



Genetic Variability, Heritability and Genetic Advance in Cowpea Genotypes in Two Agro-ecological Environments

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ABSTRACT

Studies on genetic variability, heritability and genetic advance were carried out with five genotypes of cowpea (*Vigna unguiculata* L. Walp) cultivated at two (rainforest and guinea savannah) agroecological environments. Analysis of variance revealed that though there was no significant interaction among the genotypes for most of the characters studied, they varied significantly for all the 16 characters at each of the two locations, indicating the existence of considerable variation for all the characters. Considerable amount of genotypic and phenotypic coefficient of variation was observed for all characters. High Heritability and genetic advance as per cent of mean were shown by clusters per plant, pods per plant, peduncle length, pod length, dry pod weight, hundred seed weight, seed per pod, number of seeds per plant and seed yield per plant indicating that these traits were controlled by additive genetic effects and could be dependable for grain improvement in cowpea.

Keywords:

Cowpea, Variance, Genetic advance,
Heritability, Genotypic variance,
Phenotypic variance

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) belonging to the family Fabaceae, is one of the most important pulse crops native to central Africa. Cowpea grain with the largest usable protein content of all cultivated legumes is arguably the world's most important protein source for most parts of the world. The crop contains about 25% protein, making it an extremely valuable crop especially in regions where many resource poor people cannot afford animal protein food like meat and fish. Cowpea feeds millions of people in the developing world with an annual worldwide production estimated around 4.5 million metric tons on 12 to 14 million ha (Diouf, 2011). Various uses of cowpea have been reported by Ogbuinya (1997) and Hall *et al.* (2003). In Nigeria, production and release of improved cowpea varieties have been slow especially in the humid and semi humid regions. Highest yields have been obtained in the dryer regions of the Nigeria (FAO, 2000).

The success of good breeding programme usually depends on the genetic variability present in the breeding material. Thus, knowledge of genetic variability, heritability and genetic advance in cowpea is essential for a breeder to choose good genotypes for its improvement. Estimates of genetic parameters do provide an indication of the relative importance of the various types of gene effects affecting the total variation of a plant character. Genotypic and phenotypic coefficients of variation and heritability accompanied with genetic advance are very important parameters in improving traits (Denton and Nwangburuka, 2011). Johnson *et al.* (1955) reported the immense importance of selecting and evaluating varieties for quantitative and yield ability in any breeding programme, before such varieties can be introduced to a given local environment.

Assessment of genetic diversity in cowpea genotypes would facilitate development of cultivars for adaptation to specific production constraints. Better knowledge of the genetic similarities and differences of breeding materials could help to maintain genetic diversity and sustain long term selection gain. Several workers (Damarany, 1994; Uguru, 1995; Pathmanathan *et al.*, 1997; Ubi *et al.*, 2001; Omoigui *et al.*, 2006) have calculated Genotypic and different components of variance, heritability and genetic advance for different yield characters in cowpea and have revealed that selection was effective for a population with broad genetic variability and character with high heritability. Owing to this, an experiment was conducted to study variability, heritability and genetic advance in some cowpea varieties tested in two agro ecological environments of rainforest and guinea savannah.

MATERIALS AND METHOD

Two experiments were conducted at two locations: Research Farm of National Centre for Genetic

Resources and Biotechnology, Moor Plantation, Ibadan and Plant Science and Biotechnology Botanical Garden of the Department of Biological Sciences, Nasarawa State University, Keffi. Six cowpea (*Vigna unguiculata* cv-gr. Biflora) genotypes used for the study were obtained from farmers' field in Nasarawa, Bauchi, Borno and Oyo states of Nigeria. The genotypes Ife brown, Early white, Banjara, Woshiki and NG/LB/ZF/10/11/02 were sown at a spacing of 50 cm between plants and 60 cm between rows on a 2m x 3m plot following Completely Randomized Block Design with three replicates in 2012 Management practices were followed in time as scheduled for its cultivation at appropriate times. Data for Agronomic and yield were recorded from five representative plants in the middle row of each plot.

The Phenotypic variation for each trait was partitioned into genetic and non-genetic factors and estimated according to Robinson *et al.* (1951). The genotypic and phenotypic coefficient of variance was computed according to formulae given by Burton and de Vane (1953). Heritability in broad sense was estimated according to Hasan *et al.* (1956). Genetic advance was calculated according to the formula given by Johnson *et al.* (1955).

