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Monographic Study of the Bambara groundnut [*Vigna subterranea* (L.) Verdcourt] Culture in Far North Region of Cameroon

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Abstract

The present work aims to determine the socio-demographic characteristics of Bambara groundnut operators, the management method of this crop (cultivation practices) and the constraints that hinder its good production in Far North region of Cameroon. To achieve this, 1412 people without sex distinguish were interviewed in 109 villages and the survey was done in 40 markets. The obtained results identified three actors namely producers, traders and consumers. Active people (18 to 40 years and 41 to 60 years old) are the most involved in Bambara groundnut production and marketing activities. Women and men participate in Bambara groundnut production activities: 59.06 % and 40.94 % respectively. Marketing activities are more devolved to women (82.8 %) than men (17.2 %). Bambara groundnut cultivation has not been abandoned as several authors have pointed out, but there is a real problem of outlets (growth markets) and transformation into other by-products in commercial spaces. The lack of improved seeds (100 % of respondents) and the lack of data on cultivation techniques would contribute to the drop in yield of this crop in the Far North of Cameroon.

Keywords: Monographic study; Bambara groundnut; Culture; Far North-Cameroon

1. Introduction

Marginal food plants have low yields, but they are adapted to their growing environment. In addition, they have an important social and cultural aspect for those who grow them [1]. Bambara groundnut (*Vigna subterranea*) is part of this category of plants. It is adapted to the growing conditions of the Sudanian and Sudano-Guinean regions [2]. This plant, like other food legumes, is highly energetic with 387 kcal/100 g, rich in vitamins (A, C and E), minerals (calcium, potassium, iron and nitrogen) and very balanced in proteins [3,4,5,6]. It is used in human nutrition [7,8,9], poultry [10] and livestock [11]. Its cultivation is widely practiced in West Africa, where 45 to 50 % of world production comes from, but also in East and South Africa where it is adapted to various climatic and ecological conditions ranging from steppes to forests and then savannahs [12]. This plant is also used in crop rotations to improve soil productivity thanks to its ability to fix atmospheric nitrogen and supply it to the soil [13,14]. It improves protein nutrition for humans and animals and increases yields of rotational crops. It serves as a cover for soil protection against water erosion, protects the soil

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against the splash effect of raindrops, slows down water flow, reduces evaporation, ensures better water retention and infiltration and serves as green manure for restoring soil fertility [15]. The haulms abandoned in the fields constitute an important source of soil enrichment in organic matter and mineral elements [16]. One of the main attributes of Bambara groundnut is its tolerance to poor soils, drought, saline stress, as well as its ability to produce in submarginal conditions where peanuts completely fail [17,18]. The cultivation of Bambara groundnut therefore confers a significant ecological advantage. In Cameroon, and particularly in the Far North, the production of this legume is nowadays neglected and abandoned in the hands of destitute farmers, in search of information on cultivation techniques to improve their production. Despite the first rank that the Far North occupies at the national level with 19,978 tons of production [19], the sector remains one of the least developed, or even non-existent ; despite the rich climatic potential of the region which is favorable to its production. Since research institutes do not really show any interest in this crop [20,21,22,23], the search for solutions adapted to the context requires an interest in existing knowledge on the management of this crop ; hence the interest of this study which aims to determine the socio-demographic characteristics of Bambara groundnut producers in the Far North, determine the management method of this crop by producers and identify some assets and constraints that could help improve the production of this grain legume in the Far North of Cameroon.

2. Methodology

2.1. Presentation of the study area

The Far North of Cameroon, whose capital is Maroua is located between 10 and 13 degrees North latitude and 13 and 15 degrees East longitude. It covers an area of 34,263 km^2, or 7.4 % of the national area [24]. It belongs to agroecological zone 1, known as Sudano-Sahelian. It has six divisions (Diamare, Mayo-Sava, Logone and Chari, Mayo-Tsanaga, Mayo-Kani and Mayo-Danay) and forty-seven subdivision. Given the importance of Bambara groundnut production in the Far North [19], five of the six divisions were retained for this study. The security context that prevailed in the division of Logone and Chari due to the incursions of jihadists from the Islamic sect Boko Haram was the reason for the abandonment of the division.

