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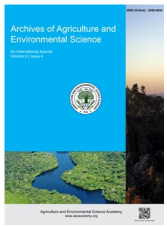

ORIGINAL RESEARCH ARTICLE

Evaluation of eight bambara groundnut (*Vigna subterranea* (L.) Verdcourt) accessions for agronomic characters and proximate composition in Uyo, Akwa Ibom State, Nigeria

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ABSTRACT

Bambara groundnut (*Vigna subterranea* [L.] Verdc.) is a valuable but underutilised legume crop grown in sub-Saharan Africa. The objective of this study was to evaluate the yield and yield components of eight Bambara groundnut accessions obtained from the National Root Crops Research Institute in Umudike, Nigeria. The experiment was conducted at the Teaching and Research farm of the University of Uyo, Uyo Southern Nigeria during the 2021 cropping seasons, using a randomised complete block design with three replications. Growth, yield and nutritional parameters were collected and subjected to analysis of variance, correlation and principal component analysis. Plant height, number of leaves, and leaf area were all significantly different (P≤0.05) among the accessions three months after planting. Number of pods per plant, seed weight, and 100-seed weight differed significantly (P≤0.05). Caly PSC (2853 kg/ha), Caly SK 46 (2803 kg/ha), Zeina (2538 kg/ha), and BNT (2488 kg/ha) were the top yielders among the accessions. Yields of Bambara groundnut differ significantly (P≤0.05) between accessions studied, ranging from 1624.67 kg/ha to 2853.33 kg/ha. Principal component (PC) analysis identified eight influential components, two of which, PC1 and PC3, contributed 27% and 17% of the total variation, respectively. In this study, the correlation analysis revealed that plant height and petiole length, plant height and number of seeds per plot were all negatively correlated. The leaf area and the number of pods per plot, the number of seeds per pod and the fibre content, the leaf area and seed weight, and the plant height and seed weight were all noted positively correlated. The nutritive value of the eight Bambara groundnut accessions varied significantly (P≤0.05). The mean protein levels of eight Bambara nut accessions studied ranged from 18.82 to 20.39%. Findings from this study clearly indicate that Bambara groundnut is suitable for production in Uyo, Akwa Ibom State. Thus, high yielding accessions identified in this study are recommended for increased production in Akwa Ibom State of Nigeria.

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INTRODUCTION

The Bambara groundnut (*Vigna subterranea* (L. Verdc) belongs to the *leguminosae* family and has been believed to have originated in the Sahel region, which is now West Africa. Bambara groundnut is a staple food in some semi-arid regions of Africa (Gonné *et al*., 2013). It is an underutilised food legume (Azam-Ali *et al*., 2001) that plays an important role in initiatives to maintain food security in Sub-Saharan Africa (Koné *et al*., 2007). Bambara groundnut is an herbaceous, short-leaved annual crop plant that grows to a height of about 15 cm and has numerous nitrogen-fixing nodules on the roots that help to improve the soil (Yakubu *et al*., 2010). Its edible seeds are high in calories, vitamins, and vegetable proteins (Minka and Bruneteau, 2000).

