



Cultivation and Utilization of Bambara Groundnut (*Vigna subterranea* (L.) Verdc.), a Neglected Plant in Cameroon

**Nono Carine Temegne^{1*}, Jules Patrice Ngoh Dooh², Pierre Nbandah¹,
Godswill Ntsomboh-Ntsefong¹, Victor Desiré Taffouo³
and Emmanuel Youmbi^{1,4}**

¹Department of Plant Biology, Faculty of Science, University of Yaounde I, P.O.Box 812 Yaounde, Cameroon.

²Department of Biology, Faculty of Science, University of Maroua, P.O.Box 814 Maroua, Cameroon.

³Department of Plant Biology, Faculty of Science, University of Douala, P.O.Box 24157, Douala, Cameroon.

⁴Tissue Culture Laboratory, African Centre for Research on Banana and Plantain (CARBAP), Njombe, P.O.Box 832, Douala, Cameroon.

Authors' contributions

This work was carried out in collaboration among all authors. Author NCT wrote the protocol, performed the data collection, managed the literature searches, performed the statistical analysis and wrote the first draft of the manuscript. Author JPND performed the data collection. Author PN performed the statistical analysis and corrected the draft of the manuscript. Authors GNN, VDT and EY corrected the draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

In order to improve the production and commercialization of Bambara groundnut (*Vigna subterranea* (L.) Verdc.) in Cameroon, an inventory on the use of available resources and peasant agronomic practices is a necessary prerequisite. Their understanding can help to establish efficient strategies to enhance this neglected crop. The objective of this work was therefore to identify the uses and the peasant knowledge on the Bambara groundnut in Cameroon. To this effect, a survey on the use of

*Corresponding author: E-mail: nonocarine2003@gmail.com, nonocarine2003@yahoo.fr;

Bambara groundnut was carried out through interviews and direct discussions with farmers in the main production areas (Far North, Adamawa, Littoral (Coastal), Centre, North-West and West) of Cameroon. The survey revealed that in Cameroon, Bambara groundnut is mainly grown by women (74%). Monoculture (60%) is the most widely used cropping system; 40% of farmers associate it with other crops such as groundnuts, maize, sesame, okra, millet, sorghum, beans, *egusi* or pumpkin, and tubers. It is produced mainly on small land areas by the elderly. It is mainly cultivated by the poor peasants and without soil amendments. Several landraces are cultivated, the preferred varieties varying according to the production basins. Seed storage is mainly done with chemicals in closed containers. Weeds, lack of improved varieties, low yields, diseases and pests (insects, rodents) are the main production constraints identified. Results of this study could be exploited for the improvement and vulgarization of Bambara groundnut in Cameroon.

Keywords: *Bambara pea; constraints; cropping system; cultivation practices; landraces; seed characteristics; seed conservation; uses.*

1. INTRODUCTION

The name Bambara comes from a tribe of Mali, but the center of origin of the Bambara groundnut (*Vigna subterranea* (L) Verdc.) is in the northeastern zone of Nigeria and northern Cameroon [1]. Bambara groundnut is a legume that adapts easily to different environmental constraints [2-8]. One of its main attributes is its tolerance to poor soils and drought and the ability to produce under conditions where groundnuts fail completely [9]. The highly nutritious content of Bambara groundnut and its high content of essential amino acids (methionine, leucine, isoleucine, lysine, phenylalanine, threonine, valine, and tryptophan) make it an important crop to consider for food safety [10,11]. Despite these properties, it remains a neglected plant in Africa. According to its biochemical composition [12] and its medicinal properties [9,11,13], it can play a role in reducing malnutrition, which is the cause of 45% under-five deaths in developing countries according to World Food Programme [14]. The popularization, improvement and exploitation of this neglected plant require knowledge of the practices of the local populations that cultivate it. The objective of this work is to identify the uses, knowledge and local practices on the cultivation of Bambara groundnut in Cameroon.

2. METHODOLOGY

2.1 Study Sites

The survey on the use and cultivation of Bambara groundnut in Cameroon was carried out between 2015 and 2016 in selected localities of seven Regions (Far North, North, North-West, Littoral, Central, West and Adamawa) covering the five Agro-ecological Zones (Fig. 1, Table 1). With the exception of the Adamawa Region,

according to statistics from the Ministry of Agriculture, these regions are the main production areas [15].

The Far North and North Regions located in the Sudano-Sahelian Agro-ecological Zone, are characterized by monomodal rainfall pattern of varying duration and intensity (from 400 to 1,200 mm.year⁻¹). Temperatures vary with averages of up to 28°C at Garoua, while maxima are in the range of 40 to 45°C in April. There are lithomorphic vertisols, vertic soils, ferruginous soils and halomorphic soils [16].

