DOI: http://dx.doi.org/10.4314/gjpas.v21i1.4

GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 21, 2015: 21-27
 ISSN 1118-0579
www.globaljournalseries.com, Email: info@globaljournalseries.com

MORPHOLOGICAL CHARACTERIZATION AND VARIABILITY STUDY OF AFRICAN YAM BEANS [*SPHENOSTYLIS STENOCARPA* (HOCHST EX A. RICH)]

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(Received 28 July 2014; Revision Accepted 5 February 2015)

ABSTRACT

Characterisation of *Sphenostylis stenocarpa* (Hochst ex A. Rich) Harms (African yam bean) was carried out to determine the degree of diversity in some accessions in Nigeria. Twelve accessions of *S. stenocarpa* collected from the International Institute for Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria, were grown for morphological variability studies in the Screenhouse facility at the Botanical garden, University of Ilorin, Nigeria. Quantitative and qualitative variables were measured 16 weeks after planting. Quantitative data were analysed using Analysis of Variance in SPSS 16.0 for Windows. Cluster analysis was conducted to group the accessions into various cluster groups. Quantitative characters such as length, width and area of terminal leaf, petiole length, number of leaves, number of branches, stem length, and stem diameter were significantly different among the accessions. Variation of leaf colour ranging from pale to deep green exists in the accessions. Stem and petiole pigmentation varied together. Stem girth was different for TSs 162 and TSs 373. Number of branches and leaves distinguishes TSs 138, 152 and 311 from the other accessions. TSs 115, 154 and 163 were morphologically comparable while TSs 41, 125, 139 and 209 had plant height, leaf length, width and area distinguishing them from the other groups. The study concluded that the differences in the accessions of *S.stenocarpa* could be explored in breeding programme for improved crop.

KEYWORDS: African yam bean, breeding, crop improvement, morphological characters, variability.

INTRODUCTION

The alarming increase in the world's population has its direct effect on food security and sustainability which has increased the demands for food production to feed the teeming human population. Although science has made enormous strides in improving the world's ability to feed itself over the past decades, a large proportion on world population are still suffering from hunger and malnutrition. Nearly 800 million people in the developing world do not have enough to eat (World Health Organization, 1999). Many important crop plants native to Africa with potentials to alleviate and reduce food insecurity in the continent are severally neglected, unimproved and under-utilised. One of such crops with unexploited potentials and quality nutritional value is *Sphenostylis stenocarpa* (Hochst ex A. [Rich] Harms) popularly called African Yam Bean (Biodiversity International, 2009).

African Yam Bean(AYB) is a leguminous crop of tropical African origin belonging to the family Fabaceae which is the second biggest and one of the most economically important families among the dicotyledons. African yam bean (*Sphenostylis stenocarpa*) was believed to originate in Ethiopia and both wild and cultivated species are found in tropical Africa as far south as Zimbabwe in east Africa from northern Ethiopia (Eritrea) to Mozambique including Tanzania and Zanzibar. It is also cultivated throughout West Africa countries particularly, Cameroon, Cote d'Ivore, Ghana, Nigeria and Togo (Potter, 1992).The crop is an annual grain legume and has a pattern of growth similar to those of other grain legumes (Ameh, 2003).

It has edible tubers and the most culturally and economically important of the seven species in the genus *Sphenostylis* (Potter and Doyle, 1994; Dutta, 2003). It is a minor grain legume and under-exploited (Nwokolo, 1987; Saka *et al.*, 2004), usually cultivated in association with yam, cassava, maize and sorghum and other crops (Togun and Egunjobi, 1997). The legume has long been used as a traditional dual seed grain and tuber food crop in Africa and it has other great potentials (Adewale and Dumet, 2010).

Due to the high cost of animal protein in developing countries, legumes are of great importance to the low socio-economic population as cheap source of protein. Nutritionally, the AYB seed contains 62.6% carbohydrates, 21-29% protein and 2.5% fat. The grain is also high in sulphur-containing amino acid (Ezueh, 1984; Potter, 1992; Okpara and Omaliko, 1995). The crop helps agriculturally to enrich the soil by its ability to fix nitrogen from the atmosphere. Studies have shown that the underutilized legumes are highly nutritious and are used as food, cover crops, green manure and natural fertilizers. Several other utilization of the crop has been reported (Potter, 1992; Ene-Obong, 1993; Klu *et al*., 2001).