RESULTS

Analysis of variance

The results of analysis of variance revealed that the genotypes exhibited highly significant ($P < 0.01$) differences for all the characters studied in combined (Table 1) at the separate environments. There was no significant genotype x environment interaction except for number of branches per plant and number of seeds per pod.

Estimates of genotypic, phenotypic, environmental and genotype x environment variability

Table 2 shows the genotypic, phenotypic, environmental and genotype x environment variances for Keffi and Ibadan locations. Values of genotypic variances ranged from 0.05 (number of branches per plant) to 16337.47 (number of seed per plant) in Keffi location and from 0.045 (clusters per plant) to 41690.50 (number of seeds per plant) in Ibadan location (Table 2). Similarly, phenotypic variances ranged from 0.10 (pods per cluster) to 19802.10 (number of seeds per plant) in Keffi location and 0.10 (pods per cluster) to 51,359.88 (number of seeds per plant) in Ibadan location. Environmental variances in Keffi ranged from 0.03 in number of pods per cluster to 3404.63 in number of seeds per plant. For Ibadan location, the range for environmental variances ranged from 0.06 in pods per cluster to 9669.38 in number of seeds per plant. Genotype x environments variance recorded for these experiments ranged from 0.001 (pods per cluster) to 14819.99 (number of seeds per plant).

Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2) and genetic advance as per cent of mean (GAM)

Genetic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), broad sense heritability (h^2) and genetic advance as per cent of mean (GAM) estimates are presented in Table 3. Generally, higher PCV values than GCV values are indications of some environmental implication alongside genotypic reasons for variations observed among varieties used in this study. GCV estimates were high for cluster per plant, pods per plant peduncle length, dry pod weight, hundred seed weight, number of seeds per plant and seed yield per plant in both locations. GCV estimates were high for number of branches and seed per pod; moderate for plant height and low for pod length in

Ibadan location (Table 3). For both locations, moderate GCV were recorded for pods per cluster. Similarly, moderate and low GCV were recorded for seed per pod and plant height respectively in Keffi location. Days to flower, days to 50% flower and days to maturity for both locations had low GCV estimates.

Heritability (broad sense) estimates were high at Keffi and Ibadan locations respectively for seed yield per plant (93.00, 88.96)%, number of seed per plant (82.50, 81.17)%, number of seeds per pod (92.47, 88.40)%, hundred seed weight (88.14, 91.67)%, pod length (92.03, 61.30)%, pods per plant (96.14, 71.99)%, cluster per plant (83.66, 61.71)%, days to maturity (79.69, 80.46)%, days to flower (77.56, 72.90)% and days to 50% flower (86.72, 87.21)%. Heritability estimates for plant height was moderate for both locations, while for other characters was high at one location and moderate at the other (Table 3).

Table 3: Coefficients of genotypic and phenotypic variations; heritability and genetic advance per cent over mean for 13 characters of cowpea in two agro-ecological zones of Nigeria

Character	GCV		PCV		h^2		GA (% of mean)	
	Keffi	Ibadan	Keffi	Ibadan	Keffi	Ibadan	Keffi	Ibadan
Plant height (cm)	9.83	15.38	14.12	20.21	48.49	57.96	14.09	24.13
No of branches/plant	4.51	28.56	7.46	33.61	36.49	72.10	5.61	49.98
Days to flower	7.59	6.38	8.62	7.47	77.56	72.9	13.77	11.22
Days to 50% flower	7.73	9.94	8.30	10.64	86.72	87.21	14.77	19.12
Days to maturity	8.16	8.47	9.13	9.44	79.69	80.46	14.99	15.65
Clusters/plant	33.97	28.14	37.14	35.83	83.66	61.71	25.89	14.88
Pods /cluster	12.96	10.93	16.03	16.54	65.31	43.69	21.57	63.89
Pods/plant	47.27	36.55	47.27	43.08	96.14	71.99	93.62	62.69
Peduncle length	23.10	33.29	31.24	36.42	54.68	83.54	35.19	21.14
Pod length	25.67	13.09	14.18	16.74	92.03	61.30	26.88	30.24
Dry pod weight	39.52	22.52	44.16	34.55	80.08	42.50	72.84	47.07
100 seed weight	24.99	23.86	26.63	24.92	88.14	91.67	48.35	42.96
Seeds/pod	19.52	22.18	20.29	23.59	92.47	88.40	38.66	42.96
Number of seeds/plant	34.72	47.15	38.22	52.33	82.50	81.17	64.95	87.50
Seed yield/plant	59.58	64.26	61.78	68.13	93.00	88.96	118.36	124.85

PCV = phenotypic coefficient of variation, GCV = genotypic coefficient of variation, h^2 (%) = broad sense heritability, GA (% of mean) = Genetic advance as per cent of mean.

