. The residual effect determines unaccounted variability of the dependent factor (seed yield). Its magnitude 0.219 indicated that the traits included in the path analysis explained 78.1% of the variation in seed yield.

***Table 3.** Estimates of direct (bold diagonal) and indirect effect (off diagonal) at phenotypic level for different traits on seed yield in 49 cowpea accessions*

	NSB	DF	DM	NPPP	NSPP	YPP	rp
NSB	**-0.143**	-0.010	0.002	0.015	0.019	0.074	0.224
DF	-0.011	**-0.135**	-0.043	-0.007	-0.018	-0.015	0.003
DM	0.002	-0.041	**-0.140**	-0.002	-0.039	0.023	-0.180
NPPP	-0.034	0.016	0.004	**0.061**	0.003	0.084	0.380
NSPP	0.009	-0.008	-0.019	0.000	**-0.288**	0.020	-0.144
YPP	-0.049	0.015	0.014	0.024	-0.030	**0.215**	0.316

Residual = 0.219

NSB = Number of secondary branches per plant DF = Days to 50% flowering, DM = Days to maturity, NPPP = Number of pods per plant, NSPP = Number of seed per pod, YPP = Yield per plant (g), rp = phenotypic correlation with seed yield.

The Genotypic direct and indirect effect of different traits on seed yield is presented in Table 4. Number of pods per plant followed by yield per plant had exerted a positive direct effect on seed yield. However, days to 50% flowering, days to maturity, number of secondary branches per plant and number of seed per pod had showed negative direct effect on seed yield. The positive direct effect of number of pods per plant on seed yield is in agreement with the previous report by [32]. Yield per plant (r = 0.438) and number of pods per plant (r = 0.439) which show high positive genotypic correlation with seed yield had also exerted considerable direct effect on seed yield.

***Table 4.** Estimates of direct (bold diagonal) and indirect effect (off diagonal) at genotypic level for six traits on seed yield in 49 cowpea accssions.*

	NSB	DF	DM	NPPP	NSPP	YPP	rg
NSB	**-0.136**	0.016	0.033	0.081	0.037	0.034	0.102
DF	0.019	**-0.119**	-0.061	-0.057	-0.014	-0.051	0.124
DM	0.025	-0.041	**-0.176**	-0.015	-0.060	-0.045	-0.258
NPPP	-0.051	0.031	0.013	**0.218**	0.026	0.086	0.439
NSPP	0.017	-0.005	-0.034	0.018	**-0.031**	0.016	-0.266
YPP	-0.025	0.033	0.043	0.102	-0.030	**0.183**	0.438

Residual= 0.0287

NSB = Number of secondary branches per plant DF = Days to 50% flowering, DM = Days to maturity, NPPP = Number of pods per plant, NSPP = Number of seed per pod, YPP = Yield per plant (g), r_g = genotypic correlation with seed yield.

Number of secondary branches per plant, number of pod per plant and number of seed per pod contributed to seed yield mainly via their highest and positive indirect effect with yield per plant. The high positive direct effect of number of pod per plant on seed yield was counterbalanced by its indirect effect via days to flowering which finally resulted in positive and low genotypic correlation with seed yield. The residual (0.0287) indicates that traits which are included in the genotypic path analysis explained 97.11% of the total variation in seed yield. Path analysis indicated that yield per plant and number of pods per plant could be used as indirect selection criteria for better seed yield. Therefore, selecting genotypes having high yield per plant and more number of pods per plant could be used to improve seed yield in the cowpea accessions.

4. Conclusion

Significant and positive correlations were observed between growth characters as well as between growth characters and seed yield of cowpea. When the correlation coefficients were partitioned into direct and indirect effects, seed yield per plant had the highest contribution followed by numbers of pods per plant. Days to 50% flowering, days to maturity and number of secondary branches per plant contributed the lowest. Implicit to this dictum, seed yield per plant and numbers of pods per plant should serve as basis for selection in cowpea improvement.

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