Even though AYB has great potentials, it has

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received very little attention both as a food crop and in the area of research, lack of acceptability and adoption over the years may to an extent be due to the presence of anti-nutritional compounds as reported by some workers (Pusztai and Bardocz, 1996; Machuka and Okeola, 2000). The success of a good breeding programme for AYB would depend on the genetic variability present in the accessions of the crop. Estimates of genetic parameters would reveal the relative various characters of importance as it affects the total variation in the crop for its improvement. Existence of wide variability in seed colour, shape and size has been reported by Oshodi *et al.* (1995). Adewale *et al.* (2010) remarked that seed characteristics are important tools in evaluation of variability in AYB, the same opinion was shared by Olasoji *et al.*(2011). Biodiversity studies of accessions of AYB was evaluated by Aremu and Ibirinde (2012) who reported that diversity existed among the accession studied and concluded that the existing diversity could be screened for developing improve cultivars.

Thus the knowledge of genetic variability, biodiversity would play a pivot role in selection and screening of desirable traits for breeding purpose. Assessment of genetic diversity of genotypes of African Yam Bean would facilitate development of improve cultivars for adaptation to specific production constraints. The aim of this study is to evaluate agronomic parameters of some accessions of AYB; to classify these accessions based on degree of variability and diversity of the accession to the characters evaluated. In addition, the study will seek to understand the genetic identity and relatedness of the accessions.

MATERIALS AND METHODS

Twelve accessions of *Sphenostylis stenocarpa* were collected from the International Institute for Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. Seed coat colour, seed shape and seed compression were physically observed and documented (Table 1). The pot experiment was carried out at the Botanical Garden, University of Ilorin, Ilorin, Kwara State, Nigeria located on latitude 8° 24’N and 8° 36’N and longitude 4° 10’E and 4° 36’E (Ilorin Atlas, 1982).

Three seeds were sown at 3 cm depth in planting bag (42 cm x 30 cm) filled with garden loamy soil and spaced 90 cm in-between the rows and plant to plant. Three replicates were made for each accession, well labelled and laid out in a Completely Randomized Design (CRD). Watering was done with equal amount of clean natural water regularly. Thinning was done at the 3rd week of sowing to two plants per pot to reduce the competition for nutrition by the seedlings. Staking was provided two weeks after emergence of the seedlings other necessary cultural practices were carried out as required.

The quantitative characters considered and evaluated at 12 weeks after sowing include plant height, leaf length, leaf width, leaf area, inter-node length and petiole length, number of leaves, number of primary branches and stem girth. Observations were also recorded on qualitative parameters such as leaf colour, main stem pigmentation and petiole pigmentation based on physical observations.

Quantitative data obtained on the twelve accessions were analyzed using SPSS 16.0 Microsoft Software for Window. The data were subjected to analysis of variance (ANOVA) to determine significant of variations that existed among the accessions. To determine the total variance accounted for by the evaluated parameters and to check for any underlying pattern of relationship, Principal Component Analysis (PCA) was employed. Cluster analysis was constructed to group the accessions into various cluster groups.

RESULTS

There was variability in the seed morphology for such as seed coat colour, shape and compression among the twelve accessions of African Yam Bean studied as shown in Table 1. The seed colour varied, ranging from reddish brown, purple-black to cream colour, accessions TSs 41, TSs163 and TSs373 had variegated seed coat. Also, seed shape varied as seeds were either round/globular, oval or oblong. Deeper seed compression was observed in TSs 115 while TSs 162, 311 and 373 slightly depressed seeds (Table 1).

Table 1: Variability in seed morphology in twelve accessions of African yam beans

Accessions	Seed coat colour	Seed shape	Seed compression
TSs 41	Variegated	Oval	Not compressed
TSs 115	Reddish brown	Oval	Compressed
TSs 125	Purple-black	Oval	Not compressed
TSs 138	Reddish brown	Round/globular	Not compressed
TSs 139	Cream	Oblong	Not compressed
TSs 152	Light brown	Round/globular	Not compressed
TSs 154	Reddish brown	Oval	Not compressed
TSs 162	Light brown	Oblong	Semi compressed
TSs 163	Variegated	Oval	Not compressed
TSs 209	Grey	Round/globular	Not compressed
TSs 311	Light brown	Oblong	Semi compressed
TSs 373	Variegated	Oblong	Semi compressed

Leaf coloration was pale green in the accessions (Plates 1a and 1b) except for TSs 163, 209 and 311 that were presented with deep green leaf coloration (Plate 1c). More also, accessions TSs 41 and

TSs 125 had purple coloured stems and petioles (Plate 2a).All the accessions with deep green leaves showed purple pigmentation in their stems and petioles (Plate 2b) Stem pigmentation and petiole pigmentation varied together, as the accessions possess either of both characters or noneof them (Table 2).

