Scientific Research and Essay Vol. 6(3), pp. 507-515, 4 February, 2011
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research paper

Morphological intraspecific variabilities in African yam bean (AYB) (*Sphenostylis stenocarpa* Ex. A. Rich) Harms

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Accepted 12 August, 2009

Intraspecific variabilities in 25 IITA accessions of African yam bean (AYB) (*Sphenostylis stenocarpa* Ex. A. Rich.) Harms were assessed through characterization of 36 morphological characters. The intraspecific variabilities among the accessions were evaluated by the following statistical analysis tools: Analysis of Variance (ANOVA), principal component and cluster analysis (Semi - partial R-squared method). The accessions showed significant differences in a number of morphological characters and the P values indicated significant differences ($p \leq 0.0001$) in 27 characters. Statistical analysis showed that terminal leaflet length, terminal leaflet width, peduncle length, pod length, pod width, number of locules per pod and number of seeds per pod contributed significantly to seed set percentages in all the studied populations. Cluster analysis on the morphological data clustered the accessions into six distinct groups with pod and seed traits contributing significantly to the grouping. Pod lengths, number of seeds per pod and seed weight were observed to be useful characters for genetic improvement of AYB.

Key words: Morphological characterization, intraspecific variabilities, *Sphenostylis stenocarpa,* cluster groups.

INTRODUCTION

African yam bean (*Sphenostylis stenocarpa* Ex. A. Rich, Harms) is an under-utilized food legume crop in the tropics that is not popular as other major food legumes (Azeke et al., 2005; Moyib, et al., 2008). It produces nutritious pods, highly proteinous seeds and capable of growth in marginal areas where other pulses fail to thrive (Okpara and Omaliko, 1997). The crop thus has the potential to meet the ever increasing protein demands of the people in the sub-Sahara Africa if grown on a large scale. Presently, low quantities are offered for sale in the markets compared to other pulses. It is a good source of high plant protein (21% by wt) and calcium (61 mg/100 g) which compares well to that of Soybean (Baudoin and Mergeai, 2001). African yam bean (AYB) contributes to sustainable agriculture, survives well in weathered soils where rainfall could be extremely high, tolerates acidic, leached and infertile soils (NRC, 2007). Asare, et al. 1984 and DSC, 2006 observed that African yam bean is a good source of fodder for ruminant animals and performed better in seed yield when intercropped with maize, yam and okra. It is resistant to crop pests such as *Clavigralla tomentosicollis*; *Maruca vitrara* than other food legumes like cowpea [*Vigna unguiculata* (L) Walp.] (Okigbo, 1973; Evans and Boulter, 1974; IITA, 1985; Nwokolo, 1987). However, with some of these attributes, very little efforts have been invested to improve the crop in terms of yield, disease resistance, reduced cooking time and other desirable qualities, when compared to other major legumes (Potter, 1991).

The IITA accessions of AYB were collected from different locations in different countries of Africa and they are bound to vary in their phenotypic and genotypic characteristics, with most of the variations induced by the

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Table 1. Qualitative morphological characters of the *S. stenocarpa* accessions studied.

Accession number	Pigmentation intensity on stem	Terminal leaflet shape	Flower color	Pod shattering	Seed coat colour	Seed shape
TSs1	Non-pigmented	Ovate	Purplish white	Present	Brown	Rhomboid
TSs3	Non-pigmented	Ovate-lanceolate	Purplish pink	Absent	Brown	Ovoid
TSs4	Non-pigmented	Ovate	Purplish pink	Absent	Brown	Ovoid
TSs7	Non-pigmented	Ovate-lanceolate	Purplish pink	Absent	Grayish brown	Ovoid
TSs10	Solid	Ovate-lanceolate	Purplish pink	Present	Speckled	Ovoid
TSs11	Moderate	Ovate-lanceolate	Purplish pink	Absent	Creamy white	Ovoid
TSs16	Moderate	Ovate	Purplish pink	Absent	Grey	Ovoid
TSs22	Non-pigmented	Ovate	Purplish pink	Present	Brown	Ovoid
TSs23	Slight	Ovate	Purplish pink	Present	Speckled	Ovoid
TSs40	Slight	Ovate	Purplish white	Present	Brown	Ovoid
TSs56	Slight	Ovate-lanceolate	Purplish violet	Absent	Brown	Ovoid
TSs60	Slight	Ovate-lanceolate	Purplish white	Absent	Brown	Ovoid
TSs61	Slight	Ovate-lanceolate	Purplish white	Absent	Brown	Ovoid
TSs63	Slight	Ovate	Purplish violet	Present	Brown	Ovoid
TSs65	Solid	Ovate-lanceolate	Purplish pink	Present	Dark brown	Ovoid
TSs82	Slight	Ovate	Purplish white	Absent	Brown	Rhomboid
TSs84	Slight	Ovate	Purplish white	Absent	Brown	Ovoid
TSs90	Non-pigmented	Ovate	Purplish pink	Present	Speckled	Ovoid
TSs94	Non-pigmented	Lanceolate	Purplish pink	Absent	Brown	Ovoid
TSs104A	Moderate	Ovate	Purplish pink	Present	Speckled	Ovoid
TSs104B	Moderate	Ovate	Purplish white	Present	White	Ovoid
TSs111	Non-pigmented	Ovate-lanceolate	Purplish white	Present	Brown	Ovoid
TSs112	Non-pigmented	Ovate	Purplish pink	Absent	Brown	Ovoid
TSs119	Non-pigmented	ovate	Purplish white	Present	Brown	Ovoid
TSs130	Moderate	Ovate	Purplish pink	Present	Speckled	Rhomboid