The Adamawa Region, located in the High Guinean Savannah Agro-ecological Zone, consists mainly of a vast plateau of altitudes between 900 and 1,500 m, with peaks reaching 1,800 m. The climate is Sudanian, tropical humid with two seasons per year. The average annual rainfall is around 1,500 mm, with about 150 days of rainfall. Due to the altitude, temperatures are moderate, with monthly averages in the range of 20 to 26°C [16].

The West and North-West Regions, located in the Western Highlands Agro-ecological Zone, have an "altitude Cameroonian" climate marked by two seasons of uneven lengths, low average temperatures (19°C average) and heavy rainfall (1,500-2,000 mm). The soils are very fertile. Several types of soil are encountered: Inceptisols on steep slopes, leached soils (oxisols) in old plateaus, soils with an illuviation B horizon (alfisols and ultisols) in closed depressions, and plateaus enriched with volcanic material (ash) [16].

The Littoral/Coastal Region is located in the Humid Forest Agro-ecological Zone with monomodal rainfall pattern. It is marked by a

very humid and hot "Cameroonian" climate, a variant of the equatorial climate. Rainfall is heavy, averaging 2,500 to 4,000 mm. The temperature varies between 22 and 29°C and the humidity between 85 and 90%, which explains the heavy nature of the atmosphere. It is characterized by volcanic soil (andosol) [16].

The Centre Region is located in the Humid Forest Agro-ecological Zone with bimodal rainfall

pattern. The average daily air temperature ranges from 23 to 24°C. It is characterized by rainfall of 1,617 mm per year. This region is also characterized by lateritic soils (Ferralsols), usually acids. The area is marked by a Guinea equatorial climate type with four seasons: a long rainy season from September to November, a long dry season from December to February, a short rainy season from March to June and a short dry season from July to August [16].

