Phenotypic and Genotypic Variance and Heritability Estimates in Bambara Groundnut (*Vigna subterranea* [L.] Verdc) in Mubi, Adamawa State, Nigeria

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ABSTRACT

Twelve accessions of Bambara groundnut collected from some villages in Borno and Adamawa states, North-eastern Nigeria were evaluated in a Randomized Complete Block Design with three replications during 2004 and 2005 wet seasons. Observed estimate of phenotypic and genotypic variance were high for all characters. Hundred seed weight, pod number per plant, seed yield per plant and pod yield per plant recorded high phenotypic and genotypic coefficient of variation. Broad sense heritability was 100% for pod width, pod length and seed width and also high for other characters with high genetic advance except for height at 8WAS which was low.

Keywords

Phenotypic and genotypic coefficient of variation, Variance, heritability, genetic advance and bambara groundnut.

INTRODUCTION

Bambara groundnut (*Vigna subterranea* [L.] Verdc) originated in the dry savannah agroecological zones of Nigeria and Cameroon (Baudion and Mergeai, 2001). The crop is a bunched herbaceous, annual, self-pollinated plant of the family papilionaceae (Leguminosae-papilionoideae, Fabaceae), that originated in Africa (Baudion and Mergeai, 2001; Aremu *et al.*, 2006 and PROTA, 2006) .Bambara groundnut was found by Dalziel in its genuinely wild state in 1901, in North Yola Province of Nigeria (Heller et al; 1997). The distribution of Bambara groundnut extends from Jos (Plateau State) and Yola (Adamawa State) in Nigeria to other parts of Nigeria including Cameroon. Total world production of Bambara groundnut was estimated at 330,000 metric tones annually with about half being produced in West Africa (Couldert, 1984; PROTA, 2006).

The major producers of Bambara groundnut are Burkina Faso, Chad, Côte d'Ivoire, Ghana, Mali, Niger and Nigeria, but the crop is also widely grown in Eastern and Southern Africa and in Madagascar (PROTA, 2006). Bambara groundnut primarily is cultivated for its subterranean pods; rich in protein which helps to alleviate nutritional disorder in human and livestock (Massawe *et. al.*, 2002). The haulms have been found to be of important nutritional value (Doku and Karikari, 1971). The leaves of Bambara groundnut had been noted to be rich in nitrogen and phosphorus, and therefore suitable as animal feed. (Rassel, 1960). It contributes soil nitrogen for other crops by fixing atmospheric nitrogen through symbiosis with *Rhizobium* bacterial and therefore beneficial in crop rotations and intercropping (Mukumbira, 1985; Karikari *et al*, 1999). Bambara groundnut competes favourably with cowpea in terms of food value and cash price (Obagwu *et. al*., 1997).

Bambara groundnut is not remarkably free from diseases and pests attack during growth (Hepper, 1970 and Anita, 1988). The Institute of Agricultural Research (IAR) Samaru, Zaria had reported a vulnerability of this crop to the attack of fungal diseases particularly brown blotch induced by *Colletotrichum capsici* (Obagwu *et. al*., 1997). Haines, (1991) and Mbata (1992) also reported *Callosobruchus subinnotatus* (Pic) and *Callosobruchus maculatus* as two major species of Bruchidae attacking Bambara groundnut during storage. One of the major constraints of Bambara production is that most of the varieties are local and are thus limited in their genetic potential, because both haulm and seed yields are invariably low (Tanimu and Aliyu 1997).

Massawe *et. al.*, (2002) reported the crop to be characterized by variable and unpredictable yields for reasons that have not been identified due to limited research carried out on the crop. Recently, there has been growing awareness of the potential of bambara groundnut to contribute to increased food production in Africa and thus the need to improve existing landraces of the crop (Anonymous, 1997). Doku and Karikari (1971) have shown that accessions of Bambara groundnut have some useful genetic variability for

maturity period, yield and seed characteristics. This serves as a useful tool for selecting traits by plant breeders. An evaluation of the components of variation and heritability among characters will facilitate improvement of this crop by plant breeders. Knowledge of the genetic variability available among and between accessions of Bambara groundnut is needed as a guide for breeders and other scientist working on the improvement of this underexploited legume crop.
Therefore this study was undertaken to evaluate the components of variance and to estimate the heritability between the various yield components of Bambara groundnut.