In addition to nutritional benefits, the roots, leaves, and seeds are used in traditional medicine (Maphosa and Jideani, 2017). This leguminous crop is well adapted to the tropics and can thrive in a variety of environmental conditions, including marginal soils where other leguminous crops cannot be grown (Abejide *et al*., 2017). Bambara groundnut cultivation has declined in Nigeria's Sahel and Sudan Savannah zones over the last 20 years. Bambara groundnut contains a substantial supply of minerals such as phosphorous, calcium, zinc, and iron, enabling it to be a complete diet and people can easily survive by feeding specifically on Bambara groundnut diet or providing all of their nutritional requirements. Bambara is used to make a variety of dishes, including a local dish known as 'okpa' in Nigeria (Oluwole and Oluremi, 2012). The seed contains approximately 24% protein, 64% carbohydrates (53% starch, 10% dietary fibre), and 6% total fat, providing nutrition and a balanced diet for humans (Azman *et al*., 2019). However, one of the drawbacks of most underutilized and neglected crop species, including Bambara groundnut, is a lack of established breeding programmes; as a result, landraces of Bambara groundnut have remained the primary source of planting materials used by farmers (Mayes *et al*., 2015). Despite the vast genetic diversity of Bambara groundnuts, Akwa Ibom State has not fully utilized this unique resource in terms of variety selection and development. It is necessary to assess its yield potential in Akwa Ibom State and determine the nutrient quantities of the selected accessions. This study will make a significant contribution by identifying high yielding Bambara groundnut accessions that are adaptable to Akwa Ibom State for increased production in Akwa Ibom State. Hence, the objective of this study was to identify high yielding and stable Bambara groundnut accessions that are adaptable to Uyo production environments.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Teaching and Research farm of the University of Uyo, Uyo Southern Nigeria during the 2021 cropping seasons. Uyo lies between latitude 15°02´ North and longitude 07°56´ East of the Greenwich meridian and altitude 38m above sea level. It is located in the humid high rainfall area of Southern Nigeria, with an annual rainfall of over 2500mm and an average daily sunshine of 3 hours 31 minutes. Throughout the year, the temperature ranges from 23°C to 34°C (Ndaeyo, 2003).

Plant materials, field layout and data analysis

Three replications of each treatment were used in the randomised complete block design (RCBD) of the field experiment. Eight accessions of Bambara nuts were obtained from the National Root Crops Research Institute in Umudike: Zeina 22, Regal green 27, Caly SK 144, BNT 89, Caly PSC 6, Caly SK 46, SDR 21 and Caly 4. Each replication was divided into 9m^2 plots (3m x 3m). Each block had 8 plots, and twenty-four seeds were sowed in each plot to a depth of 5 cm. There were 30 cm between seeding locations. Data were collected on various agro-morphological parameters from the five (5) plants in the middle of each plot and the growth and harvest stages served as the basis for the evaluation and. Data collected were subjected to Analysis of Variance (ANOVA) and the means were separated using the Least Significant Difference (LSD) test at a 5% level of significance.

Sample collection

Mature and dried *Vigna subterranean* (L.) Verdc seeds used for this study were harvested from the experimental site, dried in the sun, carefully removed from their hulls, ground into powder using a mortar and pestle, and stored in a plastic bag ready for analysis.

Proximate composition

The moisture content was determined by drying 5 g of powdered sample to constant weight in a 105 °C oven. The moisture content of the seed was calculated as the difference in weight between before and after drying (AOAC, 2006). Ceirwyn (1998) described a method for determining ash content that involved dry ashing in a muffle furnace at 600 °C until greyish white ash was obtained. According to the AOAC (2006) method, crude lipid content was determined using a soxhlet apparatus and n-hexane as the solvent. The crude protein of the sample was calculated by multiplying the value obtained from Kjeldahl's nitrogen analysis by a protein factor of 6.25 (AOAC, 2006). Available carbohydrate was calculated by subtracting the sum of the percentages of ash, crude lipid, crude protein, and crude fibre from 100%. The calorific value was calculated using the equation described by Asibey-Berko and Taye (1999).

$$Available\ Carbohydrate\ (\%) = 100 - (\%\ ash + \%\ protein + \%\ lipid\ \%\ fibre)$$

$$Energy\ (kcal/100g) = (crude\ protein\ x\ 2.44) + (crude\ lipid\ x\ 8.37) + (available\ carbohydrate\ x\ 3.57)$$

RESULTS AND DISCUSSION

Variation among growth characters of eight Bambara groundnut accessions

Table 1 shows the mean values of various growth parameters for the eight Bambara groundnut accessions three (3) months after planting. The results in Table 1 indicate that plant height, number of leaves, and leaf area differed significantly (P< 0.05) among the eight accessions, but petiole length did not. The tallest plant was Caly SK 144 (56.50 cm), followed by BNT 89 (39.00 cm) and SDR 21 (37.80 cm). These three accessions had plant heights greater than the grand mean (37.52 cm), while Caly PSC had the shortest plant height (29.78 cm) at 3 MAP (Table 1). At 3 MAP, the number of leaves of the various accessions studied differed significantly. BNT 89 had the most leaves (533.40), followed by SDR 21 (37.80) and Caly PSC (449.80), while Caly SK 144 had the fewest leaves (171.00). The petiole length of the Bambara groundnut studied did not differ

Table 1. Mean values of growth parameters of eight Bambara groundnut accessions at 3 MAP.

