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COLLECTION AND PHENOTYPIC CHARACTERIZATION OF SOME NIGERIAN BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA*) GERMPLASM USING SEED MORPHOLOGY

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Abstract: Bambara groundnut is an indigenous African legume with great potential to tackle food insecurity in Nigeria. A germplasm collection mission was carried out in collaboration with the Agricultural Developments Project (ADP) Extension officers of Nigeria between October and December 2014. Bambara groundnut seeds were collected from farmers in Kaduna, Niger, Kogi, Benue, Plateau, Adamawa, Nasarawa, Jigawa, Enugu and Federal Capital Territoy (FCT) Abuja. Some seeds were also collected from National Centre for Genetic Resources and Biotechnology (NACGRAB). A total of 45 original seed lots were collected which comprised of mixed seeds (different seed coat colours) and pure seeded accessions (comprising of one seed coat colour). A total of 24 distinct seed morphotypes were identified from the collections. The highest number of accessions were collected from NACGRAB (11) followed by Niger State (10) and the lowest from Benue, Jigawa and Adamawa States (2). Niger State also had the highest number of mixed seeds. The different seed phenotypes observed in the study are important for field production of true to type lines and can be exploited for the genetic improvement of bambara groundnut.

Keywords: Bambara groundnut, characterization, collection, germplasm, phenotypic.

Introduction

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is a herbaceous plant with substerranean fruit-set cultivated by smallholder farmers in semi-arid region of Africa [AZAM-ALI & al. 2001]. It is an indigenous African leguminous crop belonging to the family Fabaceae and sub-family Faboideae [ABEJIDE & al. 2020]. It has different names by different language groups in Nigeria. In Hausa language bambara groundnut is called “Gurjiya” or “Kwaruru”. In Goemai language of Plateau State it is known as “Kwam”, and Kanuri people refer to it as “Ngamgala”. In Igbo language, it is commonly known as “Okpa” while the Yoruba’s call it “Epa-roro”or “Epa-kuta”. Although the name “bambara groundnut” was derived from the Bambara tribe which presently lives in Mali where the crop is also believed to have originated from [NWANNA & al. 2005].

Bambara groundnut is a high protein crop that is largely cultivated for its seeds used as human food. Chemical analyses showed that the seed contains 32.50-32.72% of total essential amino acids including lysine, histidine, arginine, leucine and isoleucine and 66.10-70.80% of the non-essential amino acids such as methionine, glycine, cysteine, tyrosine and proline [AMARTEIFIO & al. 2006]. It also contains 63% carbohydrate, 19% protein, 6.5% oil and minerals like calcium (95.5-99 mg/100 mg), iron (5.1-9 mg/100 mg), potassium (11447-14355

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mg/100 mg) and sodium (2.9-10.6 mg/100 mg) as reported by MAYES & al. (2012).

Bambara groundnut is a potential crop in contributing to world food security and reducing malnutrition [MSHELIA & al. 2004; OUEDRAOGO & al. 2008]. The seeds can be eaten fresh when boiled and can also be processed by milling to make flour; a paste is then made from the flour and then used in the preparation of various fried or steamed products like "akara" and "moin-moin" [OKPUZOR & al. 2010]. Another much loved Nigerian delicacy made from bambara groundnut is 'Okpa', which is produced by wrapping the doughy paste in banana leaves or polythene and then boiled. The seeds can also be used to produce vegetable milk that is comparable with soy milk. Following a protein functionality test on the ground seeds, BROUGH & al. (1993) indicated that bambara groundnut can compete with or replace other conventional flours in a range of processed products. Bambara groundnut seeds can be used as animal feed and the leafy shoots are also used as fodder [BRINK & al. 2006].

