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Genetic Assessment of Three Colour Variants of African Yam Bean[*Sphenostylis Stenocarpa*] Commonly Grown in the Midwestern Region of Nigeria

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Abstract Three varieties of African yam bean (*Sphenostylis stenocarpa*) were collected from six different locations in Edo State, Nigeria (Ekpoma, Benin City, Auchi, Igueben, Igbanke and Sabongida Ora). These seeds were then characterized based on seed colour into black, brown, and light grey. The seeds were screened in the field for agronomic and yield associated characters as well as chemical composition of the seeds. Considerable variations were observed in both agronomic and yield associated characters like shoot height, leaf area, grain yield and total ash content of the seeds. The black colour variant was significantly ($p<0.05$) highest in grain yield per hectare (1542.28kg/ha) compared to both brown variant (1304.23kg/ha) and the light grey type (1259.97kg/ha).

Keywords African Yam Bean, Agronomy, Heritability, *Sphenostylis Stenocarpa*

1. Introduction

Nigeria, like many third world countries is a food deficit country especially with the increasing population growth. Most rural communities cannot afford animal proteins and over three million children lack sufficient proteins within the last decade, and therefore suffer grossly retarded physical growth and development. Protein deficiencies also directly or indirectly affect the health and economic productivity of adult populations[1]. With the ever increasing population pressure and fast depletion of natural resources, it has become necessary to explore the possibilities of exploiting new plant resources to meet the growing needs of the human society, which incidentally has depended only on a small fraction of plant resources comprising less than 30 crops; among which is the African yam bean, a leguminous crop[2]. The African yam bean[*Sphenostylis stenocarpa* (Hochst. Ex A. Rich) Harms] is a climbing legume adapted to lowland tropical conditions. It is one of the lesser-known legumes[3, 4, 5] and widely cultivated in the southern parts of Nigeria. The legumes are a good source of dietary protein[6]. They are cheaper than animal products such as meat, fish, poultry, egg – therefore they are consumed worldwide as a major source of cheap protein and especially in the developing or poor countries where consumption of animal protein may be limited as a result of economic, social, cultural or religious-factors[7]. Global food security however is becoming shaky with increasing dependence on a few major staple crops. This has resulted in an alarming reduction not only in crop diversity but also in the variability within crops. This therefore emphasizes the need for the collection and conservation of diversity within species. Usually when this done, there is the possibility for stockpiling crops of converse characteristics - for example, stockpiling low yielding varieties with high yielding ones.

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2. Objectives

Biodiversity of species assures their evolutionary continuity. The collection and conservation of diversity within species is a safeguard against the loss of germplasm. They provide a buffer against environmental threats and assure continual and sustainable productivity. This is particularly achievable when the traits of these diverse species are documented as well. In Edo State, for example, a visit round markets in the areas chosen for study (Auchi, Benin City, Ekpoma, Igbanke, Igueben, and Sabongida Ora) show predominance of three colour variants of African yam bean – black, brown, and light grey colours. The present study therefore comparatively assesses some agronomic traits and chemical composition of seeds of three colour variants of African yam bean commonly grown in the Midwestern Region of Nigeria.

3. Materials and Methods

3.1. Planting Materials

Three varieties of African yam bean were collected from six different locations in Edo State (Auchi, Benin City, Ekpoma, Igbanke, Igueben, and Sabongida Ora). These towns are located in separate Local Government Areas of the State. The seed characteristics were measured and then characterized based on seed colour into black, brown, and light grey. Similar colour variants were pooled together from all the sources, and planted as described below.

3.2. Germination Tests

Germination tests were carried out on 2 disks of Whitman No.1 filter paper in 9 cm Petri dishes previously moistened with water. Twenty (20) seeds of the various variants were sown in each Petri dish. Seeds observed to have protrusions of the radicle were considered to have germinated[8, 9].

3.3. Cultivation in Wooden Boxes

Seeds were sterilized by immersing into 2 % sodium hypochlorite for 7 minutes and rinsing repeatedly in distilled water[10]. Seeds were separately germinated in wooden boxes (57 cm x 41 cm x 15 cm) containing a mixture of top soil of known physicochemical property (Table 1) and organic manure in the ratio 2:3. Growth characteristics of the seedlings were taken into record for 3 days. Seedlings were transplanted after 14 days growth, into the field.