environmental differences. To reveal their genetic differences, the accessions can be raised in a common environment and subjected to common treatments, so that any variations exhibited can be attributed to genotype. This kind of genetic studies has not been carried out on AYB. Also, the taxonomy, evolution and nature of the gene pool of the wild and the cultivated species of *Sphenostylis* are not completely known (Potter and Doyle, 1992), despite the fact that genetic differences and similarities in the *S. stenocarpa* complex can not be ruled out.

Knowledge of the genetic attributes of the highly variable species is necessary for the development of sound strategies for genetic improvement, conser-vation and utilization of the species. Among some of the scanty reports on the genetic variability of AYB includes: Machuka and Okeola (2000), Ajibade et al. (2005) and Moyib et al. (2008). The work of Okoye and Ene-Obong (1992) revealed high genotypic diversity through correlation among pod and seed characters of AYB. However, AYB has not been subjected to concerted research investigations and efforts are needed to exploit its agronomic qualities to improve its utilization for food, medicine and fodder. While characterization and evaluation of genetic resources has been a major goal in evolutionary biology and plant breeding, information concerning the genetic diversity within a group of species is essential for rational use of genetic resources (Bandoin and Marechal, 1988; Schaal et al., 1991).

This study is aimed at assessing the genetic relationships of the 25 IITA accessions of AYB collected from different countries of Africa through morphological characterization.

MATERIALS AND METHODS

Seeds of 25 accessions of AYB were collected from the Genebank of the International Institute of Tropical Agriculture (IITA), Ibadan. The descriptive list of the 25 genotypes is in Table 1. The cultivation and morphological characterization were carried out on an experimental field at IITA, Ibadan. The experimental plot was ploughed, harrowed and ridged before planting. Three seeds of each accession were initially planted per stand; these were later thinned to one plant per stand after emergence and establishment. The sowing was in the spacing of 1 × 1 m. The resultant plant population for each accession per plot was ten plants. The experiment was laid out in a randomized complete block (RCB) design with three replicates. Sticks of about 3 m length were pro-vided to support the plants as stakes at three weeks after planting. The field was kept clean by regular hand weeding with hoes. The plants were

Table 2. List of characters studied on the AYB accessions.

Characters	Abbreviations
Days from sowing to emergence	DSE
Days from sowing to production of primary leaflets	DSP
Days from sowing to production of tertiary leaflets	DST
Terminal leaflet length	TLL
Terminal leaflet width	TLW
Petiole length	PL
Rachis length	RL
Hypocotyl length at 2 weeks old	HL
Internode length	IL
Number of stem per plant	NSP
Number of leaves per plant	NL
Number of main branches per plant	NMB
Days to 50% flowering	DF
Days from flowering to maturity	DFF
Days to pod maturity	DPM
Standard petal length	SPL
Standard petal width	SPW
Number of flower per peduncle	NFP
Peduncle length	PDL
Number of pods per peduncle	NPP
Total pods per plant after harvesting	PPP
Length of pod	LP
Width of pod	WP
Number of locules per pod	NLP
Number of seeds per pod	NSPP
Seed set percentages	SS%
Seed length	SL
Seed width	SW
Seed thickness	ST
100 seed weight	100 WT

protected from insect attacks by regular spraying with0.5% karate at 10 days interval from the period of flower bud initiation to pod maturity.

Morphological studies

Morphological studies were carried out on vegetative and reproductive characters of the 25 accessions of AYB. A total of 36 qualitative and quantitative variables were generated to classify the 25 accessions; Table 1 showed six qualitative traits while Table 2 showed thirty quantitative traits.

The qualitative characters were scored based on visual evaluation while the quantitative traits were counted, measured using metric rulers or vernier caliper and weighed using weighing balance. On the field, data were recorded on the five middle plants (sampling units). Ten readings were made for each of the quantitative characters. All the characterizations were based on International Plant Genetic Resources Institute (IPGRI) descriptors for related legumes e.g. cowpea, *Phaseolus vulgaris*. Descriptions of colours were done with Methuen handbook of colours chart (Kornerup and Wanscher, 1978).