MATERIALS AND METHODS

Entries of twelve cultivars of Bambara groundnut (Table 1) used in this evaluation were sourced from farmers' collection in the north eastern Nigeria; they had been maintained in the Department of Crop Science and are true-to-type. Five cultivars namely BG7001BS, BG7006BS, BG7007BS, BG7009BS and BG70012BS were source from farmers' collection in Gwoza, Borno State, Nigeria. While BG7002AS, BG7003AS, BG7004AS, BG7005AS, BG7008AS, BG70010AS and BG70011AS were sourced from farmers' in Mubi/Hong; Adamawa state. Field evaluation was carried out at the teaching and research farm, Adamawa State University Mubi, Nigeria ($10^0 3^1$N and $13^0 7^1$E), in July 2004 and 2005 cropping season. This period coincide with the planting season for bambara groundnut in this location. Field experiment was laid out in a randomized complete block design with three replications, each plot was $10m^2$ and a total experimental area was $595m^2$. The experimental site was ploughed and harrowed, two seeds of each cultivar were sown at 50cm between plants, a total of 64 plants were established per plot.

Weeding was done manually using hand hoe at 4 and 8 weeks after sowing. Fertilizer application of 60kg super phosphate per hectare was applied shortly after planting as recommended by Hepper (1970), benlate (Benomyl) was sprayed at the rate of 30g/20L of water, at 5^{th} and 6^{th} weeks after sowing. Data was collected on all the plants within the two middle rows. Characters measured includes: plant emergence and emergence percentage at 2 weeks after sowing. Plant height (cm) at 8 weeks after sowing was measured on ten randomly selected plants within the two middle rows. Prior to harvest, the number of plants was estimated. The number of pods per plant was the mean number of pods of ten randomly selected plants, and pod yield per plant was taken as the mean number of harvested pods of ten randomly selected plants after drying. Seed yield per plant was estimated as the average weight (g) of seeds of the ten randomly selected plants on each plot after winnowing. While weight of hundred seeds was estimated by weighing 100 clean and uniform seeds picked randomly from the bulk of seeds harvested per plot.

Shelling percentage was computed =

$$\frac{Weight\ of\ dry\ seed\ (g)}{Weight\ of\ dry\ pods(g)} \times 100 \cdot$$

While pod width and length were measured (cm) using Venier calipers from ten randomly selected pods per plot. In the same vein both length and width of seeds were determined. The seed yield (kg/ha) was determined on plot basis and this was computed for seed yield per hectare.

The mean for each trait over three replication and two years was computed for each cultivar and submitted for statistic using PROC MEANS using PROC GLM procedure of SAS (1999).

Broad sense heritability was computed as specified by using the method of Singh and Chaudhary (1985 and Moll *et al.*, (1960) as:

$$H_B = \frac{\delta_g^2}{\delta_p^2}$$

Where H_B = broad sense heritability,

$\delta_g^2 = genotypic\ \text{var}\ iance$

$\delta_p^2 = phenotypic\ \text{var}\ iance$

Table 1: Description of the cultivars used in the study.

Entry name	Local name	Area of collection	State	General characteristics
BG7001BS	Danngwaji	Gwoza	Borno	Creamy colour, dominated by black stripes, smooth shiny seed coat with white eye
BG7002AS	Gurlela	Mubi	Adamawa	Creamy colour, oval shaped with smooth shiny seed coat and white-eye, which is surrounded by sky-blue colour.
BG7003AS	Idon Kule	Mubi	Adamawa	A creamy colour having few spotted light brown colour, smooth shiny seed coat with white-eye, surrounded by patches of light brown/black colour.
BG7004AS	Bambwus	Mubi	Adamawa	Creamy colour, having brown stripes, smooth shiny seed coat, white eye surrounded by sky blue colour
BG7005AS	Tanyanyi	Mubi	Adamawa	Light brown having dotted black colours, oval shaped, smooth shiny seed with white eye.
BG7006BS	Kara Magdanda	Gwoza	Borno	Brown colour seed with creamy patches mostly surrounding the eye, oval shaped with white eye
BG7007BS	Indara Ayaghayagha	Gwoza	Borno	Completely black, oval shaped, smooth seed coat with white-eye.
BG7008AS	KwadaZwalang	Hong	Adamawa	Completely white, round shaped, smooth shiny seed with white-eye.
BG7009BS	Wacha Ghagha	Gwoza	Borno	Creamy colour, having black stripes, smooth shiny seed coat, with white-eye that is surrounded by blue/brownish colour.
BG70010AS	Kurvu	Hong	Adamawa	Completely dark red, oval shaped shiny smooth seed coat with white-eye.
BG70011AS	Wada hoba shen	Hong	Adamawa	Light brown shiny seed coat with white-eye.
BG70012BS	Achaghwaghwa	Gwoza	Borno	Creamy colour, round shaped with white eye surrounded by dark brown colour having few brown stripes.