Accessions	Plant Height	Number of leaves	Petiole Length	Leaf Area
SDR 21	37.80	498.80	2.30	33.20
Caly 4	36.20	432.25	2.90	27.40
Caly PSC	29.78	449.80	2.50	25.55
Caly SK 144	56.50	171.00	2.10	25.12
Grand mean	33.76	423.57	2.26	25.03
Regal green 27	32.50	410.60	2.04	24.30
Caly SK 46	34.38	432.00	2.10	24.20
BNT 89	39.00	533.40	2.20	20.68
Zeina 22	34.02	413.60	2.30	19.75
Grand mean	37.52	423.57	2.30	25.03
LSD ($P \leq 0.05$)	4.43	188.76	NS	7.42

Table 2. Mean values for yield characters of the eight accessions of Bambara groundnut.

Parameters	Number of pods per plant	Weight of dried pods	Seed weight (kg/ha)	100 seeds weight	Dry matter
Zeina 22	83.33	81.00	2538.67	86.00	63.33
Caly SK 46	66.33	103.00	2803.33	83.00	43.00
Caly 4	69.67	115.33	1674.67	82.00	85.33
Caly SK 144	110.00	111.00	2307.33	80.00	45.67
SDR 21	77.33	76.33	2357.33	78.00	45.33
Grand mean	78.13	88.92	2331.00	76.83	68.42
BNT 89	74.33	67.33	2488.67	72.00	52.67
Regal green 27	73.00	56.00	1624.67	67.00	128.00
Caly PSC	71.00	101.33	2853.33	66.67	84.00
LSD ($P \leq 0.05$)	37.64	48.07	1045.52	7.59	35.50

significantly at 3 MAP, as shown in Table 1. Caly 4 had the longest petiole length (2.90 cm), followed by Caly PSC (2.50 cm), and Regal green 27 had the shortest (2.04 cm). Table 1 also showed that the leaf area of the accessions studied varied significantly (P<0.05) at 3 MAP. The leaf area's grand mean was 25.03 cm^2. SDR 22 had the largest leaf area (33.20 cm^2), followed by Caly 4 (27.40 cm^2), and Zeina 22 had the smallest leaf area (19.75 cm^2).

Yield and yield related traits variation in eight Bambara groundnut accessions

The mean values of different yield parameters of eight Bambara groundnut accessions at harvest are shown in Table 2. The number of pods, weight of dried pods, seed weight, weight of 100 seeds, and dry matter of Bambara groundnut accessions differ significantly (P≤0.05). There was a significant difference (P≤0.05) in the number of pods per plant among the Bambara groundnut accessions. Caly SK 144 had the most pods per plant at harvest (110.00), followed by Zeina 22 (83.33) and SDR (77.33). Caly SK 46 produced the fewest pods per plant (66.33). At harvest, the weight of dried pods varies significantly among Bambara groundnut accessions. Caly 4 had the highest dried pod weight (115.33 g), followed by Caly SK 114 (111.00 g) and Caly SK 46 (103.00 g). Regal green had the smallest weight of dried pods (56.00 g). The yield (seed weight) of the Bambara groundnut accessions differed significantly (P≤0.05). Caly PSC had the highest yield (2853.33 kg/ha), followed by Caly SK 46 (2803), Zeina 22 (2538.67 kg/ha), BNT 89 (2488.67 kg/ha), and SDR 21 (2357.33 kg/ha). The seed weights of these five accessions were greater than the grand mean (2331.00 kg/ha). Regal green had the lowest yield (1624.67 kg/ha). The weight of 100 seeds of the Bambara groundnut accessions differed significantly (P≤0.05). Zeina 22 had the highest 100 seed weight (86.00 g), followed by Caly SK 46 (83.00 g) and Caly 4 (82.00g). Caly PSC had the lightest weight of 100 seeds (66.67 g). Table 2 also showed that there was a significant difference (P≤0.05) in dry matter between Bambara groundnut accessions. Regal green had the highest dry matter (128.00%), followed by Caly 4 (85.33%) and Caly PSC (84.00%). Caly SK 46 had the least dry matter (43.00%).