The demand for bambara groundnut is increasing due to its many uses, its high nutritional value and medicinal value as it is believed to be suitable for consumption by diabetic and hypertensive patients. The crop also serves as a major diet for poor subsistence farmers who cannot afford expensive animal protein. In Nigeria, despite the nutritional value, uses and agronomic advantages of bambara groundnut, it is still one of the less cultivated and underutilized legumes. This has been attributed to lack of improved varieties [MAYES & al. 2011]. The crop has received little attention by Scientists [HILLOCKS & al. 2012]. It is cultivated from local land races as there are no true varieties of the species bred for specific traits in Nigeria [ANCHIRINAH & al. 2001]

The increasing world population requires that efforts be made towards increasing food production. Bambara groundnut is a potential crop that can be used to tackle food insecurity and malnutrition in Nigeria. Being a highly nutritious crop, bambara groudnut is relevant to food security. Bambara groundnut also plays an important role in income generation for resource poor farmers in Nigeria as demand for the crop is on the increase due to increasing awareness of its nutritional value. It fetches a high market price and there is therefore a great need to increase its productivity.

Bambara groundnut germplasm is abundant in Sub-Saharan Africa, as the crop is grown in every tropical region of the continent. So far, wild relatives of cultivated bambara groundnut have only been found in North Eastern Nigeria and Northern Cameroon. It is believed that the crop originated from this part of the continent. Electrophoretic studies conducted by HOWELL & al. (1994) did not reveal a significant difference between the cultivated genotypes and the supposedly wild forms, and it was concluded that the wild plant might simply be an escape from the cultivated ecotype. The major germplasm collection held by IITA has been characterized and evaluated. A few other countries such as Zambia, Burkina Faso, Ghana have also characterized their germplasm.

The collections of bambara groundnut available in most national programs may not reflect all the diversity existing in the respective countries. The crop germplasm is often collected in an opportunistic manner. Plant collectors use a collecting mission for a major crop to include sampling of bambara groundnut. For example, scientists at IITA have usually collected bambara groundnut samples during collecting missions for cowpea or rice. Collecting missions primarily devoted to bambara groundnut need to be organized in many countries producing the crop in order to save those ecotypes that are in the process of extinction. It is based on this that Bambara groundnut germplasm were collected from major growing areas in Nigeria and characterized based on their seed morphology.

Materials and methods

Collection of bambara groundnut germplasm

A germplasm collection was carried out in collaboration with the Agricultural Development Projects' (ADP) Extension Officers of Nigeria between October and December 2014. The major bambara groundnut producing States in Nigeria such as Kaduna, Niger, Kogi, Benue, Plateau, Adamawa, Nassarawa, Jigawa, Enugu and Federal Capital Territory (FCT) Abuja were visited in order to collect the germplasm. Some germplasm was also collected from National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan. The seeds were collected packed and sealed in thick paper envelopes each of which was given an entry number, information regarding the locality and local name were also recorded.

Characterization of bambara groundnut germplasm using seed morphology

The seeds collected from farmers and NACGRAB were characterized based on their seed coat colour and pattern and also eye colour and pattern according to the descriptor list of *Vigna subterranea* produced by the International Plant Genetic Resource Institute (IPGRI, 2000). Each original seed lot collected comprising of mixed seeds were sorted out into their distinct seed morpho-types. Royal Horticultural chart was used to identify the colours.

Results

A total of 45 original seed lots were collected during the survey comprising of 34 seed lots collected from farmers and 11 from National Centre for Genetic Resources and Biotechnology (NACGRAB) Ibadan (Table 1). The highest number of accessions were collected from NACGRAB (11) followed by Niger State (10). The least number of accessions were collected from Benue, Jigawa and Adamawa States (2). It was observed that farmers possessed both pure seeds (with same seed coat colour pattern and eye colour pattern) and mixed seeds (comprising of a variety of seed coat colour pattern and eye colour pattern). Out of the original seedlots collected during the survey, Niger State had the highest number of mixed seeds (4) and the least was observed in Nassarawa State (0) with all the accessions having pure seeds and no mixed seeds. NACGRAB had the highest number of original seed lots comprising of pure seeds (9) and the least was observed in Benue, Jigawa and Adamawa States having one accession that is pure seeded (Table 1).