2.2. Data collection

The study was conducted by administering a semi-structured survey. The questionnaire were administered to producers, traders, consumers and a few resources persons in the five study areas. Among producers, the information researched is focused on socio-demographic characteristics, cultivation practices, internal factors (strengths and weaknesses) inherent to the crop and external factors (opportunities and threats) related to the crop production environment. Among traders, the information sought focused on socio-demographic characteristics, the best-selling accessions and sales periods. Among consumers, in addition to socio-demographic data, the data focused on preferences and the justification for the choice of accessions. The questionnaire consisted of closed questions where the answer is yes or no, open questions giving the actors the latitude to express their points of view at will and leading questions to which several answers to choose are proposed to the respondents. The sampling which consists of choosing a representative part of the total population of the study was done according to the method described by [25]. The production data from the National Institute of Statistics from 2017 allowed to choose the zones and villages taking into account the volume of Bambara groundnut production in the entire study area [26]. The chiefs of agricultural posts and the extension agents of the zones helped to constitute an exhaustive list of producers taking into account the distribution of the zones where Bambara groundnut is more cultivated in the Far North. From this exhaustive list where each producer was identified by a number, a draw of eighty percent (80 %) of the producers was made by the simultaneous random method and without replacement. A sample of 846 producers (Table 1) was chosen from a study population of 1062 and submitted to the questionnaire drawn up for this purpose. Among traders, the sampling criterion was the sale of seeds of Bambara groundnut. Forty (40) markets were crisscrossed and ninety-three (93) traders were surveyed in the five study areas (Table 2). Given the small number of traders, all were surveyed. Among consumers, the sample included producers, traders and all persons purchasing Bambara groundnut in the markets. A total of 1628 persons constituted the study population and 1412 were subjected to the questionnaire. The data collected are all qualitative and were obtained by the “Scoring” method set out by [27] which consists of counting the number of times a modality appears and assigning them scores. The same applies to internal factors (strengths and weaknesses) and external factors (opportunities and threats) which were determined by the same method.

2.3. Data analysis

The raw data were entered and formatted using the Microsoft Office Excel 2013 spreadsheet. These data were then imported as text files into the SPSS software, version 20.0. which was used to calculate the absolute frequencies

(numbers) and relative frequencies (percentages) of each variable category taken into account. From these frequencies, histograms were plotted.

Table 1 Study population and sample of producers surveyed by zones in the Far North

Divisions	Subdivisions	Villages	Study population	Sample surveyed
Mayo-Sava	Tokombéré	Serawa, Mamsa, Gatoa, Mambeza, Dala-Zoulgo, Kotrabar ;	81	65
		Makilingaï, Mokio, Lalawaï ;	41	33
		Mada, Zoucoudou, Bjemilé	44	35
	Mora-Massif	Oudjila et Tala-Mokolo	48	38
Mayo-Tsanaga	Bourrha	Bourrha, Zouvou, Djimi ;	48	38
		Guili, Gamboura, Walbana ;	45	36
		Chivi, Walbana, Haow	50	40
	Mogodé	Amsa, Sir, Rhoumsou, Siracouti	34	27
	Koza	Koza	30	24
	Souledé-Roi	Dimché, Mazam, Guirdé, Doumsaraï	28	22
	Hina	Hina	29	23
Diamaré	Maroua 1er	Miskine, Katoual, Massinika	25	20
	Meri	Ouazzang-Gabo, Mbozo, Douroum	26	21
		Dogba, Doulek, Godola	26	21
		Douvangar, Mikiri, Makouzek	28	22
	Dargala	Gassayel, Yoldéo, Ourodalla, Dolwo	26	21
	Gazawa	Bantadje, Hodango, Mbankara	29	23
	Ndoukoula	Ndoukoula, Gawel, Moulandi, Dagai	29	23
Mayo-Danay	Wina	Houyouk, Hougno, Djongdong, Djengreng	44	35
	Datchéka	Doubangou, Zouaye, Golompoui, werféo	29	23
	Tchatibali	Tchatibali, Djaolane, Bicharé, Kaolaré	28	22
	Kalfou	Kalfou, Bougaye, Ngalaï, Gobio,	28	22
	Gobo	Dompia, Nouldaïna, Djelmé, Guiriou	31	25
	Nguéré	Bangana, Nguéreng, Gourvaye, Ngaïna	34	27
Mayo-Kani	Taïbong	Goundaye, Golonguini, Tibegué, Domba	29	23
	Guidiguis	Guidiguis, Féo-Eba, Doubané, Djoddedi	26	21
	Kaélé	Lara, Boboyo, Midjivin, doumourou	31	25
	Porhi	Touloum, Tsaï-Tsaï, Bizili, Nimbakri	28	22
	Moutourwa	Moutourwa, Magada, Mouda, Tinting	30	24
	Mindif	Mogom, Dir, Gagadji, Doyang, Djappaï	28	22
	Moulvoudaye	Moulvoudaye, Horlong, Kolara, Daram	29	23