Table 2: Qualitative characters of twelve accessions of African yam beans

Accessions	Leaf colour	Stem pigmentation	Petiole pigmentation
TSs 41	Light green	Present	Present
TSs 115	Light green	Absent	Absent
TSs 125	Light green	Present	Present
TSs 138	Light green	Absent	Absent
TSs 139	Light green	Absent	Absent
TSs 152	Light green	Absent	Absent
TSs 154	Light green	Absent	Absent
TSs 162	Light green	Absent	Absent
TSs 163	Deep green	Present	Present
TSs 209	Deep green	Present	Present
TSs 311	Deep green	Present	Present
TSs 373	Light green	Absent	Absent

There were significant differences among the accessions for all the vegetative characters studied as shown in Table 3. TSs 162 performed best in all the vegetative characters studied with significantly highest values except for leaf length (LL) and number of branches (NB).Performance of in TSs 311 and 373 with respect to leaf length were similar, leaf width (LW) in TSs 115 and 154 were also similar. Significant variations were recorded in all the vegetative characters studied (Table 3). The variability among the vegetative characters considered was in the decreasing order of PH > LL > LW > LA > IL > PL > NL > SG > NB, with the first four characters accounting for about 92 % of the total variances (Table 4).

Table 3: Vegetative characters of twelve accessions of African yam beans showing the mean, standard error and coefficient of variation

Accession	PH(m)	LL(cm)	LW(cm)	LA(cm^2)	IL(cm)	PL(cm)	NL	SG(cm)	NB
TSs 41	0.87^{abc}	10.30^{de}	4.47^{abc}	34.46^{bcde}	11.17^{bc}	7.47^{cde}	114.33^{abc}	0.60^{cd}	17.00^{a}
TSs 115	2.35^{de}	9.40^{e}	3.60^{c}	25.56^{e}	10.50^{bc}	6.40^{e}	116.00^{abc}	0.50^{d}	11.33^{bc}
TSs 125	2.75^{bc}	11.90^{abc}	4.40^{abc}	39.59^{abc}	9.83^{bc}	7.80^{bcde}	117.67^{abc}	1.13^{ab}	14.33^{abc}
TSs 138	2.17^{de}	10.50^{cde}	4.47^{abc}	35.29^{bcde}	9.23^{bc}	7.70^{cde}	108.30^{bc}	1.07^{ab}	13.33^{abc}
TSs 139	2.78^{bc}	10.77^{cde}	4.60^{abc}	37.09^{bcd}	8.20^{c}	8.90^{abc}	125.00^{abc}	1.03^{ab}	10.33^{c}
TSs 152	2.10^{e}	10.60^{cde}	3.90^{c}	30.93^{cde}	10.90^{bc}	8.30^{abcd}	104.00^{c}	0.97^{abc}	11.33^{bc}
TSs 154	2.25^{de}	9.90^{de}	3.60^{c}	26.94^{de}	9.40^{bc}	7.80^{bcde}	125.30^{abc}	0.80^{bcd}	9.67^{c}
TSs 162	3.07^{a}	12.40^{ab}	5.33^{a}	49.62^{a}	18.00^{a}	9.40^{a}	149.00^{a}	1.23^{a}	16.67^{ab}
TSs 169	2.70^{c}	10.10^{de}	4.00^{bc}	30.43^{cde}	11.50^{b}	6.90^{de}	117.00^{abc}	0.97^{abc}	12.00^{abc}
TSs 209	2.67^{c}	13.30^{a}	4.40^{abc}	43.67^{ab}	10.80^{bc}	9.20^{ab}	123.33^{abc}	1.07^{ab}	12.33^{abc}
TSs 311	2.40^{d}	11.00^{bcd}	4.10^{bc}	34.58^{bcde}	11.80^{b}	6.80^{e}	110.67^{bc}	0.90^{abcd}	10.67^{bc}
TSs 373	2.97^{ab}	11.00^{bcd}	5.00^{ab}	42.04^{ab}	17.60^{a}	8.90^{abc}	143.00^{ab}	1.20^{ab}	13.67^{abc}

Mean with the same letter(s) down the column are not significantly different while means with different letter(s) down the column are significantly different p-value < 0.05 α level.