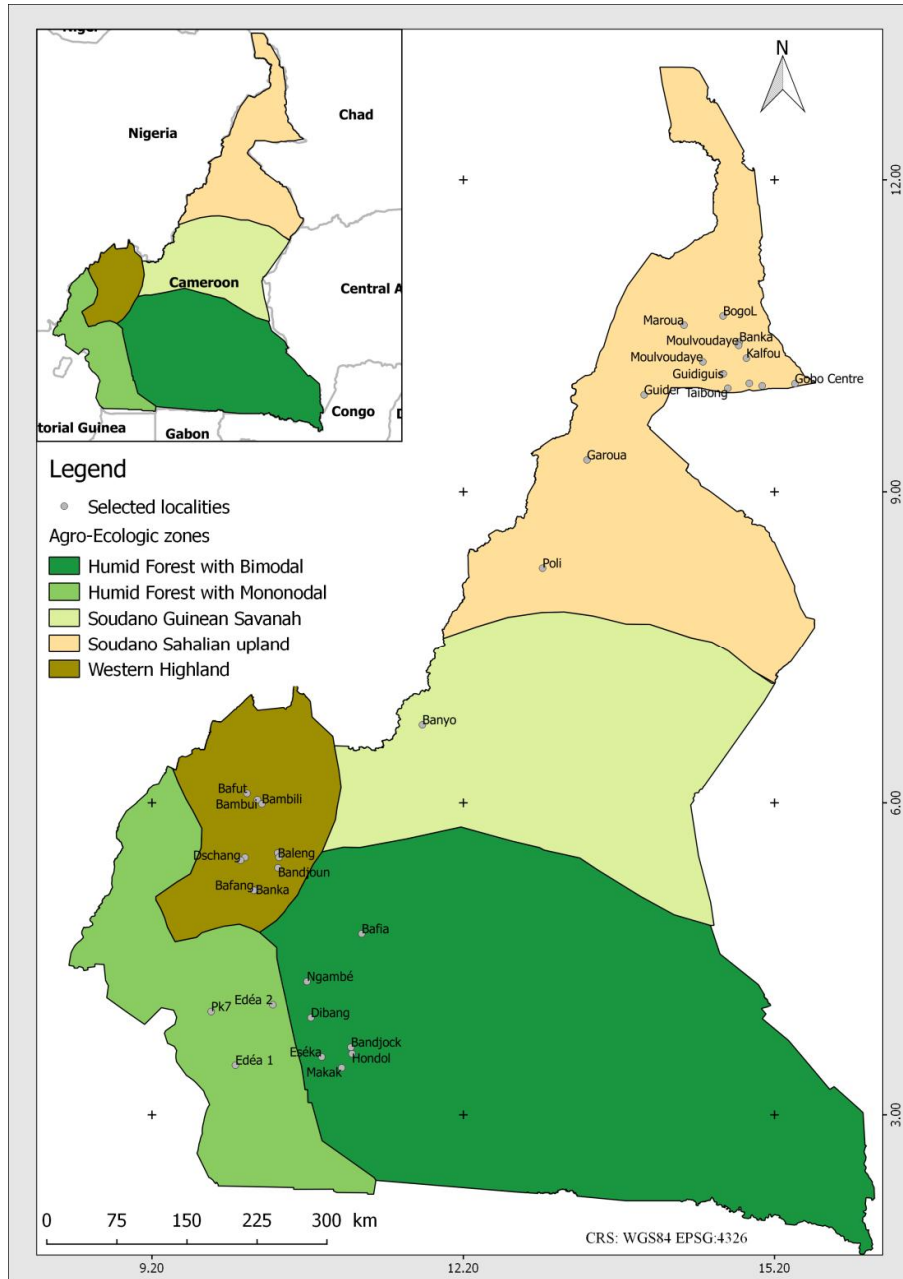


Fig. 1. Study areas

Table 1. Localities surveyed and Bambara groundnut local names

Regions	Number of farmers	Localities surveyed	Local names
Far North	54	Datcheka, Gobo, Kalfou, Kar-Hay, Maroua, Tchatibali Guidiguiss, Moulvoudaye, Porhi, Taibong	Ngalaa-ji (Fulfudé), Mogran (Toupouri), Souonchié (Moundang)
North	10	Garoua, Poli, Guider	Ngalaa-ji
Adamawa	18	Banyo	Ngalaa-ji, Debbi (Foulbé), Deppi, Jwə/Djué/matobɔ (Ghomala), Moto/Moto/Matoba (Fe'efe'e)
Centre	26	Eséka, Boga, Dikonop I, Sombo, Maboye, NyaTchio, NgodiLom, Mahole, Peslipan, Bafia	Atob/Metop (Ewondo), matobo (Bafia), Kezo Ke Zon (Nugunu)
Coastal	16	Hondol, Kanga, Pahè, Nong, Mabel, Sasa, Ngambé, Manga'a, Edea, Ndokok, Olamze Sud, Pk14	Matob (Douala), Matop/Wondenkana (Bassa'a)
North-West	22	Bafut, Azire, Nkewn, Atukum, Alabukam Mankon, Bambui, Bambili, Ntutunu Mankon	ndzu/Ndən (Mankon)
West	32	Bafang, Bafoussam I, II and III, Dschang, Banka, Bandjoun	Moto/Moto/Matoba (Fe'efe'e), Jwə/Djué/matobɔ (Ghomala)

2.2 Sampling and Data Collection

A survey was carried out involving the use of questionnaires and interviews. The data collection was done through direct interviews with farmers randomly selected in the main production areas. The proportion of Bambara groundnut farmers by gender (male or female) was determined during this study. The cultivation mode, technical itinerary, the most appreciated varieties, seed conservation methods and seed selection were recorded from the surveyed farmers. Besides, data were collected on socio-demographic characteristics (age, education, marital status, household size, planted area, etc.) of farmers. They were also gathered on Bambara groundnut production, consumption and marketing, use (dishes, animal husbandry, medicinal uses, etc.), production constraints and cultural management by farmers. A total of one hundred and seventy eight (178) Bambara groundnut farmers were surveyed.

2.3 Data Analysis

Data analysis was carried out by descriptive statistics using IBM SPSS Statistics 20 [17] and Microsoft Excel 2010 software programs. A data input spreadsheet was previously prepared. Then, an input code was assigned to each data. Data processed in SPSS were transferred to the Excel program for the production of diagrams and figures.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic Characteristics

Survey results show that Bambara groundnuts are mainly cultivated by women (74% vs 26% men) (Fig. 2A) and the elderly (Fig. 2B). This result corroborates those of different authors in Niger [18], Côte d'Ivoire [19], Ghana [20], Malawi [21] and Benin [22] who found that women are more interested in growing Bambara groundnut than men. This result may be explained by the fact that men in the northern part of the country are more interested in cotton cultivation for Sodecoton (Cotton Development Corporation) than in the cultivation of Bambara groundnut. In addition, IRAD points out that in the Western Highlands, the cultivation of the formerly widespread Bambara groundnut is declining without any apparent agronomic reason [23]. Achigan et al. [24] also noted that Bambara groundnuts are cultivated by elderly farmers (men and women) with low resources on soils that cannot support the growth of other crops.

39% of surveyed farmers have a low level of education (illiterate: 10%, primary: 29%, vs secondary: 26%, tertiary education: 35%) (Fig. 2C). The majority of farmers are married (62%), 16% are single, 3% divorced and 19% widowed. Approximately 40% of farmers have no other occupation and almost 30% are traders (Fig. 2D).