The objective of this study was to identify high yielding and stable Bambara groundnut accessions that are adaptable to Uyo production environments, as well as to determine the relationships between the traits (plant height, grain yield, hundred grain weight, leaf area, and petiole length). Plant growth traits (plant height, number of leaves, and leaf area) showed highly significant (P<0.05) differences three months after planting. This demonstrates that the climatic conditions in the Uyo production environment were variable. Bambara groundnut grows best in climates with abundance of sunlight, high temperatures, and rain (Mabhaudhi and Modi, 2013). The yield in this study ranged from 1624.67 kg/ha to 2853.33 kg/ha, which was considerably higher than the yields reported by Unigwe *et al.* (2016) and Shegro *et al.* (2013). Their yields ranged from 9.90 to 126.03 kg/ha and from 13.33 to 191.73 kg/ha. This suggests that the Bambara groundnut genotypes used in this study were capable of adapting to the production environments in Uyo, Akwa Ibom State. Temperature, altitude, rainfall, soil type, and genetic constitution are all factors that influence Bambara groundnut growth (Shegro *et al*., 2013). According to Sagor *et al*., (2021), environmental conditions and genetic constitution are the two most important factors influencing crop yield performance. Among the accessions evaluated, four accessions; Caly PSC (2853 kg/ha), Caly SK 46 (2803 kg/ha), Zeina (2538 kg/ha) and BNT (2488 kg/ha) were top yielders. According to Ellah and Singh (2008), Nigeria has the highest Bambara groundnut yield

Table 3. Proximate analysis of Bambara groundnut accessions.

Accessions	Moisture (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)	Protein (%)	Carbohydrate (%)
Caly SK 46	7.80	5.80	4.60	3.55	18.29	60.24
Zeina 22	6.80	5.96	4.71	3.58	19.35	59.62
Caly 4	6.74	5.91	4.65	3.88	19.34	59.49
Caly SK 144	7.58	6.48	5.32	3.58	18.82	58.23
BNT 89	6.39	6.30	5.48	3.92	19.87	58.06
Regal green 27	7.91	6.38	5.35	3.60	18.82	57.96
SDR 21	7.18	6.60	5.59	3.51	20.21	56.92
Caly PSC	7.25	6.32	5.42	3.82	20.39	56.81
LSD ($P \leq 0.05$)	0.04	0.04	0.06	0.06	0.13	0.33

potential of any African country, ranging between 500 and 2600 kg/ha. According to Unigwe *et al.* (2016), Bambara groundnut is very adaptable compared to other crops and grows well under harsh environmental conditions (high wind, heavy rain, and cold temperature), despite the fact that Uyo, Akwa Ibom State, is located in Nigeria's humid rainforest zone, which experiences seasonal heavy rain. In most crops, yield and other yield traits are reported to be highly influential parameters for crop improvement (Khan *et al.*, 2020). Grain yields per hectare ranged from 115.34 kg/ha to 1446.67 kg/ha. Light, temperature, water, moisture, rainfall, soil texture, and nutrition are all environmental factors that affect plant growth (Mabhaudhi and Modi, 2013). Berchie *et al.* (2010) reported pod and seed yields of 4173.05 and 3084.43 kg/ha, respectively, in Ghana. Researchers have found significant variation in grain yield and other traits among landraces (Alake *et al.*, 2015). This suggests that Bambara groundnut grown in Uyo, Akwa Ibom State, can produce high yields. There was a significant difference in hundred seed weight among the accessions in this study. In this study, the 100-seed weight ranged from 66.67 to 86.00 g. According to Akpalu *et al.* (2012), these findings demonstrate the significance of seed quality in determining seed yield. Seed size can be used to predict seed vigour, which is a component of seed quality (Mandizvo and Odindo, 2019). In the evaluation of morphological traits, hundred seed weight has been cited as an important yield enhancing trait (Unigwe *et al.* 2016). It is an important yield measure and an appropriate indicator for observing the tradition of quantitative traits influenced by genotype and environment (Rogé *et al.*, 2016). Interestingly, phenotypic variation among genotypes was significant in the study, indicating that accessions had high genetic diversity for the traits of interest.