Key:PH- Plant height,LL= leaf length, LW= Leaf width, LA=Leaf area, IL= Internode length, PL = Petiole length, NL= Number of leaves, SG = Stem girth, NB = Number of branches.

Table 4: Principal component analysis of twelve accessions of African yam beans

	Initial Eigen values			Components	
Component	Total	% of Variance	Cumulative %	1	2
PH	5.753	63.921	63.921	.814	.388
LL	1.394	15.490	79.411	.752	-.399
LW	.729	8.102	87.513	.943	.065
LA	.395	4.389	91.902	.964	-.135
IL	.348	3.868	95.770	.709	.376
PL	.225	2.498	98.268	.793	-.456
NL	.115	1.282	99.550	.807	.200
SG	.040	.448	99.998	.724	-.549
NB	.000	.002	100.000	.631	.611

The grouping of the accessions into cluster by Dendogram showed two broad groups (A and B), Group A consisting of accessions TSs 162 and 373. On the other hand, group B consists of all other accessions (Fig 1). Group B is sub-divided into two groups (I & II). There are three accessions in group I while group II had seven accessions. However, the seven accessions in group II were further split into two clusters of three and four accessions for clusters (i) and (ii) respectively (Fig 1).

The clustering of accessions to different groups based on morphological parameters evaluated is shown in Table 5. TSs 162 and 373 were different from the other accessions on the basis of stem girth (SG), TSs 138, 152 and 311 have distinguishing number of branches and leaves (NB and NL). PH, LL, LW and LA separate TSs 41, 125, 139 and 209 from the other accessions (Table 5).

Plates1(a): Young and **(b)** matured light green leaves in TSs 41, 115, 125, 138, 139, 152, 154, 163 and 373 accessions of African yam beans evaluated.

Plate1c: Deep green colouration of TSs 162, TSs 209 and TSs 311 accessions of evaluated African yam beans.

Plate2a: Coloured stem with pale (light) green leaves in TSs 41 and TSs 125 accessions of African yam bean

Plate2b: Coloured stem with deep green leaves in TSs 163, TSs 209 and TSs 311 accessions of African yam bean

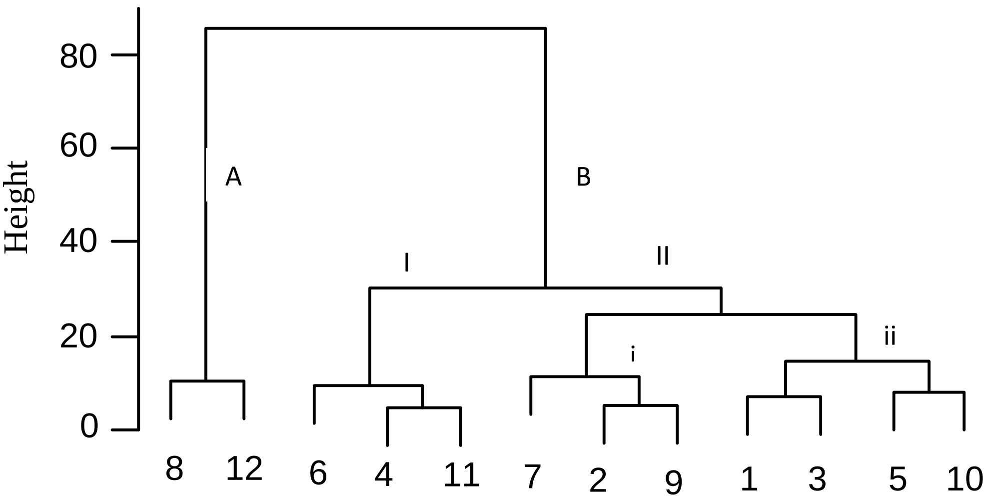

Figure 1: Cluster analysis of the 12 accessions of AYB using flexible method
Key:1 = TSs 41, 2 = TSs 115, 3 = TSs 125, 4 = TSs 138, 5 = TSs 139, 6 = TSs 152, 7 = TSs 154, 8 = TSs 162, 9 = TSs 169, 10 = TSs 209, 11 = TSs 311 and 12 = TSs 373.