Table 1. Number of bambara groundnut accessions collected during the survey

Geopolitical zone	State	Number of accessions	Number of pure seeds	Number of mixed seeds
North-Central	Kogi	3	2	1
	Benue	2	1	1
	Plateau	3	2	1
	Niger	10	6	4
	Nassarawa	2	2	0
	FCT	3	2	1
North-West	Kaduna	3	2	1
	Jigawa	2	1	1
North-East	Adamawa	2	1	1
South-East	Enugu	4	2	2
NACGRAB	NACGRAB	11	9	2
Total		45	30	15

The 45 bambara groundnut accessions collected during the survey were made up of 24 distinct seed morphotypes (Figure 2) with varying seed coat colours and eye colours. A total of 21 descriptors were used to describe their seed coat colours. They are cream (B, C, M), cream purplish spots (D), cream brown spots/stripe (R), cream black stripe (S), cream dark brown patches (U), cream light grey spots (T), cream black patches (K), black (A), red (N), light red (I), dark red (E, F), brownish red (Q), brown speckled with black (H), red speckled with black (G), brown (J), brown with brown pattern below hilum (L), brown with black pattern below hilum (O), cream black (P), grey brown (V), grey black (W), variegated red (X) (Figure 2).

Figure 1. Mixed and pure seeds of bambara groundnut accessions.
A, B, C: samples of mixed seeds of bambara groundnut accessions collected during the survey
D, E, F: samples of pure seeds of bambara groundnut accessions collected during the survey

Figure 2. Variations in bambara groundnut seed coat colour collected during the survey.
A – black; B, C, M – cream; D – cream purplish spots; E, F – dark red; G – red speckled with black; H – brown speckled with black; I – light red; J – brown; K – cream black patches; L – brown with brown pattern below hilum; N – red; O – brown with black pattern below hilum; P – cream/black; Q – brownish red; R – cream brown spots/stripes; S – cream purplish stripes; T – brown with grey spots; U – cream with brown patches; V – grey brown; W – variegated red; X – grey black

Table 2. Characteristics of bambara groundnut accessions (original seed lots) collected from peasant holders in Nigeria

S/N	Accession number	Local government	State	Seed type	Local name	Diversity score
1.	NG-KG-O1	Dekina	Kogi	Brownish red	Okpakpikpa	1.0
2.	NG-KG-02	Ankpa	Kogi	Mixed	Jatoaka	3.0
3.	NG-KG-03	Ofu	Kogi	Cream	Okpafufu	1.0
4.	NG-EN-O4	Igbo-Etiti	Enugu	Brownish red	Aki naukwaa	1.0
5.	NG-EN-05	Igbo-Etiti	Enugu	Mixed	Eyo	3.0
6.	NG-EN-06	Igbo-Etiti	Enugu	Mixed	Oddy	4.0
7.	NG- EN-07	Igbo-Etiti	Enugu	Cream	Caro	1.0
8.	NG-KD-08	Zaria	Kaduna	Mixed	Kwaruru/ gurjiya	7.0
9.	NG-KD-09	Jemaá	Kaduna	Cream	Kwaruru	1.0
10.	NG-KD-10	Sanga	Kaduna	Cream purplish spots	Kwaruru	1.0
11.	NGR-PL-11	Jos	Plateau	Mixed	Kwam	2.0
12.	NGR-PL-12	Jos	Plateau	Brownish red	Kwam	1.0
13.	NGR-PL-13	Jos	Plateau	Cream purplish spots	Kwam	1.0
14.	NGR-BN-16	Ogbadibo	Benue	Mixed	Karo	2.0
15.	NGR-NS-14	Laffia	Nassarawa	Cream	Ikpeyi	1.0
16.	NGR-NS-15	Obi	Nassarawa	Cream black stripes	Kirikiri	1.0
17.	NGR-JG-17	Kazaure	Jigawa	Mixed	Kwaruru	3.0
18.	NG-NI-18	Chanchaga	Niger	Black	Kwaruru	1.0
19.	NG-NI-19	Chanchaga	Niger	Ceam	Kwaruru	1.0
20.	NG-NI-20	Bida	Niger	Mixed	Edzu	11.0
21.	NG-NI-21	Katcha	Niger	Cream	Edzubokun	1.0
22.	NG-NI-22	Kotangora	Niger	Variegated cream black	Yarkasa	1.0
23.	NG-NI-23	Kotangora	Niger	Mixed	Kwaruru	3.0
24.	NG-NI-24	Kotangora	Niger	Mixed	Kwaruru	1.0
25.	NG-NI-25	Shiroro	Niger	Mixed	Kwaruru	5.0
26.	NG-NI-26	Shiroro	Niger	Cream	Yarkasa	1.0
27.	NG-NI-27	Shiroro	Niger	Cream purplish spots	Kwaruru	1.0
28.	NGR-AD-28	Yola	Adamawa	Mixed	Kwaruru	2.0
29.	NGR-AB-29	Zuba	FCT	Cream purplish stripes	Kwaruru	1.0
30.	NGR-AB-30	Dakwa	FCT	Cream purplish spots	Kwaruru	1.0
31.	NGR-AB- 31	Yaba	FCT	Mixed	Kwaruru	2.0
32.	NGR- BN-32	Kwande	Benue	Cream	Sisi	1.0
33.	NGR-JG-33	Hadejia	Jigawa	Cream	Gurjiya	1.0
34.	NGR-AD-34	Yola	Adamawa	Cream	Kwaruru	1.0
35.	NGB-01486	-	NACGRAB	Cream	-	1.0
36.	NGB-01493	-	NACGRAB	Cream	-	1.0
37.	NGB-01492	-	NACGRAB	Cream	-	1.0
38.	NGB-01496	-	NACGRAB	Cream purplish spots	-	1.0
39.	NGB-01489	-	NACGRAB	Cream	-	1.0
40.	NGB-01491	-	NACGRAB	Cream	-	1.0
41.	NGB-01311	-	NACGRAB	Cream	-	1.0
42.	NGB-01646	-	NACGRAB	Mixed	-	3.0
43.	NGB-01645	-	NACGRAB	Mixed	-	2.0
44.	NGB-01488	-	NACGRAB	Cream	-	1.0
45.	NGB-01487	-	NACGRAB	Cream	-	1.0