Nutritional qualities of Bambara groundnut accessions

The results presented in Table 3 show the proximate analysis of Bambara groundnut accessions. Table 3 shows that the proximate composition of the eight Bambara groundnut accessions tested differed significantly ($P \leq 0.05$). Table 3 shows that there was a significant difference ($P \leq 0.05$) in the moisture content of the Bambara groundnut accessions. Regal green 27 had the highest moisture content (7.91%), closely followed by Caly SK 46 (7.80%) and Caly SK 144 (7.58%). BNT recorded the lowest moisture content (6.39%). Furthermore, there was a significant difference ($P \leq 0.05$) in the crude fat content of the Bambara groundnut accessions. SDR 21 had the highest crude fat content (6.60%), followed by Caly SK 144 (6.48%), and Regal green (6.38%). Caly SK 46 had the lowest crude fat content (5.80%). The crude fibre of the Bambara groundnut accessions differed significantly ($P \leq 0.05$). SDR 21 had the highest crude fibre content (5.59%), followed by BNT 89 (5.48%) and Caly PSC (5.42%). Caly SK 46 had the lowest crude fibre content (4.60%). The total ash of the Bambara groundnut accessions differed significantly ($P \leq 0.05$). BNT 89 had the highest ash content (3.92%), followed by Caly 4 (3.88%) and Caly PSC (3.82%). SDR 21 had the lowest total ash content (3.51%). The protein content of the Bambara groundnut accessions differed significantly ($P \leq 0.05$). Caly PSC had the highest protein content (20.39%), followed by SDR 21 (20.21%) and BNT 29 (19.87%). Caly SK 46 had the lowest protein content (18.29%). The available carbohydrate of the Bambara groundnut accessions differed significantly (P0.05). Caly SK 46 had the highest available carbohydrate content (60.24%), followed by Zeina 22 (59.62%) and Caly 4 (59.49%). Caly PSC 6 had the least available carbohydrate (56.81%). The current study examined into the variations in the proximate analysis of Bambara groundnut seed during the rainy season. The nutritive value of the eight Bambara groundnut accessions differed significantly. These findings were similar to those reported by Abdalla Saleem *et al.* (2012) when investigating the nutritive value of three Grewia species' leaves and fruits. The proximate and mineral results clearly show the potential of Bambara groundnut as a source of scarce nutrients such as protein. Under proper management, location, and planting season, Bambara groundnut protein content can reach 24. 02%, which compares favourably with that reported for more conventional legumes such as faba beans (Musallam *et al.*, 2004), but is higher than the records of Nworgu (2004) which was 18.3%, Aletor and Omodara (1994) which was 10.4%. The protein content of the Bambara groundnut seed investigated in this study ranged from 18% to 20%, which was higher than the 7% minimum crude protein level required for optimum rumen function (Van Soest, 1994; Fasakin, 2004). The current study's high ash content could be attributed to high concentrations of minerals that are precursors to proximate formation. The ash content in this study was less than 8%, as reported by Gohl (1981), who concluded that ash content greater than 8% indicates fat contamination. Abdalla Saleem (2012) added that high ash contents are also indicative of low organic matter. The moisture content of the eight Bambara groundnut accessions studied in this study was less than 8%, which is considered low. Bambara nut seeds are known for their low moisture content, which indicates that they have good storage qualities. The storage value is reduced when there is a high moisture content. Okonkwo and Opara (2010) obtained a similar result for the same plant.

Table 4. Correlations Pearson correlation coefficients (r) between the growth and yield traits of eight accessions of Bambara nut.