The phenotypic, environmental and genotypic variances $\left(\delta^2_{ph}, \delta^2_e, \delta^2_g\right)$ were used for the estimation of phenotypic and genotypic coefficient of variation (Singh and Chaudhary, 1985) as follows:

$$PCV = \frac{\sqrt{\delta^2_p}}{\bar{x}} \times 100$$

$$GCV = \frac{\sqrt{\delta^2_g}}{\bar{x}} \times 100$$

Where:
PCV = Phenotypic coefficient of variation
GCV = Genotypic coefficient of variation
$\bar{x}$ = Grand Mean
δ^2_p = Phenotypic variance
δ^2_g = Genotypic variance

Broadsense Heritability were computed according to the method of Singh and Chaudhary (1985) and Moll et al., (1960) as:

$$H = \frac{\delta^2 g}{\delta^2 p}$$

Where:
H = broadsense heritability
δ^2g = Genotypic variance
δ^2p = Phenotypic variance

$$\text{Genetic advance (GA)} = \frac{Hk\delta p}{\bar{x}} x\,100$$

Where:
H = Broadsense heritability
K = selection differential
δp = Phenotypic standard deviation

$\bar{x}$ = Grand mean

RESULTS AND DISCUSSION

Table 2 showed the pooled mean ± standard error, coefficient of variation, environmental variance, genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation, broadsense heritability and genetic advance for agronomic and reproductive characters in twelve accessions of Bambara groundnut evaluated in 2004 and 2005 cropping season. Seed yield/ha recorded the highest estimate of coefficient variation (16.9%), followed by seed yield/plant (14.3%) and germination percentage at 2 weeks which recorded approximately equal value of coefficient of variability≈(12%) with germination count at 2 weeks after sowing. The pod width recorded the lowest coefficient of variability of approximately 2%. The environmental variance was highest for both years (2004, 2005) in germination percentage at 2 weeks (87.26) and lowest 0.001 in both pod width and seed width.

Furthermore, the phenotypic variance for hundred seed weight was highest, followed by pod yield per plant and pod number per plant. Lowest phenotypic variance was recorded by seed width (0.01). The genotypic variance pooled for the two years presented a range between 0.01 (seed length and seed width) to 492.2 (hundred seed weight). High estimates of genotypic variance were recorded for germination percentage, pod number/plant, pod yield/plant and hundred seed weight. Pod width, seed length and width recorded low genotypic variance of 0.03, 0.01 and 0.01 respectively. Estimates of genotypic and phenotypic coefficient of variation were high for hundred seed weight (26.15 and 26.56) respectively. Genotypic components that were equal in magnitude were recorded for pod width, pod length and seed width. The lowest genotypic and phenotypic coefficient of variation was recorded for shelling percentage in both years of the trial. The phenotypic and genotypic coefficients of variation for the individual years (2004, 2005) showed similar trend (Table 3 and 4).

Broad sense heritability was 100% for pod width, pod length and seed width. High values were also recorded for seed yield/ha (93%), hundred seed weight (97%) and seed yield/plant (90%). The lowest estimate of broadsense heritability was recorded by height at 8 weeks after sowing (24%), followed by seed length (50%). The remaining characters recorded heritability estimates above 70% and high genetic advance.

The components of genetic variation pooled across years (2004 and 2005) for agronomic and reproductive characters of Bambara groundnut showed that the coefficient of variation was high in seed yield/ha suggesting that these trait was the most variable character among characters evaluated. Karikari (2000) obtained a similar result in his variability studies between local exotic Bambara groundnut landraces in Botswana.