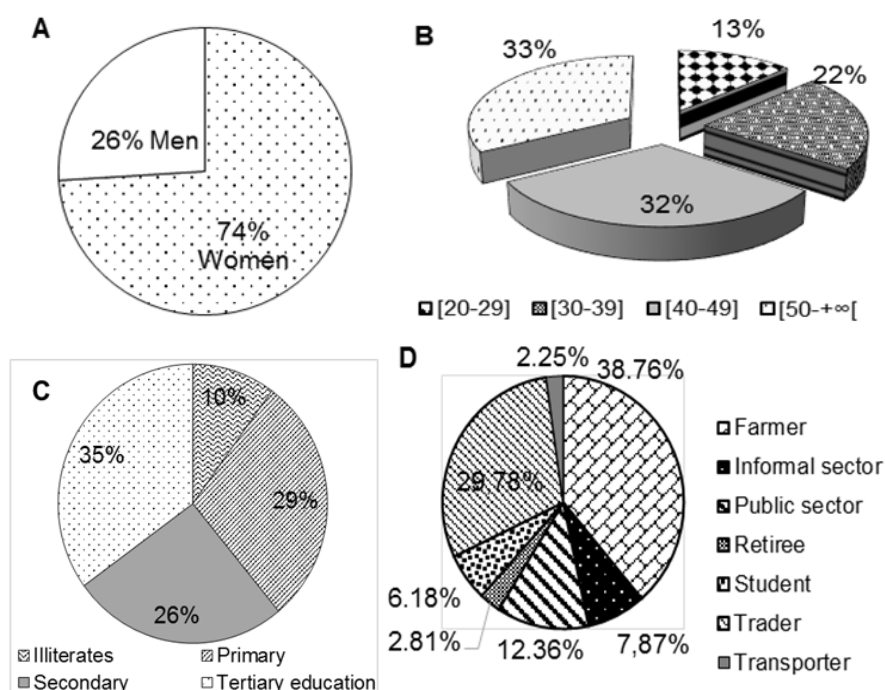


Fig. 2. Socio-demographic characteristics and growing system

A: Gender, B: Age, C: Education level, D: profession of farmers

The local names of the Bambara groundnut cultivated in Cameroon vary according to the production zones (Table1).

3.2 Cropping System

More than 60% of Bambara groundnut is cultivated in monoculture or pure culture (Fig. 3A). The remaining 40% is cultivated in combination with other crops such as groundnut (*Arachis hypogaea* (L.)), maize (*Zea mays* L.), sesame (*Sesamum indicum* L.), okra (*Abelmoschus esculentus* (L.) Moench), millet (*Pennisetum* sp.), sorghum (*Sorghum bicolor* (L.) Moench), bean (*Phaseolus* sp.), egusi (*Citrullus* sp.) or pumpkin (*Cucurbita* sp), plantain (*Musa* sp.) and tubers (cassava, yam, cocoyam and taro). This result is similar to those of Issa et al. [18] who found that in Niger 73% of the Bambara groundnut producer's surveyed practiced pure culture against 27% who associated it with other plants such as millet and sorghum. Similarly, Yaya et al. [19] noted that monoculture is practiced by 54% of farmers in the savannas of Côte d'Ivoire and crop association (46%) is done with groundnut, maize, cowpea and yam. This preference of farmers for pure culture is due to the fact that it requires good sunlight for its growth, contrary to the negative effects of shade

caused by the associated plants. In addition, most plants (millet, sorghum, peanut, etc.) used in association with Bambara groundnut do not produce shade. Bambara groundnuts (79%) are produced mainly on small areas (Fig. 3B).

3.3 Bambara Groundnut Seed Conservation

Post-harvest seed conservation and seed selection prior to sowing are essential for good yield. Most Bambara groundnut farmers (76% vs. 24%) conserve grains for seeds (Fig. 4A). 12% of them (vs 88%) use products to conserve the seeds (Fig. 4B); of which, 9% use plant powders/ash, 50% insecticides (Poudrox, Lyndol), 5% fungicides and 36% hydrocarbons and oil (gas oil, petrol, oil, palm oil) (Fig. 4C). According to Issa et al. [18], about 98% of farmers retain part of their crop as seed for the next cropping year. Bambara groundnut farmers, particularly those in the northern regions of Cameroon, use products such as plant powders / ash, pesticides, hydrocarbons, and oil to treat seeds. Some farmers say they use the insecticides offered by SODECOTON. Tinkeu et al. [25] highlighted in their work in the North Region of Cameroon that farmers use eight industrial chemical insecticides and 18 repellent

plants to limit the damage caused by pests. Chemicals, ash, salt and potash are commonly used in Niger for the conservation of Bambara groundnut seeds [18]. Other farmers use dried

neem (*Azadirachta indica* A. Juss.) leaves [19], pepper/chilli (*Capsicum* sp.) powders and other plant species to preserve the seeds of Bambara groundnut.