	PH	LN	PL	LA	NPPP	WDP	SW	WHS	DM	M	Fat	Fibre	Ash	Protein	CHO
PH															
LN	-0.228														
PL	-0.063	0.036													
LA	0.421*	-0.111	0.041												
NPPP	0.030	0.007	-0.255	0.243											
WDP	0.201	0.158	0.184	0.101	0.183										
SW	-0.052	0.118	0.175	0.095	0.178	0.383									
WHS	0.526**	-0.250	-0.158	0.184	0.163	0.169	-0.135								
DM	-0.032	-0.216	-0.073	-0.174	-0.219	-0.043	-0.332	-0.377							
M	-0.069	-0.220	0.204	-0.204	-0.258	0.316	-0.011	0.012	0.343						
Fat	0.126	-0.242	-0.449*	-0.054	-0.208	-0.126	-0.310	0.264	0.290	0.131					
Fibre	0.056	-0.166	-0.491*	0.037	-0.193	-0.189	-0.307	0.294	0.264	0.012	0.942**				
Ash	-0.106	0.070	-0.148	0.113	0.047	-0.211	0.149	0.193	-0.407*	-0.641**	-0.154	0.043			
Protein	0.185	-0.163	-0.413*	0.249	0.160	-0.426*	-0.224	0.134	0.141	-0.574**	0.453*	0.575**	0.418*		
CHO	-0.096	0.273	0.474*	-0.096	0.077	0.264	0.310	-0.283	-0.308	-0.009	-0.873**	-0.925**	-0.107	-0.730**	

"PH - Plant height, Ln - Leaf number, PL - Petiole length, LA - Leaf area, NPPP - Number of pods per plant, WDP - Weight of dried pods, SW - Seed weight, WHS - Weight of 100 seed weight, DM - Dry matter, M – Moisture, CHO - Carbohydrate".

Pearson correlation coefficients (r) between the growth and yield traits of twelve accessions of Bambara groundnut

Table 4 displays the Pearson correlation coefficients (r) between the evaluated agronomic traits and nutritional qualities of the Bambara groundnut accessions. The correlation coefficient of the Bambara groundnuts accessions studied showed both positive and negative associations with yield and yield-related traits (Table 4). Plant height had a positive but significant association (r = -0.421*) with leaf area. Plant height recorded a positive and highly significant correlation (r = 0.526**) with weight of hundred seeds. Number of pods per plant recorded a positive association (r = 0.178) with seed weight. Weight of dried pods recorded a negative and significant relationship (r = -0.426*) with protein content. Weight of hundred seeds had a positive correlation (r = -0.135) with seed weight. Fibre had a positive and highly significant association with fat content (r = 0.942**). Protein had a negative but highly significant relationship (r = -0.574**) with moisture. Also, protein recorded a positive and significant (r = 0.453*) relationship with fat as well as a positive and highly significant relationship (r = 0.575**) with fibre. Carbohydrate had a negative but highly significant correlation (r = -0.730**) with protein. The specific coefficient, according to Silva *et al.* (2016), is a correlation estimate for the purpose of selection for direct and indirect breeding because it indicates how closely two or more traits are genetically and non-genetically related. In this study, plant height and petiole length were negatively correlated, while leaf area and number of pods per plot, number of seeds per pod and fibre content, leaf area and seed weight, plant height and seed weight were positively correlated. The positive correlations among and between the various traits indicate that selecting for any of these traits in a Bambara groundnut improvement programme will have a positive influence on selecting for related traits (Unigwe *et al.*, 2016). It is critical for breeding programmes to develop vegetative growth and yield collections (Gao *et al.*, 2020). Selecting for these traits may be useful in breeding Bambara groundnut for future production (Alake and Ayo-Vaughan, 2017).