Data analysis

Mean and standard error (SE) were calculated for all the quantitative traits. Numerical codes were used to describe the states of each qualitative trait. The resultant data matrix of 25 X 36 was initially standardized (mean = 0, and standard deviation = 1) before subjecting it to multivariate analysis (principal component (PC) and cluster (Semi – partial R-squared) analysis. The eigenvalues of each genotype in three PC axes were further generated to construct two-dimensional scattered graphs. SAS / PC software package version 9.1 was employed for all the analysis. Analysis of variance (ANOVA) and coefficient of variation were equally generated.

RESULTS

The qualitative morphological characters of the 25 accessions of AYB studied are shown in Table 1. Phenotypic variations exist among the 25 genotypes for: plant pigmentation intensity, terminal leaflet shape, flower

Table 3. Descriptive statistics of vegetative characters of twenty–five accessions of AYB.

Acc. No.	DSE	DSP	DST	TLL	TLW	PL	RL	HL	IL	NSP	NL	NMB
TSs1	5.67	10.33	20.67	12.51	5.47	5.18	2.52	15.27	13.47	4.33	28.67	3.33
TSs3	5.33	12.33	20.33	14.60	6.01	5.84	2.36	15.36	13.53	5.33	31.33	4.33
TSs4	5.67	11.67	22.00	13.41	5.86	6.94	2.37	16.25	15.55	5.67	30.33	4.33
TSs7	7.33	13.67	21.67	12.68	5.32	6.09	2.67	17.16	15.54	4.67	30.33	4.00
TSs10	7.67	13.33	19.67	13.51	6.10	5.80	2.30	16.63	15.15	4.67	29.67	4.33
TSs11	6.67	12.33	18.33	12.55	5.42	6.09	2.55	14.78	12.63	5.67	28.67	3.33
TSs16	6.67	11.33	18.67	13.21	5.75	6.43	2.20	15.86	15.16	5.67	31.33	3.00
TSs22	7.00	12.67	23.00	12.39	5.27	5.77	2.45	16.54	14.18	4.67	27.00	4.67
TSs23	6.33	11.67	23.00	13.75	5.77	6.34	2.55	15.79	15.22	3.33	27.33	4.33
TSs40	5.67	10.67	22.00	13.79	5.63	7.17	2.69	14.72	14.26	4.00	31.00	3.00
TSs56	7.67	12.33	23.67	11.07	4.57	4.65	2.10	16.26	14.51	3.67	33.33	2.67
TSs60	6.00	12.33	23.33	13.34	5.29	5.32	2.29	14.83	11.19	2.67	32.67	3.67
TSs61	7.33	13.33	19.67	12.43	4.89	4.90	2.24	12.36	12.35	3.00	32.33	2.67
TSs63	5.67	12.67	19.67	13.51	5.95	5.49	2.35	11.31	11.65	4.00	33.33	1.67
TSs65	6.67	10.67	21.67	11.19	4.54	4.97	1.98	12.75	11.88	5.00	33.00	2.00
TSs82	7.00	11.00	20.00	9.02	4.40	4.96	2.00	13.61	11.70	5.00	29.00	2.00
TSs84	7.00	11.00	21.67	10.58	4.38	5.22	2.08	12.78	11.06	4.67	30.00	2.67
TSs90	6.67	11.33	21.00	10.50	4.40	4.69	1.88	13.14	11.37	3.67	28.33	3.67
TSs94	4.67	12.33	23.00	13.15	5.36	5.68	2.30	15.05	11.18	4.33	26.67	2.67
TSs104A	5.67	12.67	24.00	12.76	5.21	6.03	2.43	13.87	14.83	5.00	35.33	4.00
TSs104B	5.33	11.00	22.33	11.75	4.41	6.71	2.48	13.83	15.63	5.33	39.33	4.00
TSs111	5.67	12.00	20.00	13.41	5.43	5.79	2.11	13.16	11.53	6.67	40.33	4.67
TSs112	6.00	11.33	20.33	13.05	5.86	5.45	2.07	14.97	10.43	7.00	41.67	5.00
TSs119	6.33	11.67	22.33	13.41	6.50	6.54	2.34	11.35	14.29	6.33	46.00	5.33
TSs130	5.33	10.33	23.33	14.94	6.56	6.27	2.44	14.15	14.58	6.67	41.67	4.67
G. Mean	6.28	11.84	21.41	12.66	5.37	5.77	2.31	14.47	13.31	4.84	32.75	3.60
SE	0.14	0.16	0.23	0.18	0.08	0.09	0.03	0.26	0.23	0.19	0.64	0.14
CV (%)	19.86	11.45	9.12	12.03	13.47	13.58	11.92	15.85	14.78	33.80	17.03	33.25
P values.	NS	*	***	***	***	***	***	*	***	***	***	***

Significance * - $p<0.05$, ** - $p< 0.01$, *** - $p<0.0001$, NS –Not significant. Minimum and maximum values in bold.

colours, pod shattering, seed coat colours and seed shape. While some genotypes did not show any pigmentation, the intensity of the pigmentation ranged from slight to moderate and solid. The shape of the seed of AYB can either be ovoid or rhomboid. Tables 3 and 4 showed the variations among the quantitative traits. Significant variation exists among all the traits except days from sowing to emergence (DSE) for the twenty-five accessions.