Table 5: Showing four cluster groups from the Dendogram and their distinguishing characters

Cluster Group	No. of accessions	Name of accessions	Distinguishing traits
I	2	TSS 162, TSS 373	SG
II	3	TSS 138, TSS 152, TSS 311	NB,NL
III	3	TSS 154, TSS 115, TSS 163	IL, PL
IV	4	TSS 41, TSS 125, TSS 139, TSS 209	PH, LL,LW,LA

PH- Plant height, LL= leaf length, LW= Leaf width, LA= Leaf area, IL= Internode length, PL = Petiole length, NL= Number of leaves, SG = Stem diameter, NB = Number of branches.

DISCUSSION

From the results, variability existed in the evaluated characters among the African yam bean accessions considered in this study. Seed morphology based on colour, shape and depression varied among the accessions and such variations in seed parameters have been used to characterize African yam bean (Adewale *et al.* 2010). Morphological dissimilarities in qualitative characters like leaf colour stem pigmentation and petiole pigmentation showed that qualitative traits varied among the accessions of African yam bean while some accessions were presented with stem and petiole pigmentation, others had the normal green colouration. Stem and petiole colourations observed in some accessions could probably be as a result of mutant form of chlorophyll expression that is localized within the area.

Analyses of the quantitative characters showed marked variation among the accessions. Quantitative traits such as plant height, internode length, stem girth and number of branches was significantly different and formed the basis for the cluster groupings. This result is in agreement with the findings of Popoola *et al.*(2011). Based on the results obtained from the various analysis of the characters evaluated, it suggests that some accessions possess characters that can be worked on to facilitate improvement in the crop and its tolerance to harsh environmental conditions, For instance, TSs 162 and TSs 373 had the thick stems which could improve their ability to store water and enhance growth in areas with low rainfall. In addition, characters such as plant height (PH) and leaf length (LL) with high contribution to variability would be more reliable for utility in breeding programme as previously opined (Okpara and Omaliko, 1999; Ameh, 2003)

It is possible to select for higher yield by selecting for longer leaves since the leaf surface is the harvester of energy needed to drive photosynthesis. Also, plant height may likely have influence on the ability of the plant to intercept sunlight which in turn determines the rate of assimilate partitioning by the plant at the pod filling stage. Since leaf parameter is primarily genetically controlled according to Potter and Doyle(1994), therefore, accessions (TSs 162 and TSs 373) which showed desirable characteristics like higher leaf area, plant height and number of leaves may be good and promising sources of genetic variability needed for the development of improved varieties of African yam bean.

From the Eigen values, the greater proportion of variation was due to leaf characteristics plant height. The high percentage variance observed in these characters indicated that the variability among accessions is significant and the accession exhibited degree of morphological diversity which could be utilized for the crop improvement. The cluster Dendogram, revealed two primary progenitors; one containing accessions TSs 162 and TSs 373 where stem girth (SG) is the distinguished attribute and the other containing the rest accessions. At higher scale, the group with larger accessions further splits to three cluster of accessions that are more related. The clustering of the accessions revealed the genetic closeness or relatedness of the accessions. Accessions with similar number of leaves and branches were clustered together, also, internode and petiole lengths give rise to a cluster while characters such as leaf length, leaf width, leaf area and plant height delimit the group with largest accession. Similar pattern of clustering was reported by Aremu and Ibirinde (2012) among the accessions of AYB studied. Accession within a cluster are genetically similar but might have been separated morphologically due to environmental influence over a period of time. Evolutions could have led to the splitting of the second primary progenitor further into three groups. Factors like geographical location, viability of accession, selection history, similarities and differences in nutrients, requirement in the field, and survival level before reproduction have been suggested to have a role in variation amongst the same species (Oyewole 1975). However, Potter and Doyle(1994)suggested that leaf/leaflet dimensions are primarily determined genetically not environmentally.

CONCLUSION

The African Yam Bean is an underutilized crop that has received little attention from researchers despite its many potentials. Improvement efforts on this crop to enhance production of nutritious food for the world's poor to a large extent depends on the identification, maintenance and use of genetic resources of the crop. Knowledge of variability in the crop therefore will play a significant role in various improvement programmes of the crop. The characters evaluated in present study shows significant variability among the twelve accessions. The accessions clustered into two major groups with the larger group sub-divided into three clusters based on characters evaluated, this may help in selection of accessions as breeding materials for new cultivars. In particular, if a new cultivar with new mixes of alleles were to be obtained, the variability existing among the accessions should be explored. Being an indigenous plant to African, exploring and improving African yam bean accessions will go a long way in alleviating food security problems that currently affects the world population, in particular, the African continent.

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