Principal component analysis for agronomic traits and nutritional qualities of Bambara groundnut accessions

Results presented in Table 5 shows the principal component analysis of agro-morphological traits and nutritional qualities of the Bambara groundnut in this study. The first five principal components (PCs) with Eigen values greater than 1.0 jointly accounted for 74.37% of the total variation in the accessions (Table 5). The traits of importance for the first component involved agronomic traits and nutritional qualities of agronomic interest. Principal component one (PC1), with eigen value of 4.17, contributed 27.81% of the total variability. PC2, with eigen value of 2.62, accounted for 17.52% of total variability. PC3, with eigen value of 2.00, accounted for 13.34%, PC4, with eigen value of 1.23, accounted for 8.20%, while PC5, with eigen value of 1.12, accounted for 7.47% of total variability observed among the eight Bambara groundnut accessions. In PC1, the traits that accounted for most of the 27.81% observed variability among the eight accessions of Bambara groundnut included fat (0.86), fibre (0.91) and protein (0.77). In PC2, the traits that accounted for most of the 17.52% observed variability among the eight accessions of Bambara groundnut included ash (0.73). In PC3, the traits that accounted for most of the 13.34% observed variability among the eight accessions of Bambara groundnut included plant height (0.71) and weight of dried pods (0.65). In PC5, the traits that accounted for most of the 7.47% observed variability among the eight accessions of Bambara groundnut included number of pods per plant (0.60). Shegro *et al.* (2013) demonstrated the merits of principal component analysis (PCA) in predicting trait relationships in Bambara groundnut accessions. Ntundu *et al.* (2006) found a strong association between landraces as well. A plant with this strong relationship grows and produces a high yield (Chijioke *et al.*, 2010). In general, the PC analysis of the 15 traits revealed that PC1 was made up of a number of traits that contributed the most variation, followed by PC3. Ntundu *et al.* (2006) reported that leaf morphology, seed size, and colour were morphological criteria used by Tanzanian farmers during selection. PC1 and PC3 made significant contributions to trait association in this study and were responsible for high Eigen values.

Table 5. Principal component analysis for agronomic traits and nutritional qualities of Bambara groundnut accessions.

	Principal Components				
	1	2	3	4	5
Plant height	0.208	0.199	0.714	-0.333	0.018
Leaf Number	-0.329	0.163	-0.332	0.466	-0.049
Petiole length	-0.592	-0.176	0.088	-0.396	-0.238
Leaf area	0.104	0.441	0.449	-0.298	0.306
Number of pods per plant	-0.075	0.486	0.212	0.271	0.608
Weight of dried pods	-0.374	-0.095	0.610	0.465	0.087
Seed weight	-0.452	0.268	0.158	0.403	0.048
Weight of 100 seed weight	0.338	0.302	0.653	0.040	-0.436
Dry matter	0.293	-0.662	-0.139	-0.179	0.462
Moisture	-0.148	-0.807	0.371	0.118	-0.077
Fat	0.863	-0.297	0.112	0.244	-0.110
Fibre	0.913	-0.151	0.020	0.249	-0.126
Ash	0.137	0.738	-0.307	0.002	-0.325
Protein	0.771	0.423	-0.196	-0.140	0.215
Carbohydrate	-0.947	0.080	-0.019	-0.129	0.003
Total	4.173	2.629	2.002	1.231	1.122
% of Variance	27.819	17.526	13.344	8.208	7.479
Cumulative %	27.819	45.345	58.690	66.897	74.377

Conclusion

Findings from this study indicate that Bambara groundnut is adaptable to the Uyo environment in Akwa Ibom State. The agronomic characteristics of the accessions in this study varied significantly. Caly PSC (2853 kg/ha), Caly SK 46 (2803 kg/ha), Zeina (2538 kg/ha), and BNT (2488 kg/ha) were the top yielders among the accessions evaluated. These accessions may be suitable for population development as well as for Bambara groundnut production in Uyo, Akwa Ibom State. The genetic potential of the accessions in this study can aid in the selection of desirable parental lines and increase the efficacy of Bambara groundnut breeding programmes. This study revealed that Bambara groundnut grown in Uyo, Akwa Ibom State, and a good source of nutrients. It is recommended that the experiments be repeated in more locations and seasons with more Bambara groundnut accessions of superior traits for high production.

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