The accessions showed considerable variations in the mean values of the characters measured. Among the accessions, TSs1 showed earliest flowering and maturity days (74 and137 days respectively) while TSs61 had the latest day to flowering and pod maturity (86 and 166 days respectively) which also performed lowest in terms of seed yield (Table 4). Accession TSs112 produced the highest number of flowers per peduncle (15.67 ± 0.32) while TSs23 had the least (8.00 ± 0.32). Number of leaves per plant was highest in TSs119 (46.00 ± 0.64) and lowest in TSs94 (26.67 ± 0.64). Accession TSs112 produced the highest number of stem per plant (7.00 ± 0.19) while TSs60 produced the least number of stem per plant (2.67 ± 0.19). Total number of pods per plant was highest in TSs119 (155.14 ± 2.98) while it was lowest in TSs61 (30.14 ± 2.98). Nine accessions produced purplish white flowers; eleven produced purplish pink flowers while two produced purplish pink / violet flowers.

The analysis of variance depicted by the p-value in Tables 3 and 4 indicated that significant differences existed for 25 accessions at ($p < 0.0001$) and for 2 characters at ($p < 0.05$). Number of pods per peduncle did not show any significant difference among the accessions. Peduncle length, total pods produce per plant, pod length, number of locules per pod, number of seeds per pod and 100 seed weight were all significant with respect to genotype effect ($p < 0.0001$). The analysis clearly put the accessions in different cluster groups that reflected their phenotypic affinities. The Dendrogram is presented as an illustration of a phenetic analysis or phylogenetic relationship of the accessions (Figure 1).

Table 4. Descriptive statistics of reproductive characters of twenty – five accessions of AYB.

Acc. No.	DF	DFF	DPM	SPL	SPW	NFP	PDL	NPP	PPP	LP	WP	NLP	NSPP	SS%	SL	SW	ST	100 WT
TSs1	74	48	137	2.64	3.16	10.00	16.40	4.00	62.58	25.54	1.50	19.83	18.25	93.01	8.68	6.87	6.67	28.83
TSs3	76	53	140	2.90	3.83	10.00	20.25	4.33	40.83	25.97	1.42	20.47	19.72	95.04	8.67	6.83	7.12	26.47
TSs4	77	69	147	2.83	3.64	9.67	19.14	4.00	41.33	28.28	1.50	19.36	17.50	91.28	9.46	6.95	7.28	30.47
TSs7	79	63	144	3.07	3.77	9.67	22.61	4.67	37.95	27.33	1.45	19.11	17.36	91.56	8.33	6.50	7.08	27.10
TSs10	82	51	147	3.04	3.69	8.67	20.97	4.00	67.03	27.44	1.75	20.53	19.17	95.33	8.79	6.59	7.20	31.60
TSs11	84	58	145	2.75	3.03	9.00	22.07	5.33	70.89	18.79	1.06	16.81	13.94	84.67	7.97	6.55	6.63	22.33
TSs16	85	56	145	2.93	4.09	9.33	23.54	4.00	55.83	28.48	1.52	20.94	18.94	91.11	8.80	6.71	6.98	31.10
TSs22	80	53	140	2.92	3.72	10.33	17.90	3.67	55.83	25.05	1.64	19.53	17.56	89.14	8.20	6.97	7.20	30.70
TSs23	84	49	144	2.97	3.89	8.00	20.74	4.33	55.14	23.24	1.49	18.20	16.39	89.21	9.16	6.69	7.03	31.77
TSs40	87	51	137	3.03	3.85	9.67	19.97	4.00	66.11	25.10	1.41	18.08	16.28	89.08	9.39	6.94	7.32	39.50
TSs56	86	48	145	2.92	3.78	11.33	14.83	4.33	62.03	27.07	1.49	20.39	18.14	90.26	9.62	6.96	6.94	32.87
TSs60	85	60	144	2.87	3.61	12.67	13.36	4.33	36.81	19.41	1.50	15.17	13.25	86.64	8.17	6.41	6.68	25.80
TSs61	86	58	166	2.88	4.12	10.00	16.38	4.00	30.14	12.58	1.01	8.03	6.72	83.32	8.53	6.84	6.73	30.57
TSs63	84	65	150	2.87	3.64	10.00	17.61	4.00	78.11	23.31	1.46	16.69	15.39	89.37	8.34	7.13	7.10	32.27
TSs65	89	62	152	2.88	3.92	10.33	15.76	3.67	72.22	19.40	1.28	15.58	14.03	89.20	8.57	6.60	6.58	26.30
TSs82	91	70	163	3.11	3.92	9.33	13.93	5.33	62.58	22.28	1.28	15.67	13.45	85.98	8.90	6.74	7.03	29.43
TSs84	93	62	147	2.88	3.66	9.67	11.57	5.00	54.17	19.97	1.28	12.28	10.36	84.19	8.67	6.90	7.18	28.73
TSs90	92	72	152	3.02	4.03	9.67	11.56	4.00	50.83	19.36	1.33	16.31	13.97	85.11	8.67	6.53	6.75	31.57
TSs94	99	69	165	2.98	3.88	10.00	12.62	4.33	52.50	18.09	1.27	13.69	11.17	82.92	9.25	6.66	6.59	30.40
TSs104A	90	67	149	2.93	3.67	13.33	19.23	4.33	57.36	27.02	1.61	16.72	14.78	85.96	8.74	7.05	7.11	30.20
TSs104B	92	57	144	2.79	3.77	15.00	20.42	4.67	50.97	26.23	1.46	20.70	18.08	91.23	8.34	7.21	7.34	26.23
TSs111	95	48	150	2.70	3.47	14.00	15.82	5.00	50.83	24.08	1.44	18.50	16.42	90.44	8.19	6.85	6.69	27.20
TSs112	94	59	140	2.88	3.50	15.67	19.71	6.67	115.14	22.19	1.45	18.89	17.36	92.82	8.02	7.07	7.19	29.33
TSs119	80	70	150	2.88	3.64	15.33	17.67	5.67	155.14	24.82	1.53	19.11	17.33	88.81	9.18	6.93	7.28	33.13
TSs130	84	71	151	2.97	4.02	15.33	21.99	6.00	83.03	30.75	1.57	21.44	20.08	95.72	8.67	6.43	6.93	30.80
G. Mean	85.92	59.56	147.76	2.90	3.73	11.04	17.84	4.55	62.62	23.67	1.43	17.68	15.83	89.26	8.69	6.80	6.99	29.79
SE	0.72	0.92	0.88	0.01	0.03	0.32	0.46	0.14	2.98	0.51	0.02	0.37	0.39	0.52	0.06	0.03	0.03	0.39
CV (%)	7.28	13.35	5.13	4.28	7.86	25.29	22.12	26.64	41.19	18.53	12.80	18.20	21.26	5.03	6.02	3.97	4.05	11.28
P values	***	***	***	***	***	NS	***	NS	***	***	***	***	***	***	***	***	***	***

