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Correlation and Path coefficient Analysis of Yield and Yield related Traits interactions in Ethiopian Cowpea *(Vigina Unguiculata Walp L.)* Accessions

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Cowpea (*Vigina unguiculata* L.) is an annual pulse crop that belongs to the family fabaceae. Even though Ethiopia is secondary center of diversity for the crop, the current knowledge about its variety development and agronomy is neither complete nor conclusive through research under Ethiopian condition. To fill the existing gaps, a field experiment was conducted during 2015 main season at Melkassa Agricultural Research Center. Thirty cowpea accessions with six standard checks were tested in triple lattice design. Data for 13 agronomic traits were measured and statistically tested. Seed yield showed positive and significant phenotypic association with pod length, number of pods bearing cluster plant-1, number of pods plant-1, number of seeds plant-1 , 100-seed weight, harvest index and biomass yield. Harvest index also showed positive correlation with seed yield at genotypic level. Therefore, any improvement of these traits may result in a substantial increase on seed yield. At genotypic and phenotypic level, seed pod, number of pods plant-1, 100-seed weight, harvest index, number of nods plant -1, and those traits exerted positive direct effect on seed yield. So, those traits are the major direct contributors to grain yield. These characters should therefore receive the highest priority in developing high yielding cowpea varieties.

Key words: Correlation, direct and indirect effect path analysis, *Vigina unguculata*

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INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is considered the second most important grain legume in Africa (Purseglove, 1974). In Ethiopia, although cowpea is grown in different regions of the country (Oromiya, Amhara, Tigray, SNNP, and Gambella), the area coverage is not recorded by the Central Statistical Authority. Moreover, there are also released varieties of cowpea which can give an average yield of 1.5-1.9 t/ha under farmers field condition (Fenta et al unpublished report). But those varieties are not landrace of Ethiopian cowpea rather they are imported from IITA and passed through different stages of selection breeding. Since Ethiopia is secondary center of diversity (Vavilove, 1951), further selection is important for identifying better varieties in the trait of interest.

One way to do this is to carry out correlation analysis which quantifies the relationship between any given pair of traits (Obisesan, 1985). However, yield is a complex trait, and it is difficult to determine from correlations alone which traits contribute more to grain yield. Therefore, it is important to carry out other analysis so as to establish the direct and indirect contribution of each trait on grain yield. Path coefficient analysis, developed by Wright (1921, 1923), determines the significance of correlations between yield components and assigns relative importance to yield relations (McGiffens et al., 1994). The coefficients generated by path analysis measure the direct and the indirect influence of a variable upon another (Dewery and Lu, 1959). This study determined the phenotypic and genotypic correlations and evaluated direct and indirectly and provides detailed information to identify important characters to be considered in cowpea improvement program.

MATERIALS AND METHODS

The study was conducted at Melkassa Agricultural Research Center (MARC), and involved 30 cowpea accessions with six released varieties as standard checks. Planting was done on July 20, 2015. The experiment was laid out in 6*6 triple lattice design with three replications. Rows, 4m long were spaced 60 cm apart with 20cm between plants. The plot had 2 rows. Data were collected from five randomly taken plants in each plot on parameters like; plant height, number of primary branch plant^{-1}, number of secondary branch plant^{-1} , number of pods per plant^{-1}, number of seeds pod^{-1}, pod length, grain yield plot^{-1}, number of nods plant^{-1}, number of pod bearing clusters plant^{-1} and dry matter yield, days to flowering, days to maturity, number of seed plant^{-1}, hundred seed weight, harvest index ,biomass yield (dry matter) .

Variance and covariance analyses for each variable and each pair of variables, respectively, were carried out. Path analysis was also carried out to determine the relationships among the yield components. Phenotypic and genotypic correlation were calculated from the variance and covariance components using the formula:

$$r\,(x,y) = \frac{\mathrm{Cov}(xy)}{\sqrt{\sigma x^2 \sigma y^2}}\mathrm{ce}$$

where $r_{(x,y)}$ = genotypic or phenotypic correlation between variables x and y;

$\mathrm{Cov}_{(x,y)}$ = genotypic or phenotypic covariance between the two variables;

$\sigma\ x^2$ = genotypic or the phenotypic variance of the variable x; and

$\sigma\ y^2$ = genotypic or the phenotypic variance of the variable y.

