Pertanika J. Trop. Agric. Sci. 18(1): 63-69(1995)

ISSN: 0126-6128

Genetic Variability, Correlations and Path Coefficient Analysis of Components of Seed Yield in Cowpea (*Vigna unguiculata*)

O.J. ARIYO
Department of Plant Breeding and Seed Technology
University of Agriculture
P.M.B. 2240, Abeokuta
Ogun State, Nigeria

Keywords: ***Vigna unguiculata*, cowpea, genetic diversity, correlations, path analysis**

ABSTRAK

*26 varieti kacang duduk (*Vigna unguiculata *L. Walp) telah dinilai di medan untuk mengkaji kebolehubahan genetik, hubungan antara-ciri dan juga analisa laluan komponen hasil biji benih. Hasil biji benih adalah ciri paling banyak berubah dengan pekali variasi genotip (gcv) dan pekali variasi penotip (pcv) masing-masing 22.11 dan 35.25 peratus. Hari-hari pengeluaran bunga adalah paling kurang berubah dengan gcv dan pcv masing-masing 1.93 dan 2.30 peratus. Berat bagi 100 biji benih mempunyai anggaran keterwarisan tertinggi 29.33 peratus, sementara bilangan peduksi bagi setiap tanaman menunjukkan anggaran ketewarisan terendah 30.11 peratus. Bilangan pedunkel dan cabang setiap tanaman serta bilangan pod pedunkel menunjukkan signifikan dan genotip positif korelasi dengan hasil biji benih. Hanya bilangan pedunkel dan bilangan cabang setiap tanaman menunjukkan penotip positif korelasi dengan hasil biji biji benih. Analisis pekali laluan menunjukkan hasil biji benih dipengaruhi oleh berat 100 biji benih, bilangan biji benih setiap pod, bilangan cabang setiap tanaman dan jumlah pod bagi setiap pedunkel.*

ABSTRACT

*Twenty-six varieties of cowpea (*Vigna unguiculata *L. Walp.) were evaluated in the field to study genetic variability, inter-character relationships as well as the path analysis of components of seed yield. Seed yield was the most variable character with genotypic coefficient of variation (gvc) and phenotypic coefficient of variation (pvc) of 22.11 and 35.25%, respectively. Days to flowering was the least variable with gvc and pvc of 1.93 and 2.30%, respectively. Weight of 100 seeds had the highest heritability estimate of 92.33% while number of peduncles per plant exhibited the lowest heritability estimate of 30.11%. Number of peduncles per plant, number of branches per plant and number of branches per peduncle showed signficant and positive phenotypic correlation with seed yield. Only number of peduncles per plant and number of branches per plant showed positive phenotypic correlation with seed yield. Path coefficient analysis revealed that seed yield was affected by weight of 100 seeds, number of seeds per pod, number of branches per plant and number of pods per peduncle.*

INTRODUCTION

Cowpea (*Vigna unguiculata*) is a grain legume which constitutes a major dietary protein in the humid and subhumid tropics. The protein content is about 24% (Elias *et al.* 1964) and the quantity is a function of the genotype and the environment (Bliss 1975).

Phenotypic variability and the heritability of character determine, to a large extent, the rate of genetic advance. Hence, it is essential to partition the overall variability into its heritable and non-heritable components in order to determine the most effective breeding procedures. The response of correlated characters can be predicted if the genetic correlations and heritabilities of the characters can be predicted if the genetic correlations and heritabilities of the characters are known. But as more characters are involved in correlation studies, the indirect associations between characters become more complex. In such a situation, path-coefficient analysis has been of great value in identifying direct and indirect associations (Dewey and Lu 1959).

Several investigations have shown that number of seeds per pod, pod length and weight of 100 seeds were moderately to highly heritable (Singh and Mehndiratta, 1969; Leleji 1975; Tikka *et al.* 1977; Erskine and Khan 1978). Erskine and Khan (1978) also reported moderate and low heritabilities for seed yield and number of seeds per pod, respectively. Kheradnam and Niknejad (1974) observed significant positive phenotypic correlations of seed yield with the number of pods per plant and number of seeds per pod.

The objectives of this study were to determine (a) genetic variability, (b) inter-character associations, and (c) the components of pod yield in cowpea.

MATERIALS AND METHODS

Twenty-six cowpea varieties were utilized for this study; 25 of these were obtained from the Grain Legume Improvement Programme of the International Institute of Tropical Agriculture, Ibadan, Nigeria.