Table 1: Genotype x environment analysis of variance for 16 characters in cowpea in two agro-ecological zones of Nigeria (mean squares)

Source of variation	DF	Plant height	Number of branches	Days to flower	Days to 50% flower	Days to maturity	Cluster / plant	Pod / peduncle	Pod / plant	Peduncle length	Pod length	Dry pod weight	Hundred seed weight	No of Seed /pod	No of seed/plant	Seed yield/ Plant
Environment	1	4853.93	18.38	4.80	8.53	24.30	12.16	0.001	33.24	10.48	0.21	0.03	1.69	2.93	31601.63	286.13
Treatment	4	1752.23**	1.62**	78.20**	137.03**	215.28**	165.54**	0.42**	1084.01*	190.60**	22.80**	2.39**	67.86**	37.97**	172397.92**	7699.44**
E x T	4	839.57ns	1.59**	2.68 ns	5.37 ns	8.55 ns	8.06 ns	0.001 ns	33.49 ns	25.17 ns	0.48 ns	0.16 ns	3.55 ns	5.59**	14819.99 ns	276.62 ns
Pooled error	16	357.14	0.34	4.92	4.21	10.71	12.27	0.06	40.82	16.53	1.53275	0.2289	1.6467	0.9714	8208.75	167.126
CV		12.85	13.96	4.45	3.83	4.63	13.51	12.88	19.92	20.53	8.87	16.02	9.26	7.81	12.61	11.72

** Significant at 0.01 p level. ns, not significant. CV, coefficient of variation.

Table 2: Means, genotypic, phenotypic, environmental and genotypic x environmental variances for 16 characters of cowpea in two agro-ecological zones of Nigeria

Character	Mean		σ^2_g		σ^2_{ph}		σ^2_e		σ^2_{ge}
	Keffi	Ibadan	Keffi	Ibadan	Keffi	Ibadan	Keffi	Ibadan	
Plant height (cm)	159.73	134.29	264.56	426.89	508.43	736.45	261.87	309.56	8.39.57
No of branches/plant	4.96	3.39	0.05	0.94	0.14	1.302	18.7	0.36	1.59
Days to flower	49.40	50.20	14.06	10.27	18.12	14.07	4.07	3.80	2.68
Days to 50% flower	54.06	53.00	17.46	27.75	20.13	31.82	2.67	4.07	5.37
Days to maturity	71.53	69.73	34.03	34.87	42.70	43.34	8.67	8.47	8.55
Clusters/plant	15.66	16.93	28.32	22.73	33.86	36.83	5.53	14.10	8.06
Pods /cluster	1.95	1.94	0.06	0.045	0.10	0.103	0.03	0.06	0.001
Pods/plant	31.01	33.11	214.95	146.57	46.35	203.58	8.30	57.01	33.49
Peduncle length	20.39	19.21	22.20	40.91	40.59	48.97	18.40	8.06	25.17
Pod length	13.86	14.03	3.56	3.384	3.87	5.52	0.31	2.14	0.48
Dry pod weight	1.89	1.83	0.56	0.17	0.70	0.40	0.14	0.23	0.16
100 seed weight	14.09	13.61	12.41	10.56	14.08	11.52	1.67	0.96	3.55
Seeds/pod	12.30	12.93	5.77	8.23	6.24	9.31	0.473	1.081	5.59
Number of seeds/plant	368.15	433.06	16,337.47	41,690.5	19,802.10	51,359.88	3404.63	9669.38	14819.99
Seed yield/plant	54.44	60.61	1,052.26	1,517.29	1,131.36	1,705.59	79.098	188.30	276.62

σ^2_g = genotypic variance, σ^2_{ph} = phenotypic variance, σ^2_e = environmental variance, σ^2_{ge} = genotype x environment