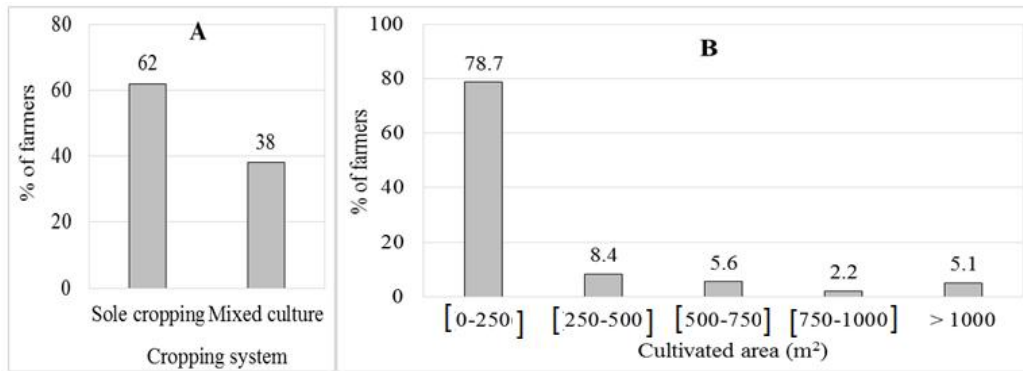


Fig. 3. Cropping system (A) and cultivated area (B) of Bambara groundnut in Cameroon

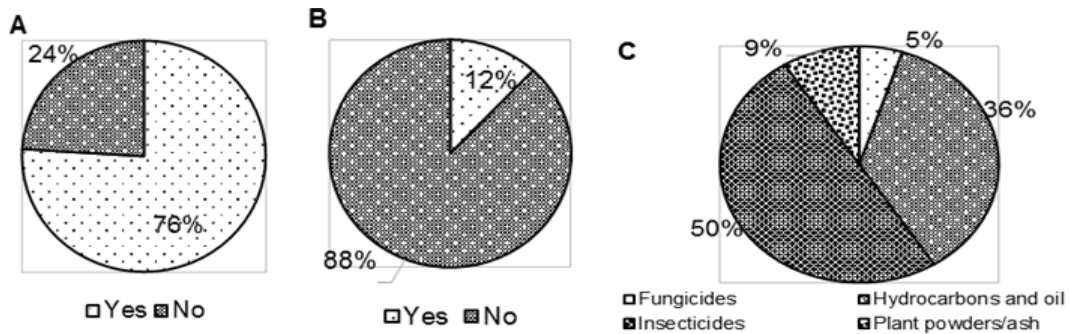


Fig. 4. Bambara groundnut seed conservation

A: % of farmers who conserved seed, B: % of farmers who used products to conserve seeds, C: Types of conservation products

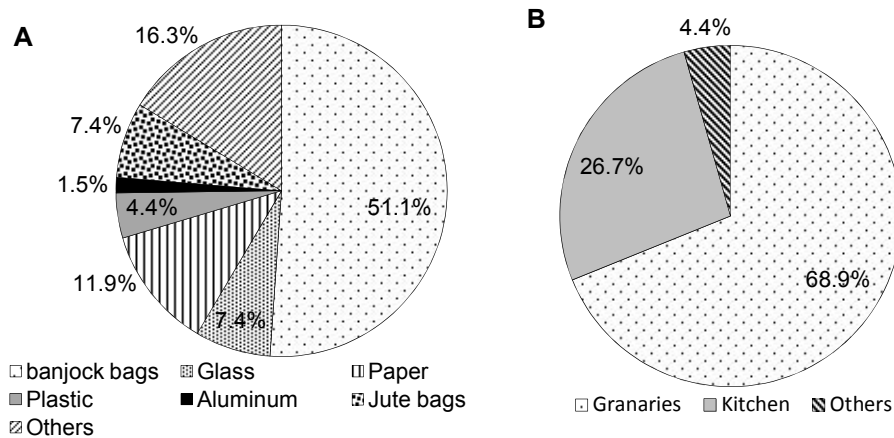


Fig. 5. Materials and places of the conservation of Bambara groundnut seeds in Cameroon

A: Materials (Others: wool bags, calabashes, rattan/raffia baskets), B: Places (Others: various types of shades or in open trays/racks)

Half of the surveyed farmers keep their seed in the “banjock” bags and 16% (other) keep them in wool bags, calabashes, rattan/raffia baskets or spread them directly on racks (Fig. 5A). Close to 70% of farmers store their seed in ceilings or locked traps; 4% in various types of shades or in open trays (Fig. 5B).

More than half (60.4%) of farmers who store Bambara groundnut seeds have conservation problems, while 39.6% do not. Insect attacks (48.2%) and more particularly weevils of the genus *Callusobruchus*, are the main constraint on seed conservation faced by the surveyed farmers (Fig. 6). Damage caused by rodents (28.7%) and fungi (23.1%) are the second and third constraints respectively.