Significance * - $p < 0.05$, ** - $p < 0.01$, *** - $p < 0.0001$, NS –Not significant. Minimum and maximum values in bold.

Principal component analysis (PCA)

Twenty-four PC axes fully explained the total variation among the twenty -five accessions. Eleven of the axes had eigenvalues above 1.0, with the cumulative variance of 85.77%.

The first five PC axes explained about 61% of the total variation. The Eigenvalues ranged from 2.5524 in PC5 to 8.7286 in PC1. PC1 accounted

Table 5. Principal component analysis of the AYB accessions studied.

	Eigenvectors				
Traits	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**
DSE	0.066514	-0.22123	-0.16133	0.00811	0.035661
DSP	0.107076	-0.18478	-0.12346	-0.08368	0.303362
DST	-0.02558	0.155668	0.150997	0.248224	0.218244
DF	-0.14449	0.11893	-0.1946	-0.02502	0.069859
DFF	-0.17006	0.134754	-0.22861	0.038843	0.067985
DPM	-0.06409	0.141716	-0.35259	-0.02475	-0.00169
HL	0.159223	-0.26837	0.135479	-0.0507	0.153793
IL	0.102159	-0.1652	0.3147	0.117483	0.048557
NSP	-0.1921	-0.05632	0.212635	-0.23221	0.021669
NL	-0.2203	0.110526	0.236187	-0.07821	0.090044
NMB	-0.13176	-0.16289	0.362954	-0.00166	0.185567
NFP	-0.22928	0.120358	0.237132	-0.06108	0.116746
TLL	0.230101	0.056281	-0.10307	0.264485	-0.04197
TLW	0.247585	0.061112	0.02262	0.187275	-0.03314
PL	0.231839	0.072231	0.019555	0.179682	0.231051
RL	0.192415	0.029766	-0.04297	0.245608	0.083394
SPL	-0.07091	0.309405	0.201851	0.004707	0.220193
SPW	-0.097	0.313394	0.052689	0.090786	0.188056
PDL	0.267819	0.003519	0.037088	0.167922	0.091413
NPP	0.071482	-0.21992	0.173103	-0.09231	0.016671
PPP	0.118259	-0.09017	0.178323	-0.04674	0.086956
LP	0.263854	0.188251	0.120872	-0.12047	-0.07538
WP	0.229836	0.190924	0.116636	-0.19532	-0.0503
NLP	0.279668	0.086047	0.119685	-0.10548	-0.14536
NSPP	0.287362	0.10671	0.101173	-0.10156	-0.14897
SS	0.265559	0.097127	0.046848	-0.08103	-0.18249
SL	-0.01696	0.357326	0.003704	0.049392	-0.03474
SW	0.081265	0.005091	-0.22618	-0.28056	0.170628
ST	0.175561	0.176405	-0.00368	-0.24622	0.323019
WT	0.032741	0.363087	-0.00547	0.015216	0.114219
PIS	0.03537	-0.07663	-0.03617	0.275161	-0.0797
TLS	0.111547	-0.05472	-0.16218	-0.11748	0.286667
FC	0.072745	-0.09838	-0.1016	0.062622	0.317802
PS	-0.07923	0.041862	0.207839	0.361757	-0.0549
SC	-0.07971	-0.07741	-0.08753	0.395118	0.119234
SES	-0.06298	0.063636	0.011374	0.022873	-0.40542
Eigenvalues	8.7286	4.0700	3.4880	3.0025	2.5524
Variance (%)	24.25	11.31	9.69	8.34	7.09