Table 2 Distribution of markets in the five study areas in the Far North

Divisions	Subdivisions	Markets
Diamaré	Maroua 1er	Meskine, Salak, Ouro-Tchédé (Para)
	Maroua 2ème	Abattoir
	Maroua 3ème	Kodek
	Gazawa Meri	Gazawa Godola Ouazzang Douroum Douvangar Meri
Mayo-Sava	Mora-Massif	Mora-Centre Oudjila Tala-Mokolo
	Tokombéré	Tokombéré Serawa Makilingaï Mada
Mayo-Tsanaga	Mokolo Bourrha	Mokolo Bourrha
		Guili Chevi
	Mogodé	Mogodé
	Koza Soulédé-Roua	Koza Soulédé-Roua
Mayo-Kani	Mindif	Mindif
	Kaélé	Kaélé Lara
	Guidiguis	Guidiguis
	Moulvoudaye	Moulvoudaye
	Porhi Taïbong	Touloum Goundaye
Mayo-Danay	Yagoua	Yagoua
	Kalfou	Kalfou
	Doukoula	Doukoula
	Gobo	Gobo
	Nguéré Wina Datchéka Tchatibali	Nguéré Wina Datchéka Tchatibali

3. Results and discussion

3.1. Distribution of respondents by area

Table 3 presents the Bambara groundnut farmers in the five study areas. Mayo-Tsanaga (24.82 %) and Mayo-Sava (20.21 %) represent the sites where we find more Bambara groundnut producers, followed by Mayo-Kani (18.91 %), Mayo-Danay 18.20 %) and Diamare (17.85 %). Traders are more encountered in Mayo-Sava (26.88 %) and Mayo-Tsanaga (23.65 %) ; followed by Diamare (18.28 %), Mayo-Danay (16.13), and Mayo-Kani (15.05 %). Buyers are more encountered in Mayo-Tsanaga (30.44 %), Diamare (29.80 %), Mayo-Sava (20.08 %) and finally Mayo-Kani (12.05 %) and Mayo-Danay (7.61 %). The high presence of producers and traders in Mayo-Sava and Mayo-Tsanaga is explained by the favorable pedoclimatic conditions for the cultivation of Bambara groundnut, and the enthusiasm they have since the existence of promising markets on their borders with neighboring Nigeria which supplies thousands of tons. The low participation of producers and traders in Mayo-Kani, Mayo-Danay and Diamare, is explained by the lack of interest in this crop, despite such favorable pedoclimatic condition. This is due to the lack of growth markets and opportunities in the environment of producers and traders. [28] in Benin have indeed shown that Bambara groundnut is a neglected and underutilized crop. In these three areas (Mayo-Kani, Mayo-Danay and Diamare), Bambara groundnut is cultivated mainly for self-consumption ; it is the surplus production that is sometimes sold as the agricultural seasons approach. [22] in Benin have shown that Bambara groundnut often occupies the penultimate or last rank (67 %) of respondents of the speculations sold. The flow of buyers in Mayo-Tsanaga and Mayo-Sava is explained by the movement of people on market days at the borders with neighboring Nigeria ; while in Diamare, this could be explained by the mixing of populations. The presence of a large number of buyers on market days is an important indicator for traders in Mayo-Tsanaga (30.44 %), Diamare (29.81 %) and Mayo-Sava (20.08 %) who take advantage of this to easily sell their goods unlike Mayo-Kani (12.05 %) and Mayo-Danay (7.61%)