Correlations and path-analyses were done to determine the interrelationships among yield components and their direct and indirect contribution to grain yield. Based on the genotypic correlations, path coefficients were calculated by solving a series of simultaneous equations as suggested by Dewery and Lu (1959).

The residual effect, which determines how best the causal factors account for the variability of the dependent factor, yield in this case, was obtained using the formula;

$$1 = P^2_{R7} + P_i y r_i y$$

where P^2_{R7} = residual effect

$P_i y r_i y$ = the product of direct effect of any variable and its correlation coefficient with yield

RESULTS AND DISCUSSION

Estimates of correlation coefficient at phenotypic and genotypic level

The analysis of the relationship among these traits and their association with seed yield is essential to establish selection criteria (Singh et al., 1990). Estimates of phenotypic and genotypic correlation coefficients between each pair of traits are presented in Table1. The magnitudes of genotypic correlation coefficients for most of the traits were higher than their corresponding phenotypic correlation coefficients, except few cases, which indicate the presence of inherent association among various traits. This is in accordance with the previous report by Adetiloye et al. (2017) in Nigerian cowpea.

Seed yield showed positive and significant phenotypic association with pod length, number of clusters plant^{-1}, number of pods plant^{-1}, number of seeds plant^{-1}, 100-seed weight, harvest index and biomass yield. The result in number of pods plant^{-1}, number of branches plant^{-1}and pod length is in close agreement with (Bhardu and Navale, 2011) Therefore, any improvement of these traits may result in a substantial increase in seed yield.

Singh et al. (2011) reported that the number of pods plant^{-1} recorded highest positive direct effect on grain yield plant^{-1} via positive indirect effects of plant height and number of primary branches plant^{-1}.

The relationship between seed yield and the number of pods plant^{-1} ($r = 0.48$) was strongly positive and significant at phenotypic level. This strongly suggests the fact that seed yield plant^{-1} improvement would be made through the selection of number of pods plant^{-1} which is in agreement with Okeleye et al. (1999).

Genetically, harvest index was showed positive and significant correlation with seed yield ($r = 0.81$) but other traits were not correlated both positively and negatively with seed yield.

Generally, positive correlation between traits at genotypic and phenotypic levels imply the possibilities of correlated response to selection and it indicated that with

Table 1: Genotypic (G) and Phenotypic (P) correlation coefficients among yield components of cowpea accessions evaluated at MARC, Ethiopia in 2015 cropping season

Traits	Corr.	YLd	DTF	DTM	ND	PHT	PL	CL	PPPL	SPPL	SPP	HSW	HI	BY
Yld	P	1	-0.26**	-0.37**	0.17	-0.29**	0.59**	0.51**	0.48**	0.42**	0.16	0.51**	0.78**	0.30**
	G	1	-0.27	-0.48	0.2	-0.31	0.62	0.52	0.5	0.44	0.17	0.53	0.81**	0.26
DF	P		1	0.55**	-0.46**	0.42**	-0.08	-0.46**	-0.57**	-0.41**	-0.06	0.1	-0.21	-0.24
	G		1	0.68	-0.54	0.43	-0.08	-0.47	-0.58	-0.43	-0.07	0.11	-0.21	-0.24
DM	P			1	-0.11	0.40**	-0.35	-0.33**	-0.41**	-0.44**	-0.19	-0.15	-0.22	-0.26**
	G			1	-0.02	0.49	-0.46	-0.4	-0.5	-0.56	-0.26	-0.23	-0.29	-0.34
ND	P				1	0.02	-0.07	0.27	0.2	0.32**	0.2	-0.2	0.16	0.07
	G				1	0.02	-0.04	0.31	0.23	0.39	0.27	-0.23	0.19	0.12
PHT	P					1	-0.3	-0.39**	-0.42**	-0.16	0.16	-0.1	-0.2	-0.17
	G					1	-0.31	-0.4	-0.43	-0.17	0.17	-0.1	-0.2	-0.19
PL	P						1	0.17	0.25	0.17	0.03	0.72**	0.39**	0.27**
	G						1	0.18	0.26	0.17	0.02	0.76**	0.4	0.29
CL	P							1	0.70**	0.42**	-0.09	-0.05	0.32**	0.37**
	G							1	0.70**	0.43	-0.1	-0.06	0.33	0.39
PPPL	P								1	0.46**	-0.25	0.05	0.44**	0.22
	G								1	0.48	-0.26	0.05	0.44	0.23
SPPL	P									1	0.64**	0.01	0.29**	0.26**
	G									1	0.62	0	0.3	0.27
SPP	P										1	-0.08	0.2	-0.01
	G										1	-0.09	0.2	-0.01
HSW	P											1	0.26**	0.24
	G											1	0.26	0.25
HI	P												1	-0.30**
	G												1	-0.31
BY	P													1
	G													1