Table 1. Physicochemical Property of the Soil used for the Present Study

Soil Properties	Value
pH	5.68
Carbon	3.91%
Total N	14.96ppm
P	36.06ppm
K	3.50 meq/100g
Ca	2.93 meq/100g
Mg	2.63 meq/100g
CEC	8.45 meq/100g
Sand	64.52%
Silt	24.41%
Clay	10.48%

3.4. Cultivation in the Field

The plot was cleared and tilled by properly mixing the soil. Mounds were made at a spacing of 60 cm x 30 cm as proposed by Okeleye *et al.*[11]. Seedlings in the wooden boxes were then transplanted after 14 days growth, into the field of known soil characteristics (Table 2). Each mound received 2 seedlings, amounting to a mean of 55, 000 plant stands per hectare.

3.5. Crop Husbandry

The plot was weeded thrice before harvest. Although the plants were exposed to the prevailing weather condition (rainy season), water requirements by the crop were supplemented during very dry days by irrigating, each mound with 400ml distilled water beyond sunset. When plants were long enough, they were staked on bamboo poles.

3.6. Parameters Determined

Shoot height was measured from the soil level to the tip of the plant using a meter rule. Number of shoot branches and number of leaves were counted *in situ*. Leaf area was determined using the graph sheet method as described by Eze[12]. Chlorophyll content was measured using the method described by Holden[13]. Root length was measured with meter rule after irrigating and carefully uprooting the plants. The number of primary root branches, number of root nodules and weight of ten root nodules were determined. Plant dry weight was determined after drying to constant weight at 70°C. Yield parameters were determined following the methods of IBPGR and ICRISAT[14]. Proximate and mineral analyses of dry harvested seeds were separately determined by using standard procedures of AOAC[15] and IITA[16]. Parameters include crude protein, crude fibre, ether extract, total ash and dry matter.

3.7. Genetic Studies

The genetic analysis was done on those parameters related to the variations in the colour of the beans. The mean squares at the treatment levels were taken as the phenotypic variance. Genotypic variance, which is the proportion of the phenotypic variance caused by variations in genes, the mean square at the error level, was subtracted from the corresponding phenotypic variance for all treatments used. The genetic parameters were as follows;

$$\text{Heritability (\%)} = \frac{\delta^2 g}{\delta^2 ph} \times 100$$

Where $\delta^2 g$ = Genotypic variance, and $\delta^2 ph$ = Phenotypic variance

$$\text{Genetic advance} = \frac{\delta^2 g}{\delta ph} \times k$$

Where k = 2.06 (selection differential at 10%).

Genetic gain was calculated in terms of the genetic advance expressed as a percentage of the population mean.

3.8. Experimental Design

The experimental design adopted was the completely randomized design (CRD) following assumption of homogeneity of the experimental plot in use. As a result, treatments were randomized over the whole plot. Each treatment consisted of 20 replicates. The results were presented as mean values. Data was analyzed using the SPSS-16 Statistical Software. A probability of 0.05 was considered as significant.

4. Results and Discussions

The seed characteristics used in the present study were measured and then characterized based on seed colour into black, brown, and light grey. Table 2 shows the seed characteristics of African yam bean collected from Edo State. Significant variations among the seeds collected for the present study were in the colour; no significant differences were recorded in seeds size, similar to findings by Beridize *et al.,[*17].

Table 2. Seed characteristics of African yam bean collected from Edo State

Location	colour variants	100 seed wt (g)	Breadth (mm)	Length (mm)
Auchi	Black	20.31[b]	5.33[a]	6.34[b]
	Brown	23.11[b]	5.06[a]	6.31[b]
	Light Grey	29.91[a]	5.38[a]	6.38[b]
Benin City	Black	23.37[b]	5.30[a]	7.00[ab]
	Brown	23.40[b]	5.30[a]	6.70[b]
	Light Grey	22.83[b]	5.30[a]	6.00[b]
Ekpoma	Black	23.67[b]	5.60[a]	8.00[a]
	Brown	22.93[b]	5.00[a]	6.30[b]
	Light Grey	22.63[b]	5.00[a]	7.30[ab]
Igbanke	Black	23.40[b]	5.30[a]	7.30[ab]
	Brown	23.47[b]	5.30[a]	7.00[ab]
	Light Grey	22.67[b]	5.70[a]	7.00[ab]
Igueben	Black	23.27[b]	5.30[a]	7.00[ab]
	Brown	22.77[b]	5.30[a]	6.00[b]
	Light Grey	22.50[b]	5.30[a]	6.30[b]
Sabongida Ora	Black	23.73[b]	5.30[a]	7.00[ab]
	Brown	22.90[b]	5.00[a]	6.00[b]
	Light Grey	22.63[b]	5.70[a]	6.00[b]
LSD (p=0.05)		3.01.	0.68.	1.12.
Mean		23.47.	5.30.	6.66.