Seed storage time ranges from 3 to 12 months depending on the region (Table 2). In the northern regions, the seeds are kept for at least 6 months while in the south they are kept for 3 to 6 months maximum (Table 2).

3.4 Landraces, Crop Management and Production Constraints

The brown landraces with black spot; ivory cream with gray eye and with the shape of a butterfly; ivory cream variegated with black stripes on the sides and with gray eye and the shape of a butterfly; black; ivory cream without eye; ivory cream with fine brown spots and gray eye with the form of a butterfly are globally the most cultivated in Cameroon. However, the red landrace is the most cultivated in the Centre

Region (Fig. 7). This result is identical to those obtained by Akpalu et al. [20] in Ghana who noted that the white landrace (ivory cream) is the most cultivated. But, it is contrary to those of Issa et al. [18] who found that the yellow landrace is more popular in Niger. Indeed, the white landrace is precocious; it ripens faster than other landraces, produces more and therefore has a more affordable price on the market. This preference of consumers and farmers of Bambara groundnut for white seeded local varieties could be due to their low level of tannins compared to local varieties with black seeds which have high tannin content [26].

In the Far North and North Regions, seed sowing takes place in July, August and sometimes in September. In the Centre Region, sowing of the Bambara groundnut occurs between March and April for the first season; and in August (rarely in September) for the second season. In the West, North-West, Littoral and Adamawa, sowing is done in March and April.

The majority of farmers surveyed (92% vs 8%) carry out a manual sorting of the seeds before sowing. The farmers interviewed (99% vs 1%) do not carry out seed germination tests before sowing. Most of the surveyed farmers (98% vs 2%) weed their field, i.e., 19% once, 70% twice and 11% thrice. The majority of Bambara groundnut farmers (84%) do not use fertilizers while 16% improve their farms with chemical fertilizers (urea, 20-10-10, 12-06-20), fowl droppings, animal droppings or compost.

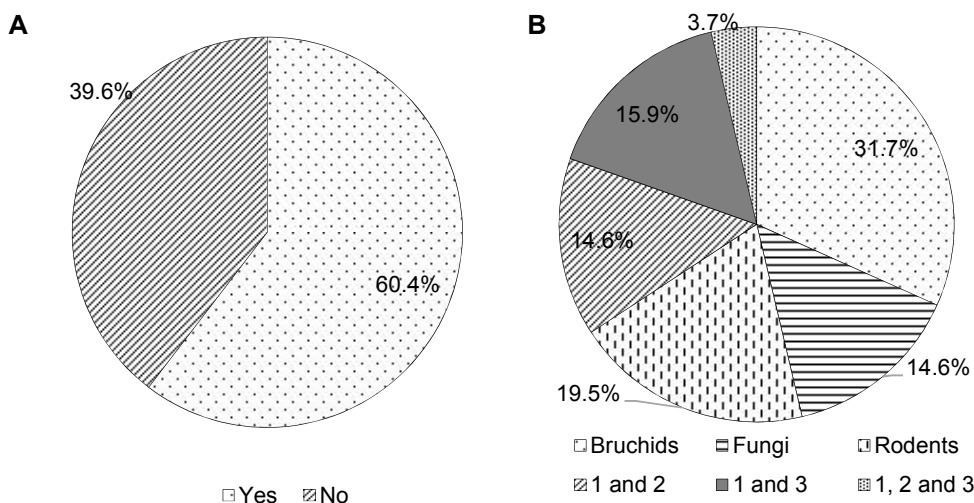


Fig. 6. Seed conservation problems

A: % of farmers having seed conservation problems, B: Origin of seed conservation problems

Table 2. Shelf life of Bambara groundnut seeds

Regions	Shelf life (months)								Total
	3	4	5	6	7	8	9	12	
Far North	0	1	1	1	12	34	0	0	49
North	0	0	1	3	0	0	0	0	4
Adamawa	10	3	0	0	0	0	0	3	16
Centre	0	1	4	8	2	0	0	0	15
Coastal	3	0	3	9	7	0	0	1	23
North-West	2	0	1	6	2	1	0	0	12
West	2	0	0	4	0	2	8	0	16
Number of farmers	17	5	10	31	23	37	8	4	135