Key: DTF = Days to flowering, DTM = Days to maturity, PHT = Plant Height (cm), PL = Pod length (Cm), CL= number of cluster per plant, PPP = Number of pod per plant, SPPL = Number of seeds per plant, SPP = Number of seeds per plant, HSW = Hundred seed weight (g), HI = Harvest Index, BY = Biomass yield.

increase in one, will entail an increase in another and negative correlation preclude the simultaneous improvement of those traits along with each other.

Correlations among other traits

Days to flowering was positively associated with days to maturity and plant height while number of nods plant^{-1} was associated with seeds plant^{-1}. Number of clusters is associated with number of secondary branches, number of pods plant^{-1}, 100-seed weight and dry matter yield. ^{1}and harvest index. Plant height was positively correlated with days to flowering and days to maturity at phenotypic level. The association of days to maturity with plant height was positive and significant as reported by Ofori and Djagbletely (1995) in cowpea.

Number of clusters also showed positive correlation with number of pods plant^{-1}, and also 100-seed weight shows positively significant correlation with pod length. direct relationship with seed yield were included in the path analysis. The phenotypic direct and indirect effect of different traits on seed yield is presented in Table 2. Seeds pod^{-1} followed by days to flowering, days to maturity, number of pods plant^{-1}, 100-seed weight, harvest index, and number of nods plant^{-1}. All the above mentioned traits had exerted positive direct effect on seed yield at phenotypic level. However, number of clusters plant^{-1}, number of seeds plant^{-1} and biomass yield had negative direct effect on seed yield.

Path coefficient analysis

The correlation coefficients were inadequate to interpret the cause and effect relationships. The phenotypic and genotypic correlations were partitioned into direct and indirect effects using seed yield as a dependent variable. In the present study, all traits that are believed to have Number of seeds plant^{-1} is associated with number of nodes plant^{-1}, number of clusters, number of pods plant^{-}

Table 2: The direct and indirect contributions of various characters to grain yield in cowpea at phenotypic and genetipic level evaluated at MARC, Ethiopia in 2015 cropping season