for almost a quarter (24.25%) of the total variation which was largely controlled by eleven morphological traits. PC2 accounted for 11.31% while PC3 accounted for variation of 9.69%. PC 4 and 5 accounted for 8.34 and 7.09% of the total variation respectively. The respective morphological traits which largely controlled each PC axes were in bold print (Table 5).

Clustering analysis

The semi partial R-square technique grouped the 25 accessions into six major clusters at the reference point of 0.05 similarity index (Figure 1). There were 4, 6, 3, 5, 2 and 5 accessions in the respective six cluster groups. Only two major groups became identifiable at 0.10 point of similarity, dividing the 25 accessions in the proportion of 72 and 28%. While this clustering system clearly separated the twenty-five accessions without any duplication, the highest point of similarity among the 25 genotypes was 0.2074. The closest accessions were TSs7 and TSs4, both tied at 0.0148.

The 25 genotypes were represented in Figures 2 and 3.

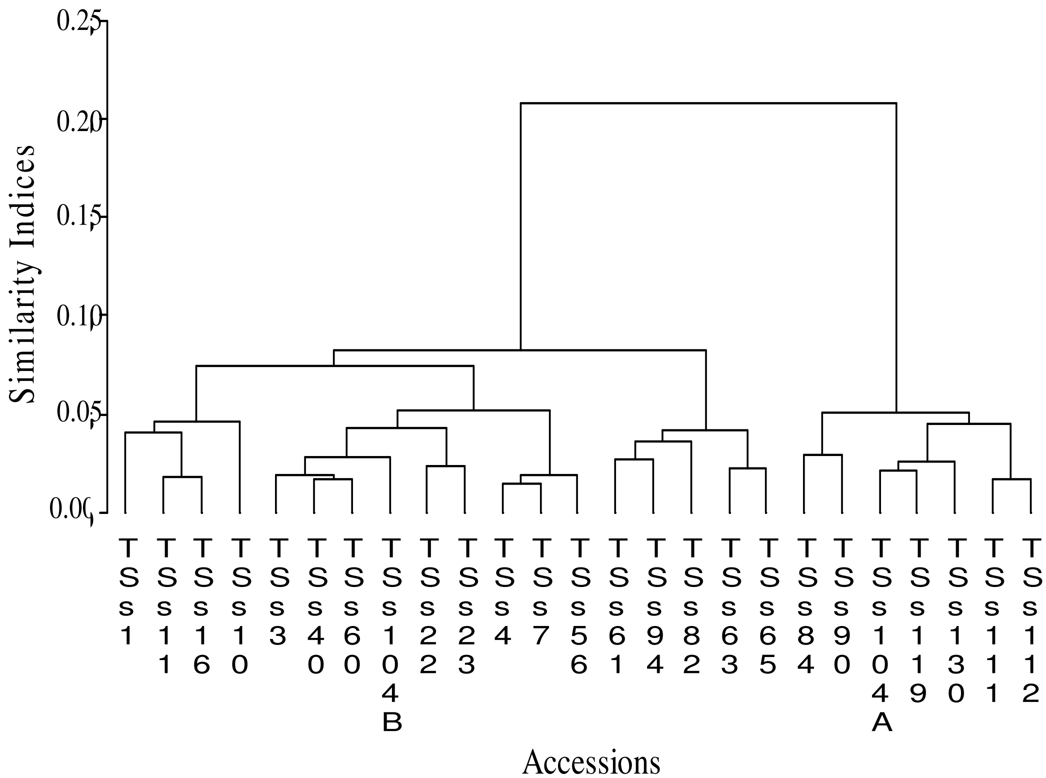

Figure 1. Grouping of twenty-five accessions of African yam bean.

Figure 2 revealed two clusters that is, I and III while Figure 3 clearly revealed four clusters (II, IV, V and VI). The two dimensional projection of the 25 accessions produced six groups that were perfectly similar to the classification by clustering analysis at the inflection point of 0.05. The PCA and the clustering method had almost a perfect agreement in classifying the 25 accessions of AYB.