Values are means of 20 determinations. Means on the same column with similar alphabets do not differ significantly (p<0.05) from each other.

Table 3 shows vegetative parameters of African yam bean. Germination percentage at 60 hours after planting (HAP), which ranged from 79.35 % to 81.46 %, did not significantly ($p<0.05$) differ among the colour variants. Mean radicle length was 29.79 mm at 60 HAP, with no significant difference among the colour variants. Similarly, differences recorded for water imbibition rates at 60 HAP were minimal and not significant. According to Valio[18] and Duke and Kakefuda[19], any differences recorded in water imbibition rates of cowpea may be attributed to thickness of seed coats. Significant variability in dry weight of germinated seeds at 60 HAP was recorded. The brown seeds weighed (0.131 g) more than the other colour variants and the mean weight (0.121 g). Figures 1 and 2 both show the rate of germination percent and increase in radicle length for 60 hours. At 3 days after planting (DAP), mean percentage seedling emergence was 78.98 %, seedling height was 4.32 cm, while dry weight of sprouted seedling was 0.23 g. No significant variability in these parameters was recorded (Table 3). At 9 weeks after planting (WAP), significant differences in plant heights of the 3 variants were recorded. The black seed variant was highest (130.36 cm) and the brown variant being the least (111.27 cm). Ikhajiagbe *et al.[*9] previously reported that average shoot height of African yam bean was 107.32 cm. Variability in leaflet area was also significant. Mean leaflet area was 51.42 cm^2. no significant change was recorded in number of primary branches, stem width, total leaf number per plant, root length as well as root dry weight. Mean values of these parameters were 15.15, 7.02 mm, 19.44, 54.98 cm, and 0.691 g respectively (Table 3). These were similar to findings by Ikhajiagbe *et al.[*9], who reported that stem girth, total leaf number per plant, root length and root dry weight of African yam bean were 7.28, 18.13, 57.41 cm and 0.655 g respectively.

Table 3. Comparative vegetative parameters of African yam bean

Parameters	Colour Variants				
	Black	Brown	Light Grey	LSD (p=0.05)	Mean
Germination percentage (%) @ 60HAP	79.35[a]	81.46[a]	80.52[a]	4.25	80.44
Radicle length (mm) @ 60HAP	29.38[a]	31.58[a]	28.43[a]	2.47	29.79
Dry Wt.of germinated seed (g) @60HAP	0.109[b]	0.131[a]	0.115[b]	0.011	0.121
Water imbibition (%) @ 60HAP	9.05[a]	8.95[a]	9.27[a]	1.23	9.09
Percentage emergence (%) @ 3DAP	78.62[a]	80.13[a]	78.10[a]	6.17	78.98
Seedling height (cm) @ 3DAP	4.45[a]	4.53[a]	3.97[a]	0.79	4.32
Fresh Wt. of sprouted seedling @3DAP	0.510[a]	0.489[a]	0.502[a]	1.11	0.50
Dry Wt.of sprouted seedling (g) @3DAP	0.229[a]	0.238[a]	0.215[a]	0.05	0.23
Shoot height (cm) @9WAP	130.36[a]	111.27[b]	123.42[ab]	15.82	121.68
No. of primary branches@9WAP	16.03[a]	14.48[a]	14.93[a]	3.71	15.15
Stem width (mm) @9WAP	7.06[a]	7.43[a]	6.57[a]	1.08	7.02
No. of leaves@9WAP	20.11[a]	18.49[a]	19.71[a]	3.62	19.44
Leaflet area (cm^2) @9WAP	52.94[ab]	54.83[a]	46.49[b]	8.23	51.42
No. of primary root branches/plant@9WAP	6.02[a]	6.85[a]	5.75[a]	1.03	6.21
Root length (cm) @9WAP	57.24[a]	54.64[a]	53.07[a]	7.67	54.98
Dry wt. of root/plant (g) @9WAP	0.644[a]	0.724[a]	0.693[a]	0.084	0.691
Shoot dry Wt. (g) @9WAP	13.93[a]	12.79[a]	12.08[a]	2.97	12.93

Values are means of 20 determinations. Means on the same rows with similar alphabets do not differ significantly (p<0.05) from each other. DAP –days after planting; HAP – hours after planting; WAP - weeks after planting.