Table 3 Bambara groundnut operators surveyed in the five study zones in the Far North

Divisions	Producers surveyed	Traders surveyed	Buyers in market
Mayo Danay	154 (18.20 %)	15 (16.13 %)	36 (7.61 %)
Mayo Sava	171 (20.21 %)	25 (26.88 %)	95 (20.08 %)
Mayo Tsanaga	210 (24.82 %)	22 (23.65 %)	144 (30.44 %)
Mayo Kani	160 (18,91 %)	14 (15.05 %)	57 (12.05 %)
Diamare	151 (17.85 %)	17 (18.28 %)	141 (29.81 %)
Total by type of operator	846	93	473

3.2. Gender distribution of Bambara groundnut producers

Figure 1 show that Bambara groundnut is practiced both by women and men : 56.7 % of women and 43.3 % of men in Diamare ; 69.6 % of women and 30.4 % of men in Mayo-Kani ; 55 % of women and 45 % of men in Mayo-Danay ; 52.6 % of women and 47.4 % of men in Mayo-Sava and 61.4 % of women and 38.6 % of men in Mayo-Tsanaga. In the five study areas, 59.06 % of women and 40.94 % of men are involved in Bambara groundnut production activities. This is explained by the renewed interest in this culture in certain production areas which would be due to the existence of promising markets. [29] explain this high involvement of women by social considerations that qualify this crop of lesser interest that occupies women outside of the most important activities for the family. [30] in Ivory Coast also revealed that Bambara groundnut is mainly practiced by women (90 %) and represents an important source of income for them. For these authors, Bambara groundnut represents the only crop where women can directly enjoy the income. Similar observations have been reported in various regions of Tanzania [31], Ghana [32], Burkina Faso [23] and Benin [22]. Nadembèga [33] explains this high female affiliation by social considerations. In certain localities in Burkina Faso (Orodara council), Bambara groundnut constitutes the staple food of the communities and is cultivated mainly by men and on large areas. Touré [34] in Ivory Coast showed that the cultivation of Bambara groundnut is a function of gender and depends on the ethnic group and local traditions ; he explains that among the Niaraforo, the culture is exclusively devolved to men, with women only intervening at the post-harvest stage for drying and shelling the pods.