Traits	Path	DTF	DTM	ND	PHT	PL	CL	PPPL	SPPL	SPP	HSW	HI	BY	r(p&g)
DF	P	**0.14**	0.14	-0.05	-0.05	-0.01	0.01	-0.04	0.22	-0.14	0.02	0.01	-0.21	-0.13
	G	**-0.13**	-0.13	-0.02	0.06	0.01	-0.01	-0.02	0.35	-0.22	0.04	0.01	-0.24	-0.13
DM	P	-0.09	**0.08**	-0.09	-0.01	-0.01	0.02	-0.03	0.16	-0.15	0.07	-0.01	-0.23	-0.14
	G	-0.03	**-0.09**	-0.03	0	0.02	-0.01	-0.02	0.31	-0.29	0.14	-0.01	-0.33	-0.19
ND	P	0.1	-0.07	**0.01**	0.1	0	-0.05	0.03	-0.08	0.11	-0.07	-0.02	0.16	0.04
	G	-0.11	0.07	**0**	-0.11	0	0.05	0.02	-0.14	0.21	-0.15	-0.01	0.21	0.07
PHT	P	-0.01	0.06	-0.03	**0**	-0.01	0	-0.04	0.16	-0.06	-0.06	-0.01	-0.2	-0.09
	G	0.03	-0.06	-0.02	**0**	0.03	0	-0.02	0.26	-0.09	-0.1	-0.01	-0.22	-0.1
PL	P	-0.01	-0.01	0.03	-0.01	**0**	0	0.02	-0.1	0.06	-0.01	0.06	0.4	0.14
	G	0.03	0.01	0.02	0	**-0.01**	0	0.01	-0.16	0.09	-0.01	0.05	0.45	0.16
CL	P	0.07	-0.08	0.04	0	0	0	0.02	-0.1	0.07	0.01	0.01	-0.09	0.19
	G	-0.04	0.16	0.04	-0.03	-0.02	0.01	0.03	-0.36	0.18	0.13	0.01	-0.24	0.4
PPPL	P	-0.08	-0.03	0.02	0.06	0	-0.08	0.04	-0.08	0.12	-0.06	-0.02	0.13	0.03
	G	0.06	0.03	0.01	-0.09	0	0.06	0.02	-0.16	0.22	-0.14	-0.02	0.19	0.04
SPPL	P	0.09	-0.07	0.03	0.03	0.01	**-0.03**	0.09	-0.27	0.15	0.03	0	0.33	0.2
	G	0.05	0.06	0.01	-0.03	-0.01	**0.03**	0.05	-0.43	0.23	0.06	0	0.37	0.22
SPP	P	-0.38	-0.08	0.04	0.02	0.01	-0.02	**0.07**	-0.38	0.16	0.09	0	0.45	0.11
	G	-0.61	0.08	0.02	-0.03	-0.01	0.01	**0.03**	-0.61	0.25	0.14	0	0.5	0.13
HSW	P	0.35	-0.06	0.04	0.03	0	-0.03	0.04	**-0.18**	0.35	-0.23	0	0.3	0.14
	G	0.53	0.06	0.02	-0.04	-0.01	0.02	0.02	**-0.3**	0.53	-0.34	0	0.33	0.15
HI	P	-0.36	-0.01	0.02	0.02	0	-0.01	-0.01	0.1	**0.23**	-0.36	-0.01	0.21	-0.01
	G	-0.55	0.01	0.01	-0.03	0.01	0.01	-0.01	0.16	**0.33**	-0.55	-0.01	0.23	0

Key: DTF = Days to flowering, DTM = Days to maturity, PHT = Plant Height (cm), PL = Pod length (Cm), CL= number of cluster per plant, PPP = Number of pod per plant, SPPL = Number of seeds per plant, SPP = Number of seeds per plant, HSW = Hundred seed weight (g), HI = Harvest Index, BY = Biomass yield.

Kutty et al. (2003) also reported that number of pods plant^{-1} had positive direct effect on seed yield in cowpea. Traits like flowering date, number of seeds pod^{-1} and number of pods plant^{-1} which ultimately affects seed yield were the components that exerted a substantial direct effect on seed yield. The residual effect determines unaccounted variability of the dependent factor (seed yield). Its magnitude was 0.035 indicated that the traits included in the path analysis explained 99.965% of the variation in seed yield. The genotypic direct and indirect effect of different traits on seed yield is presented in Table 2. Number of nodes plant^{-1}, plant height, number of clusters plant^{-1}, number of pods plant^{-1}, number of seeds per pod, 100-seed weight, harvest index had positive direct effect on seed yield whereas days to flowering, days to maturity, pod length, number of seeds plant^{-1} and biomass yield showed negative direct effect on seed yield. The positive direct effect of number of pods plant^{-1} on seed yield is in agreement with the previous report by Jatasra et al. (1978) in chickpea. The magnitude of genotypic path coefficient analysis 0.0202 indicated that the traits included in the path analysis explained 99.97% of the variation in seed yield.

SUMMARY AND CONCLUSION

This study shows the presence of genetic variability among Ethiopian cowpea landraces which can be used to broaden the genetic basis of the crop for better use of its genetic potential. Seed yield showed positive and significant phenotypic association with pod length, number of clusters plant^{-1}, number of pods plant^{-1}, number of seeds plant^{-1}, 100-seed weight, harvest index and biomass yield. This result indicated that the traits that correlated positively could effectively be utilized and considered when planning improvement program in cowpea.

Seeds pod^{-1} followed by days to flowering, days to maturity, number of pods plant^{-1}, 100-seed weight, harvest index, number of nods plant^{-1} exerted positive direct effect on seed yield at phenotypic path coefficient analysis. Its magnitude, 0.035 indicated that the traits included in the path analysis explained 99.965% of the variation in seed yield. At genotypic level number of nodes plant^{-1}, plant height, number of primary branches, number of secondary branches, number of clusters plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight and harvest index had positive direct effect.

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