Table 4. Yield parameters and yield components of African yam bean at 9 weeks after planting

Yield Parameters	Colour Variants				
	Black	Brown	Light Grey	LSD (p=0.05)	Mean
No. of root nodules/plant	21.04[a]	22.38[a]	23.00[a]	3.79	22.14
Av. Nodule dry wt. (x10^{-2} g)	8.59[a]	9.38[a]	9.08[a]	1.87	9.02
Days to 50% flowering (DAP)	72.06[b]	75.42[ab]	78.00[a]	5.25	75.23
Days to 50% maturity (DAP)	88.43[a]	89.75[a]	89.42[a]	6.13	89.19
No. of flowers/plant	129.98[a]	136.79[a]	133.12[a]	8.11	133.29
No. of penduncle/plant	4.64[a]	5.38[ab]	5.98[a]	1.61	5.35
Penduncle length (cm)	21.49[a]	20.63[a]	20.72[a]	2.93	20.95
Pod length (cm)	18.68[a]	16.43[a]	19.63[a]	3.26	18.25
No. of pod/penduncle	4.008[a]	3.38[b]	3.27[b]	0.18	3.44
No. of pods/plant	22.03[a]	19.69[a]	20.73[a]	3.39	20.82
No.of seeds/pods	12.29[ab]	13.28[a]	11.88[b]	1.38	12.48
No. of seeds/plant	279.13[a]	266.37[a]	248.02[b]	18.16	264.23
100 seed wt (g)	10.02[a]	9.01[a]	8.49[a]	2.06	9.17
Grain yield (kg/ha)	1542.28[a]	1304.23[b]	1259.97[b]	110.06	1368.82

Values are means of 20 determinations. Means on the same rows with similar alphabets do not differ significantly (p<0.05) from each other. DAP –days after planting.

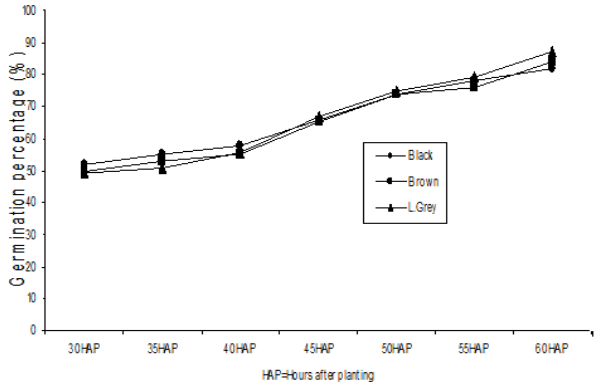

Figure 1. Comparison of percentage of germination of the three colour variants of African yam bean grown in Edo State

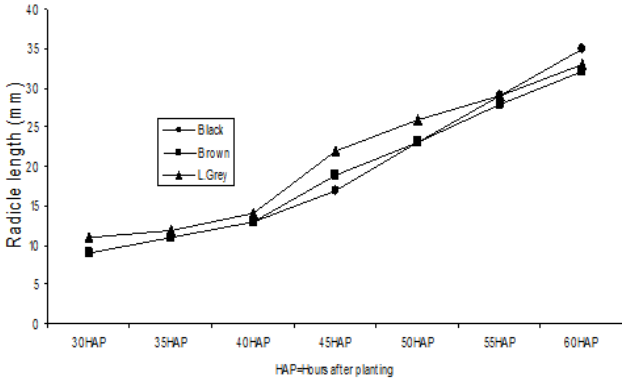

Figure 2. Comparison of radicle lenths of the three colour variants of African yam bean grown in Edo State

Average nodule dry weight at 9 weeks after planting (WAP) was 9.02 x 10^{-2}g (Table 4), where as there were 22.14 root nodules per African yam bean. These results did not significantly differ among the three colour variants. This agrees with the previous report of Ikhajiagbe *et al.[*9] that average number of nodules per plant was 21.38 and 9.02 x 10^{-2} g as nodule weight of African yam bean. There was significant delay in attaining 50 % flowering in the light grey bean variety (78 DAP), compared to the black bean type (72.06 DAP). Mean number of days to 50 % flowering was 75.23 DAP. No significant change in 50 % maturity was however recorded (mean 89.19 DAP).