The varieties were grown at the University of Agriculture Teaching and Research Farm, Abeokuta, during the late rainy season (September) of 1991. The varieties were grown in randomized complete block design with three replications. Each variety was grown in 2 x 2 m plots, each containing 44 plants. The plants were spaced 50 cm between rows and 20 cm apart within the row to give 11 plants per row. With the exception of the varieties at the borders, which had five rows to offset the border effect, each variety had four rows. Plants were sprayed with Cymbush (Cypermethrin) at the rate of 1.5ml/l every 2 weeks to control insect pests, while weeding was done when necessary.

From the competitive plants in the harvest area of $4m^2$ data were collected on the following characters: seed yield per square met, weight of 100 seeds, number of seeds per pod, pod length, number of pods per peduncle, number of branches per plant, number of peduncles per plant and number of days to flowering.

The plot means were subjected to analysis of variance and covariance according to the procedures outlined by Snedecor and Cochran (1967) and Kemphorne (1973).

A random model was assumed. Genotypic and phenotypic coefficients of variation were estimated using the formula suggested by Burton (1952). Broad-sense heritability estimates were calculated according to the formula suggested by Allard (1960). Genotypic and phenotypic coefficients of correlation were also calculated from the genotypic and phenotypic variances and covariances and of the characters. Environmental correlations were calculated as outlined by Falconer (1960).

Path-coefficients were calculated using the genotypic coefficients of correlations as outlined by Dewey and Lu (1959). The nature of the causal scheme, including characters and seed yield, is presented in *Fig. 1.*

RESULTS

Table 1 shows the analysis of variance and the range of the eight characters evaluted. The varieties were different from each other for all the characters evaluated except for number of branches per plant.

Table 2 presents the means, genotypic and phenotypic coefficients of variation and heritability estimates for the eight characters. Seed yield was the most variable character with genotypic coefficient of variation (gvc) and phenotypic coefficient of variation (pvc) of 22.11 and 35.25%, respectively. Number of days to flowering was the least variable exhibiting gcv and pcv of 1.93 and 2.30%, respectively. The other characters showed intermediate variation.

Weight of 100 seeds, which had intermediate gcv and pcv had the highest heritability estimate of 92.23%, followed by pod length, which had the heritability estimate of 82.12%. Number of pods per peduncle and number of days to flowering also exhibited high heritability estimates of 80.00 and 70.62%, respectively. Other characters showed low to intermediate heritability estimates.

Table 3 shows the genotypic, phenotypic and environmental correlation coefficients among the eight characters. Significant genotypic, phenotypic and environmental correlation coefficients were observed between number of peduncles per plant and number of branches per plant, number of pods per plant and days to flowering and between weight of 100 seeds and