DISCUSSIONS

All the 25 accessions of AYB studied revealed morphological similarities and differences. The statistical analysis of mean values of all the 25 accessions confirmed variations in all the 36 characters studied. The intensity of pigmentation was more noticed to be very pronounced in TSs10 than any other accessions. Other pattern of pigmentation revealed that TSs11, TSs16, TSs104A and TSs104B were moderate with light red stem colour. The accessions with higher values for number of leaves per plant, stems per plant, main branches per plant and internodes length were observed to produce higher total number of pods per plant and consequently higher number of seeds per plant. The results also indicated that majority of the accessions with long duration of flowering (TSs119, TSs112, and TSs130) produced higher number of total pods per plant than those with short duration of flowering like TSs1 and TSs3. The high seed yield recorded for some of the accessions can be attributed to the long vine length and luxuriant growth habit of the accessions, which encouraged production of large number of flowers that matured into pods and seeds. Similar observations have been reported for cowpea and pigeon pea (Wien and Summerfield, 1984). Accession TSs1 showed traits of early maturity compared with TSs94 which flowered and matured late, hence, TSs1 is identified as a useful parent in breeding for early maturity in the species. Accession TSs61 showed poor performance in some agronomic traits, having the shortest pod length, lowest number of locules per pod and number of seeds per pod. Though high number of flowers per peduncle is indicative of high floral productivity and hence high pod and seed yields, most of the flowers produced by the plants of this accession aborted at early stages of development. TSs130 had the highest pod length, number of locules per pod and number of seeds per pod which make it a good candidate for high seed yield.

Statistical analysis indicated that terminal leaflet length, terminal leaflet width, peduncle length, pod length, pod width, number of locules per pod and number of seeds per pod are characters that contributed significantly to the high seed set percentages in all the accessions. Therefore, selections based on these characters could enhance seed productivity considerably. Significant differences ($p < 0.0001$) were observed in the characters

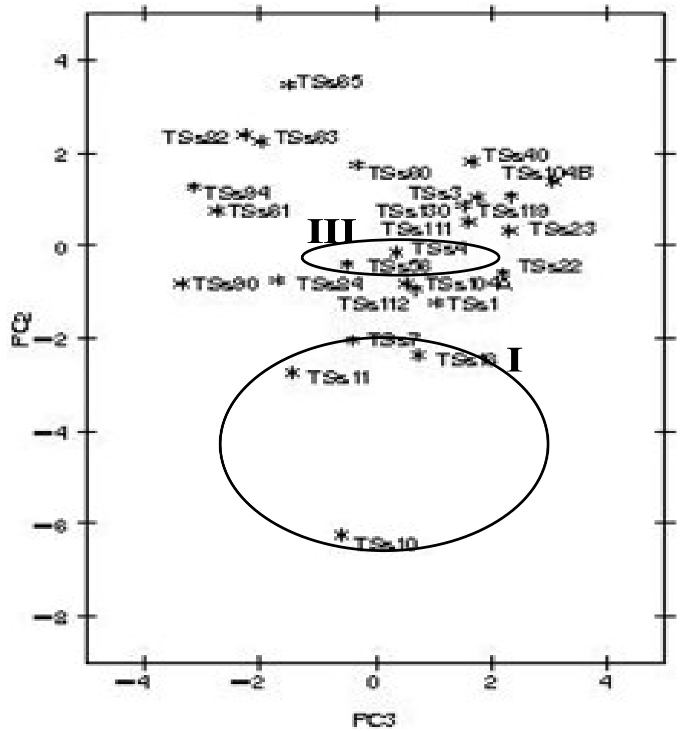

Figure 2. Two-dimensional scattered plot of twenty-five accessions of AYB.

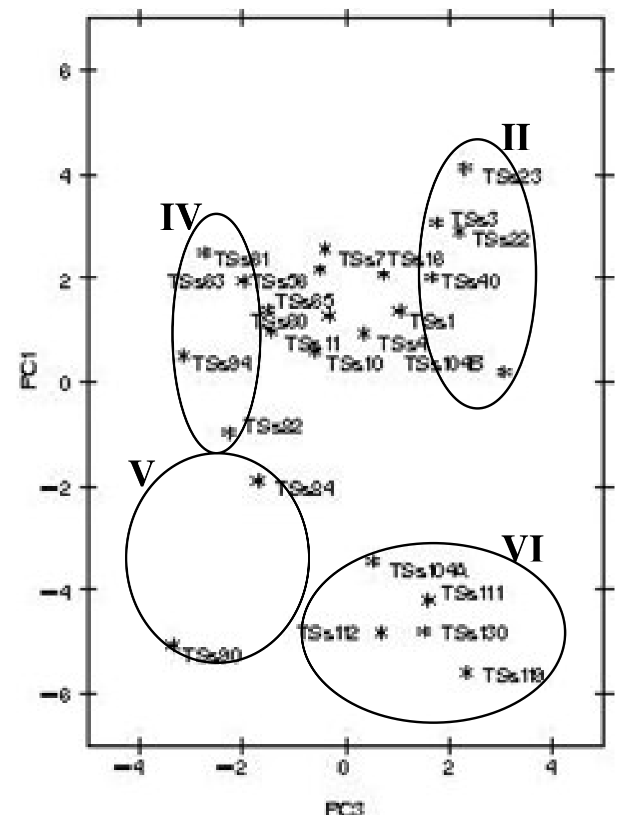

Figure 3. Two-dimensional scattered plot of twenty-five accessions of AYB.