135 is equivalent to 76% who conserve the seed

The main constraints of Bambara groundnut production (Fig. 8) in Cameroon are weeds (21%), insects (20%), rodents (19%), low yields (13%), difficulty in trade (8%) and the lack of improved varieties (7%). The action of other pests such as birds, snails, the destruction of farms by oxen, molds, and harvest difficulties due to heavy rains are the minor constraints identified. This result is similar to those of Gbaguidi et al. [22] who found that insects are the main biotic factors influencing cowpea and Bambara groundnut production in Benin. These insects are beetles (Coleoptera), Heteroptera, Lepidoptera and Thysanoptera [25,27-28]. Some destroy the root system while others destroy the

inflorescences. Insects affecting pods and those affecting storage can cause 100% loss [28]. The main abiotic constraints that reduce the yield of Bambara groundnut are poor soils, irregular rainfall and drought [22]. In general, poor soils are the major constraints to the production of plants in Cameroon [29]. Some farmers deplored the lack of improved varieties of Bambara groundnut. Indeed, Rubyogo and Nounamo [30], in their mission to evaluate legumes for the C2D project (Contract Deleveraging Development), noted that there may be no variety of Bambara groundnut released or disseminated in Cameroon, although this is an important crop for the most arid regions.



Fig. 7. Seed of some Bambara groundnut landraces (picture used for the survey)

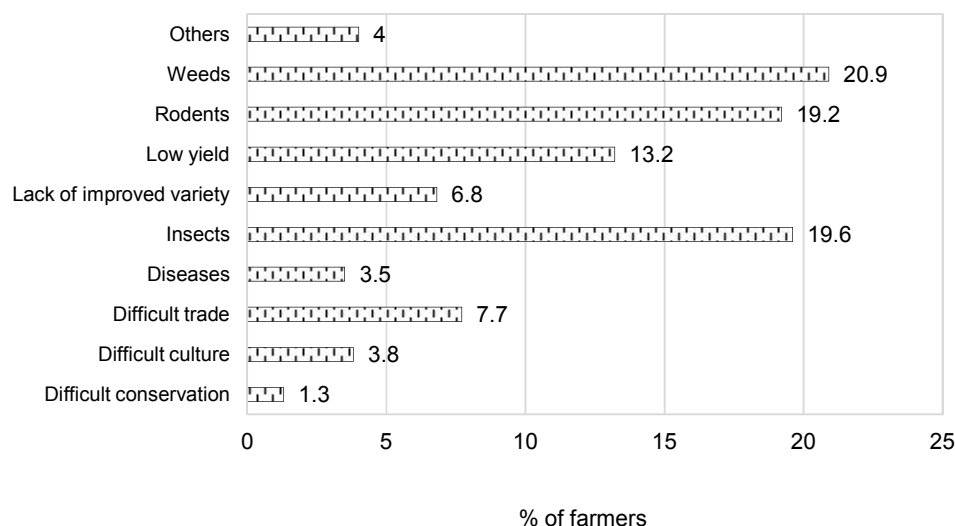


Fig. 8. Constraints of Bambara groundnut production in Cameroon

The neglect of this crop cannot be explained, as many consider that the Bambara groundnut adapt more easily to difficult conditions, in particular drought, salt stress and poor soils [3,9, 31-34]. This Bambara groundnut shift is due to the fact that it is considered as an indigenous culture consumed by the poor in rural areas (food for the poor people) and not as a lucrative cash crop [10], but wrongly. During the survey, the estimated yield of Bambara groundnut is relatively low in the south of Cameroon compared to the northern part. However, the calculated average yield (2014) of Bambara groundnut ($8,750 \text{ hg}\cdot\text{ha}^{-1}$) in Cameroon according to FAO [35] is higher than the calculated world average yield ($7,053 \text{ hg}\cdot\text{ha}^{-1}$); but this production remains low, far below national demand.

3.5 Uses of Bambara Groundnut

All Bambara groundnut farmers use it to prepare delicacies (Fig. 9). They also use it in the traditional pharmacopoeia and as animal feed. The majority of Bambara groundnut (42%) are used for making cakes ("koki", food, paste, pounded). The fresh pods are boiled and eaten in snacks (12%). Bambara groundnuts are also eaten as the common bean (stew) where the seeds are boiled and then fried in oil with spices, salt and flavors (12%). Dry seeds are roasted and eaten like peanuts (7%). They are also consumed in the form of couscous/fufu (12%), porridge/soup (9%) and raw seeds (2%). Various

(3%) sauces (Nigerian, okok, foléré, tomato) are also made with Bambara groundnut seeds (Fig. 9A). The majority of consumers (83%) do not encounter any difficulty in making dishes. Cooking time (54%) and seed crushing (35%) are the main difficulties encountered (Fig. 9B) by other consumers (17%). These results are contrary to those of Mazahib et al. [36] who noted that boiling is the most commonly used cooking method for the preparation of Bambara groundnut for consumption. These authors also noted that it is primarily cultivated for human consumption, and can be used as an ingredient in dishes, to make flour, or eaten as a snack. This cooking mode will reduce the cooking time. Indeed, the results of the survey showed that one of the constraints of use of the Bambara groundnut in Cameroon is the long cooking time. Short cooking time would have become a major feature sought by farmers and end-users of Bambara groundnut [37].