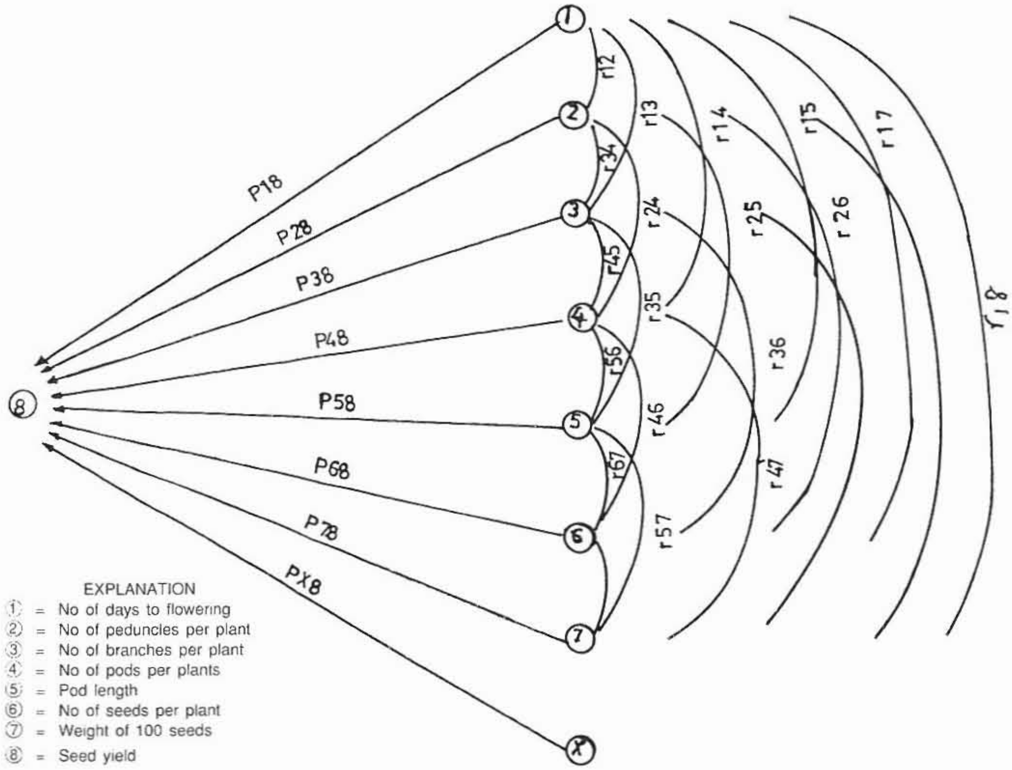

Fig 1: Path diagram of factors influencing pod yield in cowpea (source : Dewey & Lu 1959)

TABLE 1
Mean squares in the analysis of variance of characters in cowpea

Source of Variation	D.F.	Days to flowering	Number peduncles/ plant	Number branches	Number pods/ peduncle	Pod length (cm)	Number seeds/ pod	Weight 100 seeds (g)	Seed yield (g/m²)
Block	2	0.17	5.88	0.52*	0.06	3.78	3.78	2.13	5879.66**
Genotype	25	2.44**	21.35**	0.35	0.40**	27.36*	7.12**	11.73**	5240.82**

*, ** = Significant at 5 and 1% levels of probability respectiely

number of seeds per pod. Similarly, all three correlation coefficients were signficant for the relationship between number of peduncles per plant, number of branches per plant and seed yield. Only genotypic correlation coefficients were signficant for the relationship between number of branches per plant, number of seeds per pod and days to flowering: between pod length, number of seeds per pod and number of peduncles per plant and between number of pods per peduncle and seed yield. Only environmental correlation was signficant for pod length and number of days to flowering, number of pods per peduncle and seed yield, and between pod length and weight of 100 seeds. Phenotypic and environmental correlations were signficant for pod length and number of pods per plant.

Table 4 gives the direct and indirect effects of seven characters on seed yield as well as the residual factors. Number of seeds per pod and weight of 100 seeds had the largest direct effects

TABLE 2
Mean values, genotypic and phenotypic coefficients of variation and heritability estimates of eight characters in cowpea

Character	Mean	Genotypic CV (%)	Phenotypic CV (%)	Broad sense (%) heritability
Days to flowering	43.6	1.93	2.30	70.62
Number of peduncles/ plant	20.36	9.84	17.92	30.11
Number of branches/ plant	3.54	7.0	11.33	37.89
Number of pods/ peduncle	2.07	16.73	18.71	80.00
Pod length (cm)	17.17	16.98	18.74	82.12
Number of seeds/pod	10.94	12.06	17.45	47.67
Seed yield (g/m^2)	153.64	22.11	35.35	39.34
Weight of 100 seeds (g)	14.47	13.47	14.47	92.23

TABLE 3
Genotypic, phenotypic and environmental correlation coefficients between eight characters in cowpea

Character		Number peduncles/ plant	Number branches/ plant	Number pods/ plant	Pod length (cm)	Number seeds/ pod	Weight 100 seeds (g)	Seed yield/m^2 (g)
Number of days to flowering	G	0.07	0.39*	0.42*	-0.29	0.45*	-0.17	0.20
	P	-0.03	0.09	0.40*	-0.05	0.27	-0.11	0.02
	E	-0.10	-0.03	0.66*	0.51**	0.30		-0.08
Number of peduncle/plant	G		0.58**	0.10	-0.51**	-0.46*	0.10	0.73**
	P		0.41*	0.01	-0.26	-0.26	0.11	0.39*
	E		0.52	-0.04	0.37	-0.31	0.11	0.46**
Number of branches/plant	G			0.34	-0.31	-0.22	-0.08	0.71**
	P			0.16	-0.19	-0.23	-0.03	0.43*
	E			0.17	-0.28	-0.34	-0.01	0.53*
Number of pods/ peduncle	G				-0.29	0.08	-0.22	0.39*
	P				-0.39*	0.01	-0.20	0.28
	E				-1.05**	-0.06	-0.13	0.37*
Pod length (cm)	G					-0.13	0.17	-0.15
	P					-0.11	0.18	-0.01
	E					-0.22	0.43*	0.12
Number of seeds/pod	G						-0.67**	-0.18
	P						-0.40*	0.06
	E						-0.50**	0.06
Weight of 100 seeds (g)	G							0.29
	P							0.16
	E							0.25