Discussion

The seeds collected from farmers during the survey revealed that farmers possess and grow both pure and heterogeneous mixtures of seeds that hold distinctive and divergent genetic attributes (Table 1). ALHASSAN & EGBE (2013) in a participatory rural appraisal of bambara groundnut in Kogi and Benue States observed that farmers possess both pure and mixed seeds. MOHAMMED & al. (2013) also reported the same in Kano State that bambara groundnut landraces exist as heterogeneous mixtures of seeds of few to several morphotypes that embraces a wide genetic potential. Farmers grow mixtures of different seed types probably because of the absence of improved varieties which has resulted into variable yields between years and localities [ABU & BUAH, 2011].

The highest number of pure seeded accessions was observed in NACGRAB (9), this could be because, being a National Centre for Genetic Resources, some level of sorting of the accessions must have been carried out. Accessions, which have cream seed coat colour, are most homogeneous due to market demand. This is because at the time of harvesting, farmers avoid mixture on Bambara groundnut seeds which possess creamy seed coat colour.

The bambara groundnut seed collections (45 seedlots) collected from farmers in Nigeria and NACGRAB phenotyped using visual techniques to describe seed morphology revealed that bambara groundnut possesses distinguishable morphological identities that can be exploited through breeding. The 24 distinct seed morphotypes (Table 2) distinguished are important for field production of true to type lines that can be used for further genetic improvement of the crop. Variations in seed feature have been previously reported by other authors such as MASSAWE & al. (2005) and ABU & BUAH (2011). ABU & BUAH (2011) reported that seeds of bambara groundnut landraces possess identifiable morphological features such as seed testa colour, seed shape, eye and hilum colour and pattern. While PADULOSI & al. (2002) reported that variations in seed coat colour and eye colour and patterns displayed by the landraces are useful to differentiate among bambara groundnut genotypes.

Conclusion

It can be concluded from the study that bambara groundnut germplasm in Nigeria embraces a wide genetic pool with distinct seed morphological identities that can be exploited and used in crop improvement. The different seed phenotypes observed in the study are also important for field production of true to type lines that can be used for further genetic improvement of bambara groundnut.

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