of the 25 accessions indicating considerable phenotypic and genetic differences among them. Hence, these genetic variations could be utilized as raw materials for genetic improvement of the species. Further studies on this species can be directed towards molecular analysis for a probable reveal of genetic differences existing among the accessions.

ACKNOWLEDGEMENT

The support given to this research work by the Genetic Resources Center of the International Institute of Tropical Agriculture IITA, Ibadan, Nigeria is highly appreciated.

REFERENCES

Ajibade SR, Balogun MO, Afolabi OO, Ajomale KO, Fasoyiro SB (2005). Genetic variation in nutritive and anti-nutritive contents of African yam bean (*Sphenostylis stenocarpa*). Trop. Sci., 45(4): 44-148.

Asare EO, Shehu Y, Agishi EA (1984). Prelimininary studies on indigenous species for dry season grazing in the northern savanna zone of Nigeria. Trop. Grasslands, 18: 148-152.

Azeke MA, Barbara F, Han BP, Wilhelm H, and Thomas B (2005). Nutritional value of African yam bean (*Sphenostylis stenocarpa*): Improvement by lactic acid fermentation. J. Sci. Food Agric., 85(6): 963-970.

Bandoin J, Marechal R (1988). Taxonomy and wide crosses of pulse crops with special reference to *Phaseolus* and *Vigna*. Proceedings of an International Conference on Crop Genetic Resources of Africa. IITA, IBPGR, UNEP, Ibadan, Nigeria, pp. 287- 301.

Baudoin JP, Mergeai G (2001). Yam bean *Sphenostylis stenocarpa* (Hochst.ex A. Rich.) Harms In: R.H. Raemaekers (Ed) Crop Production in Tropical Africa. Directorate General for International Cooperation (DGIC) Brussels, Belgium. pp. 372-377.

National Research Council (NRC) (2007). Lost Crops of Africa: Vol II: Vegetables and Yam bean Development, Security and Cooperation Policy and Global Affairs (DSC) Washington, D. C., USA. pp. 322-344.

International Institute of Tropical Agriculture (IITA) (1985). Annual report, Ibadan, Nigeria.

Kornerup A, Wanscher JH (1978). Methuen Handbook of Colour - Third Edition London, Eyre Methuen.. Third Edition. (Revised by Don Pavey)

Nwokolo EA (1987). A nutritional assessment of African yam bean *(Sphenostylis stenocarpa)* and Bambara groundnut *(Voadzeia subterranean)*. J. Sci. Food Agric*.,* 41: 123-129.

Moyib OK, Gbadegesin MA, Aina OO, Odunola OA (2008) Genetic variation within a collection of Nigerian accessions of African yam bean (*Sphenostylis stenocarpa*) revealed by RAPD primers. Afr. J. Biotechnol., 7(12): 1839-1846.

Okigbo BN (1973). Introducing the African yam bean *Sphenostylis stenocarpa* (Hochst. Ex. A. Rich). Harms. In Proceedings of the First IITA Grain Legume Improvement Workshop, IITA, Ibadan, Nigeria, pp. 224-238.

Okoye FI, Ene-Obong EE (1992). Genetic variability and correlation studies in the African Yam Bean (*Sphenostylis stenocarpa*) Nig. J. Bot., 5, 75-83.

Okpara DA, Omaliko CPE (1997). Response of African yam bean *Sphenostylis stenocarpa* to sowing date and plant density. Indian J. Agric. Sci*.,* 67(50): 220-221.

Potter D (1991). Systematic studies of *Sphenostylis* and *Nesphostylis.* Ph.D Dissertation, Cornell University.

Potter D, Doyle JJ (1992). Origins of the African yam bean *(Sphenostylis stenocarpa* Leguminosae*)*; Evidence from Morphology, Isozymes and Chloroplast DNA, Eco. Bot., 46: 276-292.

Schaal BA, Leverich WJ, Rogstad SH (1991). A comparison of Methods for Assessing Genetic variation in plant conservation Biology. In Falk DA and Holsinger KE (eds). Genetic and Conservation of Rare Plants. Center for Plant Conservation, Oxford University Press, New York, pp.123 -134.

Wien HC, Summerfield RJ (1984). Cowpea (*Vigna unguiculata* (L.) Walp.). In: Physiol. Tropical Field Crops (Eds P. R. Goldsworthy and N. M. Fisher) p. 353-383.