In Cameroon, Bambara groundnuts are also used for animal husbandry, especially in the northern part of the country. The leaves are given to cattle, goats and sheep while the seeds are used to feed poultry and pigs. Indeed, studies reported that seeds are used successfully to feed chicks, leaves are suitable for grazing animals, since they are rich in nitrogen and phosphorus [12]. The use of Bambara groundnut and *Leucaena leucocephala* or *Gliricidia sepium* leaf protein foods increased the weight of tilapia [37].

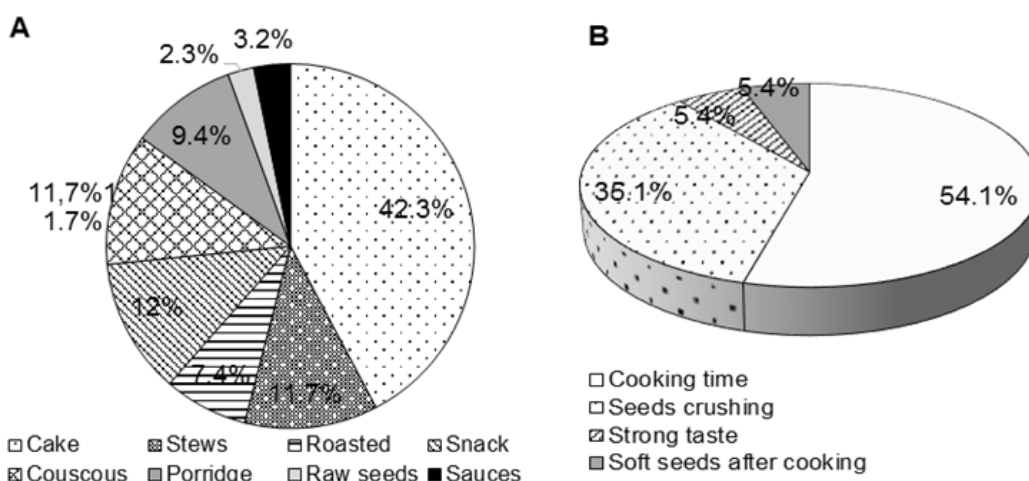


Fig. 9. Cooking of Bambara groundnut
A: Different types of dishes made with Bambara groundnut, B: Difficulties in using it

The farmers surveyed use Bambara groundnut to control amoebic dysentery, sore throat, headaches, gastric ulcers, joint pain and bone decalcification. It stimulates the production of milk in lactating women and is given to women who have just given birth to dress their wounds. In fact, according to many authors, various formulations of seeds and /or leaves are used to treat diarrhea, anemia, abscesses, internal wounds, ulcers, infected wounds, epilepsy, cataracts, menorrhagia during pregnancy, nausea in pregnant women, kwashiorkor and venereal diseases; and in preventing heart, eye and colon cancer [9,13,18,20]

Bambara groundnut has a great cultural value in the Bassa'a area of Cameroon, where the pod is sometimes offered as a gift to young boys who have just been circumcised; they consume it with a prepared cock as proof of their manhood. Bambara groundnut broth is also very popular during rituals of widowhood, mourning and wedding ceremonies.

About 49% of Bambara groundnut production is for consumption, 47% for consumption and marketing, and 4% for marketing. According to agricultural crops statistics for the 2009 and 2010, 51% of Cameroon's production of Bambara groundnut is for self-consumption, 38% for marketing, 9% for seeds and 2% for processing [15]. Leaves and seeds are given to poultry, goats, cattle, sheep and pigs. Prices for pods and grains of Bambara groundnut in the northern region are significantly lower than in the south of the country. They range from less than

250, 2,500, 500 and 5,000 CFA per cup of the fresh pods, bucket of fresh pods, cup of dry grains and 5 L bucket of dry grains respectively in the north of the country. The cost is higher in the southern part of the country. Estimating yield was difficult due to the diversity of harvesting materials (bag, bucket, etc.), product condition (seeds or pods, fresh or dry). But, for the same container, the yield was higher in the north than in the south of the country.

4. CONCLUSION

The Bambara groundnut (*Vigna subterranea*) is mainly cultivated by women in Cameroon and mostly in small farms. Monoculture is the most common practice and the choice of seeds is made by manual sorting to more than 90%. Seed storage is mainly done with chemicals in closed containers. There is a great diversity and a very rich vernacular nomenclature of the Bambara groundnut in Cameroon, varying from one region to another and from one ethnic group to another. Management of weeds, insects, rodents, low yields and the absence of improved varieties are the main production constraints of the Bambara groundnut identified. Very few peasants amend the soil for the cultivation of Bambara groundnut. Any technology to improve its culture in the regions of Cameroon must imperatively take into account gender considerations.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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