The estimates of phenotypic variance were greater in magnitude as compared with their corresponding genotypic variance and environmental variance for most of characters evaluated. This agrees with Tanimu and Aliyu (1997) and Tanimu *et al.*, (1990) in Bambara groundnut. Similarly, genotypic variances were greater than the environmental variance for most characters when the data was pooled across the years. This revealed the greater role of environmental variation in altering the expression of these characters among the population of Bambara groundnut accessions in this study. Also the estimates of phenotypic coefficient of variation for pooled data were greater in magnitude as compared with their corresponding genotypic coefficient of variation for most characters evaluated. Similar results were reported by Agbo and Obi (2005), Vanaja and Luckins (2006) and Uguru (1995), Adebisi *et al.*, (2004), Kadams and Sajo (1998). A very close estimate between the phenotypic coefficient of variation and genotypic coefficient of variation as found in pooled data across the years of evaluation, suggested that environment influenced all the characters measured. This agrees with Agbo and Obi (2005). This indicated a wider scope for genetic improvement in this crop. Situations wherein both the genotypic coefficient of variation and phenotypic coefficient of variation were equal in magnitude as observed for pod width, pod length and seed width in the pooled data indicates there was interaction between the accessions with the environment. Also heritability estimates were high for the pooled data and this is an indication of a rapid response to selection for these characters. A high heritability and genetic advance estimates observed in this study for most yield parameters agrees with Kadams and Sajo (1998) and Karikari (2000), Vanaja and Luckins (2006). The 100% broadsense heritability estimate recorded for pod width, pod length and seed width for the pooled years of evaluation agrees with the findings of Vanaja and Luckins (2006). Allard (1960) had noted that 100% heritability implies that the phenotype could provide a perfect measure of the genotype value and therefore such characters will respond to selection. A low heritability estimated in this study for plant height at 8WAS for the pooled years agrees with Kadams and Sajo (1999) in Bambara groundnut studies

Table 2: **Mean ± Standard error (SE), Range, Coefficient Variation (CV) and Components of Genetic Variation Pooled across years (2004 and 2005).**

Characters	Mean ± SE	Range	CV (%)	Envir. Variance	Genotypic Variance	Phenotypic Variance	Genotypic Coefficient Variation	Phenotypic Coefficient Variation	Heritability (%)	GA (%)
GC2wk	45.41 ±0.99	35.7-56.2	12.2	35.81 ±1.25	36.16 ±2.19	41.61 ±2.19	13.24	14.20	87	21.18
GP2wk	75.90 ±0.56	59.7-85.5	12.3	87.26 ±1.95	89.54 ±3.44	103.0 ±3.44	12.46	13.37	87	21.97
Ht8wk	14.90 ±0.21	12.3-16.9	8.5	1.60 ±0.26	0.24 ±0.42	1.01 ±0.42	3.29	6.74	24	4.21
SC	45.53 ±0.92	32.0-56.2	11.5	30.69 ±1.15	43.87 ±2.46	51.79 ±2.46	14.55	15.81	85	20.05
PN/plt	45.91 ±0.95	38.0-71.6	11.2	32.13 ±1.18	86.90 ±3.70	110.81 ±3.70	20.30	22.93	78	17.97
PY/plt	62.34 ±1.08	43.4-87.1	10.8	42.01 ±1.35	106.68 ±3.77	123.46 ±3.77	16.57	17.82	86	19.19
SY/plt	39.00 ±0.87	26.7-53.0	14.3	27.01 ±1.08	35.09 ±2.08	38.93 ±2.08	15.19	16.00	90	26.57
100wt	84.83 ±0.94	55.1-123.3	6.7	32.07 ±1.18	492.24 ±7.28	507.45 ±7.28	26.15	26.56	97	13.36
SP	67.91 ±0.42	61.6-72.6	3.7	6.20 ±0.52	7.80 ±1.22	11.21 ±1.22	4.11	4.93	70	5.29
PW	1.39 ±0.01	1.11-1.65	2.3	0.001 ±0.01	0.03 ±0.06	0.03 ±0.06	12.46	12.46	100	4.45
PL	1.88 ±0.01	1.53-2.31	2.9	0.003 ±0.01	0.08 ±0.09	0.08 ±0.09	15.04	15.04	100	5.48
SW	1.07 ±0.01	0.95-1.26	3.3	0.001 ±0.10	0.01 ±0.03	0.01 ±0.03	9.35	9.35	100	7.70
SL	1.29 ±0.01	1.15-1.53	4.2	0.03 ±0.01	0.01 ±0.04	0.02 ±0.04	7.75	10.96	50	3.99
SY/ha	2.05 ±0.06	1.58-2.71	16.9	0.12 ±0.10	0.13 ±0.12	0.14 ±0.12	17.59	18.25	93	32.71

GC2WK = Germination count at 2WAS, GP2WK = Germination percentage at 2WAS, Ht8WK = Height at 8WAS, SC = Stand Count Prior to harvest, PN/plt = Pod number per plant, PY/plt = Pod yield per plant, SY/plt = Seed yield per plant, 100wt = 100 seeds weight, SP = Shelling Percent, PW= Pod width, PL= Pod length, SW = Seed width, SL = Seed Length, SY/ha = Seed yield

CONCLUSION AND RECOMMENDATION

The results of this study revealed that components of variance, heritability and genetic advance estimates obtained could serve as guide for the improvement of Bambara groundnut and also aid farmers to select more productive genotypes. However, more research should be conducted on these accessions over a number of years and location to ascertain their stability.

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