DISCUSSIONS

Highly significant differences exhibited for all characters studied (Table 1) indicated the existence of sufficient genetic variability among the selected materials and scope for improvement in cowpea. Non-significant difference ($P > 0.05$) in genotype $\times$ environment interaction for most of the characters studied is an indication of the adaptability of these genotypes in the two locations of the study. For all the characters studied, and in both locations, values for phenotypic variances were higher values than genotypic variances indicating the variation observed among varieties studied was not only due to genotype but also due to environment (Table 2). High genotypic variance accompanied by corresponding low environmental and genotype $\times$ environmental variances were observed for days to 50% flowering, days to maturity, clusters per plant, pods per plant, number of seeds per plant and seed yield per plant. These results are in accordance with the report of several authors (Damarany, 1994; Umaharan *et al.*, 1997; Ubi *et al.*, 2001; Omoigui *et al.*, 2006; Manggoel *et al.*, 2012) and suggest that these traits maybe under genetic control rather than environmental influence. Hence improvement of these traits can be achieved through selection (Oyiga and Uguru, 2011).

For characters like seed yield per plant, number of seeds per plant, number of seeds per pod, hundred seed weight, dry pod weight, pod length, pods per plant and clusters per plant, phenotypic coefficient (PCV) and genotypic coefficient of variation (GCV) were higher at both locations relative to other characters studied (Table 2). This implied the existence of greater magnitude of variability in the characters listed above and the possibilities for their improvement through selection. The results corroborate with reports of Selvam *et al.* (2000); Lesley (2005) and Vineethi-Kumari *et al.* (2003). GCV and PCV values were moderate for pods per cluster but low for number of branches, days to flower, days to 50% flowering and days to maturity. This result is in line with findings of Lesley (2005) and indicates that selection for these characters is less effective when compared to those characters with high GCV and PCV.

High broad sense heritability values recorded in both environments for most characters are within the values reported from several published studies in cowpea (Umaharan *et al.*, 1997; Nakawuka and Adipala, 1999; Ubi *et al.*, 2001; Omoigui *et al.*, 2006; Adeyanju and Ishiyaku, 2007; Manggoel *et al.*, 2012), Mungbean (Khan, 1985; Makeen *et al.*, 2007) and bambara groundnut (Adeniji *et al.*, 2008; Oyiga and Uguru, 2011). And suggest the influence of fixable additive gene effects for inheritance of these traits and therefore, selection for these traits will lead to fast genetic improvement (Table 3). Similar results of high heritability estimates have been reported for cluster per plant, pods per plant and seed yield (Nehru *et al.*, 2009) and for days to 50% flowering, days to maturity, pod length, pod weight, seed per pod and 100 seed weight (Idahosa *et al.*, 2010).

Heritability combined with genetic advance is a more reliable index for selections of traits (Ubi *et al.*, 2001). A high heritability and high genetic advance as per cent of mean (GAM) attributable to highly additive gene effect was observed for cluster per plant, pods per plant, peduncle length, pod length, dry pod weight, seed per pod, number of seeds per plant, 100 seed weight and seed yield per plant (Table 3). These observations were in agreement with the findings of Nehru *et al.* (2009); Vineeta Kumasi *et al.* (2003); and show the docility of these characters for improvement through selection. Ashok *et al.* (2000) suggested mass selection breeding method as a means of improvement of traits controlled by additive gene action. High heritability coupled with moderate GAM was noticed in number of days to flower and days to 50% flower (Table 3). Similar results have been reported for days to flower (Lesley, 2005; Manju and Screelethakumary, 2002; Apte *et al.*, 1987), days to 50% flower and days to maturity (Lesley, 2005). This phenomenon may be as a result of the result of non-additive gene action which may be epistatic and/or dominance effects. Family based selection may provide a good procedure for improvement of these characters (Pathak *et al.*, 1986).

CONCLUSION

The results of this study showed that characters like clusters per plant, pods per plant, peduncle length, pod length, dry pod weight, hundred seed weight, seed per pod, number of seeds per plant and seed yield per plant showed high heritability and high genetic advance as per cent of mean and will be effective for selection as compared to selection of days to maturity, days to 50% flowering, days to flower, number of branches and plant height in cowpea improvement programme involving these genotypes in both rainforest (Ibadan) and guinea savannah (Keffi) environments.

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