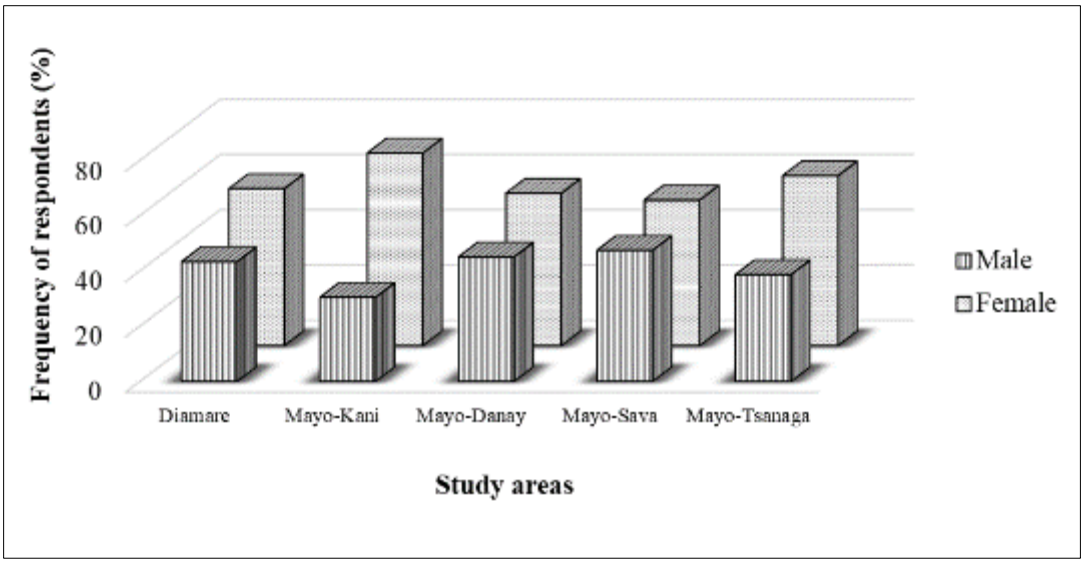

Figure 1 Gender distribution of Bambara groundnut producers in the study areas

3.3. Distribution by gender of Bambara groundnut traders

Figure 2 show that 82.4 % of women against 17.6 % of men are involved in the commercialisation of Bambara groundnut seeds in the diamare ; in Mayo-Kani, women represent 92.9 % against 7.1 % of men ; in Mayo-Danay, women represent 80 % against 20 % of men ; in Mayo-Sava, women represent 76 % against 24 % of men and in Mayo-Tsanaga, women represent 86.4 % against 13.6 % of men. Women are more involved (82.8 %) than men (17.2 %). In the five areas, the sale of agricultural products is an dynamics activity that interest both sexes. The sale of legume or cereal in markets is generally done in detail. This is an activity reserved for women because men are specialized in wholesale sales. In most cases, the sellers combine Bambara groundnut with other products intended for sale. [22] in Benin showed that 70 % of those who trade in Bambara groundnut are retailers, 25 % are both wholesalers and retailers and only 5 % are wholesalers. This could explain the low number and low enthusiasm of men to invest in the marketing of Bambara groundnut.

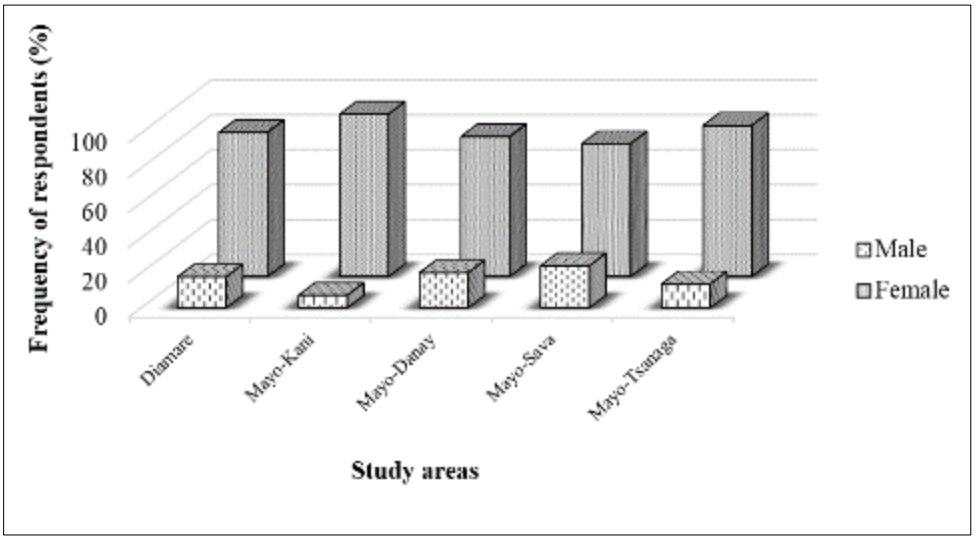

Figure 2 Gender distribution of Bambara groundnut traders in the study areas

3.4. Age distribution of Bambara groundnut operators

Figure 3 shows the average age distribution of Bambara groundnut operators in the five study areas among producers and traders (Figure 2A and 2B). Young people (18 - 40 years) and adults (41 - 60 years) are the most involved in production and commercialisation in the five study areas. People aged sixty-one and over are rarely encountered among producers and traders. Children and adolescent (less to 17 years old) are almost absent. All age groups consume

Bambara groundnut seeds : adolescents, young people, adults and the elderly. The high proportion of young people in Mayo-Tsanaga and Mayo-Sava is explained by the existence of promising markets in these areas. [29] showed that among the 98 % of women involved in the production and marketing activities of Bambara groundnut, 54 % were over 40 years old ; 37 % between 30 and 40 years old and 9 % under 30 years old. This confirms the effectiveness of active people in the production and commercilisation of this crop in the Far North region of Cameroon.