Grain yield per hectare was significantly (p<0.05) highest in the black variant (1542.28 kg), compared to the brown variant (1304.23 kg) and the light grey variant (1259.97 kg). The average grain yield comparative among the three colour variants was 1368.82 kg/ha, and this did not compare significantly with the value (1057.55 kg/ha) previously obtained by Ikhajiagbe *et al.[*20] and the 3025 kg dry seeds per hectare obtained by Okigbo[21]. Ezeuh[22] and Okoye and Ene-Obong[23] previously reported that the black variant had higher number of pods and seeds. No significant variability was recorded in the nutritional composition of the various colour variants of African yam bean seeds (Table 5). However, the black colour variant was significantly higher in total ash (3.17 %) compared to average value (2.98%). Average crude protein content was 23.59 %, crude fibre was 5.17 %, and ether extract was 7.76 % while dry matter was 87.86 %.

Table 5. Nutritional composition of seeds of African yam bean

Parameters (%)	Colour Variants				
	Black	Brown	Light Grey	LSD (p=0.05)	Mean
Dry matter	87.79[a]	88.51[a]	87.36[a]	4.21	87.86
Crude protein	24.06[a]	23.59[a]	23.14[a]	1.68	23.59
Crude fibre	5.20[a]	5.33[a]	4.98[a]	0.43	5.17
Total ash	3.17[a]	2.79[b]	2.98[ab]	0.38	2.98
Ether extract	7.89[a]	8.13[a]	7.28[a]	1.23	7.76

Values are means of 20 determinations. Means on the same rows with similar alphabets do not differ significantly (p<0.05) from each other.

The broad based heritability estimates, genetic advance and genetic gain of the yield parameters in all three variants have been presented in Table 6. The heritability estimates 66.85 - 97.95% were moderate to high in all colour variants. Genetic gain ranged from 15.31 – 46.18.

Table 6. Genetic parameters of yield parameters of the three variants of African yam beans

Character	Mean	Phenotypic Variance (δ^2ph)	$\sqrt{(\delta^2 ph)}$ or δph	Genotypic Variance (δ^2g)	Heritability (%)	Genetic Advance	Genetic Gain
Shoot height (cm)	121.68	267.22	16.35	202.39	75.74	25.50	20.96
No. of leaves/plant	19.44	4.69	2.17	4.12	87.91	3.91	20.12
Pod length (cm)	18.25	20.17	4.49	18.37	91.10	8.43	46.18
No. of pods/plant	20.82	5.38	2.32	3.59	66.85	3.19	15.31
No. of seeds/pod	12.48	2.05	1.43	1.54	75.02	2.02	16.18
Grain yield (g)	1368.82	80304.58	283.38	78659.46	97.95	571.81	41.77

Although the vast genetic and economic potentials of African yam bean have been recognized, especially in reducing malnutrition among Africans, the crop has not received adequate research attention. Up till now, it is classified as a neglected underutilized species. Devos *et al*.[24] stressed that the danger of losing essential germplasm hangs over all cultivated food crop species in tropical Africa, especially those not receiving research attention. The quantity and availability of African yam bean germplasm is decreasing with time. At one time, Klu *et al*.[25] had speculated that the crop was nearing extinction; its inherent ability to adapt to diverse environments[26] may have been responsible for its continual existence and survival. Nevertheless, scientists think that the genetic resources of African yam bean may have been undergoing gradual erosion. The International Institute for Tropical Agriculture (IITA) keeps over 80 accessions of the crop, but otherwise, its conservation in Nigeria is very poor and access to its genetic resources is severely limited. Improvement of the crop is possible only when the intraspecific variability of the large genetic resources of the species is ascertained. The present study showed that of the three colour variants of African yam bean, the black colour variant was significantly better when considered for agronomic purposes, particularly given the fact that it was highest in shoot growth and overall grain yield, compared to both brown and light grey variants.

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