*, ** = Significant at 5 and 1% levels of probability respectively

G, P and E are genotypic, phenotypic and environmental correlation coefficients respectively

TABLE 4
Direct and indirect effects of some characters on seed yield in cowpea

Character	Direct effect on seed yield	Number days to flowering	Number ped-uncles/ plant	Number branches/ plant	Number pods/ peduncle	Pod length (cm)	Number seeds	Weight 100 seeds (g)	Genotypic correlation coefficient
Number of days to flowering	-1.218		0.117	0.350	0.365	-0.324	1.143	-0.293	0.20
Number of peduncles/plant	1.667	-0.085		0.524	0.087	-0.467	-1.168	0.173	0.73**
Number of branches/plant	0.903	-0.475	-0.967		0.296	-0.284	-0.559	-0.138	0.71**
Number of pods/peduncle	0.870	-0.511	0.167	0.307		-0.266	0.203	-0.378	0.39*
Pod length (cm)	0.916	0.353	-0.850	-0.280	0.252		-0.534	0.293	-0.15
Number of seeds/pod	2.539	-0.548	-0.767	-0.199	0.070	-0.199		-1.156	-0.18
Weight of 100 seeds (g)	1.725	0.207	0.167	-0.072	0.191	0.156	-1.701		0.29

*, ** = Significant at 5 and 1% levels respectively.
Residual Factors = -0.579.

on seed yield in spite of their low correlations. Only number of days to flowering had negative direct effect on seed yield.

Although number of seeds per pod had the largest direct effect on seed yield, it also had a large indirect effect through reduction in weight of 100 seeds. Similarly, weight of 100 seeds had a large indirect effect through the reduction in the number of seeds per pod. Although the direct effect of number of days to flowering was negative, it had a large indirect effect through increase in the number of seeds per pod.

The residual factors accounted for -0.579.

DISCUSSION

The wide range of variability observed for the eight characters evaluated may be attributed to the diverse genetic background of the varieties studied.

Heritability estimates alone indicate the effectiveness with which selection of genotypes can be based on phenotypic performance. However, heritability in conjuction with genetic coefficient of variation provides a more dependable measure of amount of genetic advance to be expected from selection (Burton 1952). The medium gcv and high heritability estimates observed for days to flowering and the relatively high gcv and low heritablility estimate for seed yield suggest limited scope for further improvement for these characters through selection.

Phenotypic correlation is a composite of genotypic and environmental correlations but it was observed that the genotypic correlation coefficients were, in most cases, higher than their corresponding phenotypic correlation coefficients. This has been ascribed to negative environmental correlations between the corresponding characters (Searle 1961).

Seed yield was genotypically correlated with number of peduncles per plant, number of branches per plant and number of pods per peduncle, indicating the reliability of these characters in selecting for yield. However, only number of peduncle per plant were phenotypically correlated with seed yield. Characters which are phenotypically correlated but not genotypically correlated will not produce repeatable estimates of inter-character associations and any selection based on the relationship is likely to result in little, if any, genetic gain. This is true of the relationship between number of pods per peduncle and pod length. Also, characters that are genotypically correlated but not phenotypically correlated will not be of practical value in selection since selection is often based on the phenotypic performance of the characters. This is true of the relationship between number of days to flowering and number of branches per plant, between pod length and number of peduncles per plant, between number of peduncles per plant and number of seeds per pod, and between number of pods per peduncle and seed yield.

The positive correlation between seed yield and number of branches per plant may be related to greater photosynthetic capacity provided by more leaves since the branches bear most of the leaves. Also, more branches imply more pod-bearing peduncles and hence number of days to flowering, and number of branches per plant suggests that early-flowering varieties produce fewer branches and thus yield less than varieties that flower late.

Negative correlation between pod length and number of peduncles per plant indicated that the varieties with long pods produced lower numbers of peduncles. Unless the length of the pod can compensate for the low number of peduncles, such varieties are likely to yield less. However, since the number of seeds per pod and the number of peduncles per plant were negatively correlated, it appears that selecting for high number of peduncles will result in a low number of seeds per pod. The fact that weight of 100 seeds and number of seeds per pod were negatively correlated indicates that by selecting for a high number of seeds per pod, one is indirectly selecting for light seeds. Since there was significant association between number of peduncles per plant, number of branches per plant, number of pods per peduncle and seed yield, such characters should be selected for whenever high seed yield is the objective.

Generally, low environmental correlation indicates that phenotypic correlation will be a good index of genotypic correlation (Falconer 1960). The signficant environmental correlation observed between number of peduncles per plant, number of branches per plant, number of pods per plant and seed yield indicates that selection for yield on the basis of the phenotypic performances of these characters will not be effective. However, the high environmental correlation and low genotypic correlation between weight of 100 seeds, number of pods per plant and pod length suggests that environmental correlation would be a more reliable index of phenotypic correlation.

Correlation measures mutual association with no regard to causation, whereas path analysis specifies causes and measures their relative importance (Dewey and Lu 1959). That the number of seeds per pod and weight of 100 seeds had the largest direct effects on seed yield in spite of their low correlation with it, indicates the defects of selecting on the basis of inter-character correlations alone. The path coefficient analysis revealed that the poor association between number of seed per pod, weight of 100 seeds and seed yield was largely due to indirect effects through reduction of weight of 100 seeds and number of seeds per pod respectively. The fact that number of peduncles per plant, number of branches per plant and number of pods per peduncles were positively correlated with seed yield, with relatively large direct effects on seed yield, indicates that these characters are also important when selecting for high seed yield.

On the basis of path analysis, it is established that seed yield in cowpea is affected by weight of 100 seeds, number of seeds per pod, pod length, number of branches per plant and number of pods per peduncle. For selection purposes, however, emphasis should be placed on those characters with high heritability in order to produce repeatable results. Therefore weight of 100 seeds, number of seeds per pod and number of pods per peduncle should be selected for whenever high yield is the objective.

ACKNOWLEDGEMENT

The author is grateful to the Grain Legume Improvement Programme of the International Institute of Tropical Agriculture (IITA), Ibadan, for making available the cowpea varieties.

REFERENCES

ALLARD, R.W. 1960. *Principles of Plant Breeding*. London: Wiley.

BLISS, F. A. 1975. Cowpeas in Nigeria. In *Proceedings of a Symposium on Nutritional Improvement of Food by Breeding*, 3 - 5 July, 1972, ed. M. Milner p. 151-158. New York: United Nations Protein Advisory Group.

BURTON, G.N. 1952. Quantitative inheritance in grasses. In *Proc. 6th International Grass Congress* 1: 277-283.

DEWEY, D.R. and F.H. LU. 1959. A correlation and path-coefficient analysis of components of crested wheat grain seed production. *Agronomy Journal* **51**: 575-578.

ELIAS, L.G., R. COLINDRES and R. BESSAL. 1964. The nutritive value of eight varieties of cowpea (*Vigna sinensis*). *Journal of Food Science* **29**: 118-122.

ERSKINE, W. and T.N. KHAN. 1978. Inheritance of cowpea yields under different soil conditions in Papua New Guinea. *Experimental Agriculture* **14:**

FALCONER, D.S. 1960. *Introduction to Quantitative Genetics*. London: Oliver & Boyd.

KEMPTHORNE, O. 1973. *An Introduction to Genetic Statistics*. Ames, Iowa: Iowa State University Press.

KHERADNAM, M. and M. NIKNEJAD. 1974. Heritability estimates and correlation of agronomic characters in cowpea (*Vigna sinensis* L.). *Journal of Agricultural Science* **82:** 207-208.

LELEJI, O.I. 1975. Inheritance of three agronomic characters in cowpeas (*Vigna sinenasis* L. (Savi). *Madras Agricultural Journal* **62**: 95-97.

SEARLE, S. R. 1961. Phenotypic, genotypic and environmental correlations. *Biometrics* **17:** 474-480.

SINGH, K.B. and P.D. MEHNDIRATTA. 1969. Genetic variability and correlation studies in cowpeas. *Indian Journal of Genetics and Plant Breeding* **29**: 104-109.

SNEDECOR, G.W. and W.G. COCHRAN. 1967. *Statistical Methods*. Ames: Iowa State University Press.

TIKKA, S.B.S., S.N. JAIMINI, B.M. ASAWA and J.R. MATHUR. 1977. Genetic variability, interrelationships, and discriminant function analysis in cowpea (*Vigna unguiculale* (L.) Walp.). *Indian Journal of Heredity* **9**: 1-9.

(Received 22 June 1994)