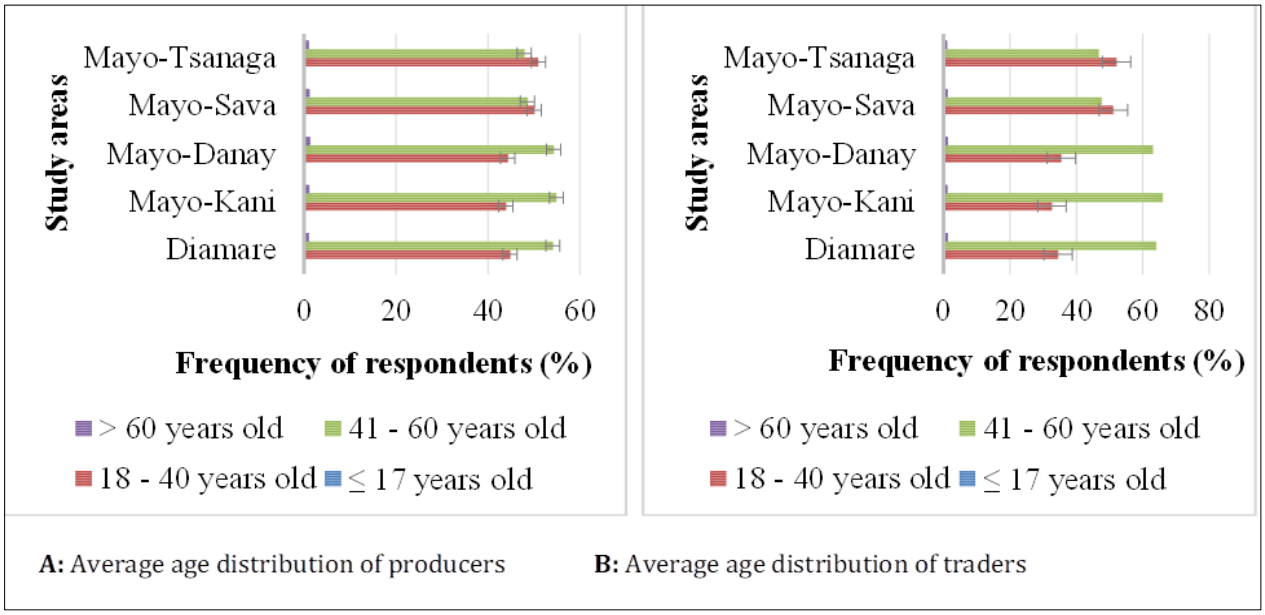

Figure 3 Average age distribution of producers, traders and consumers in the study areas

3.5. Saling period of Bambara groundnut seeds

The period from June to August is favorable for the sale of Bambara groundnut seeds in the five study areas : Diamare (64.7 %); Mayo-Kani (71.4 %); Mayo-Danay (73.3 %); Mayo-Sava (72 %) and Mayo-Tsanaga (68.2 %). This is explained by the approach of the sowing period of this legume seed when seeds are highly sought after. This period results in soaring prices of seeds in the different markets of the study areas. These descriptions are similar to those of [29] who indicate a surge in the prices of seeds between the months of June and July. The period from September to February coincides with the harvests, supply is generally abundant and demand low ; prices are low during this period of the year. [23] in Burkina Faso showed that commodity prices vary from one region to another and from one period to another.

3.6. Preference of Bambara groundnut accessions

Three accessions based on seed coat coloration are preferred by the majority of farmers (Figure 4). These are cream-colored, multi-colored, and single-colored seed. Cream-colored seed with white hilum are more preferred by consummers : Diamare (75.2 %), Mayo-Kani (63.2 %), Mayo-Danay (58.3 %), Mayo-Sava (62.1 %), and Mayo-Tsanaga (68.8 %). The reasons for preference are diverse: organoleptic quality, cooking time, ease of flow, and ease of digestion. [35] in Ivory Coast and [23] in Burkina Faso showed that cream-colored seeds were more preferred. [36] also showed that cream-colored seeds are more consumed in the majority regions of Africa. Monocolored seeds or dark colors are not too appreciated because of antinutritional factors and their bland taste [37,38].

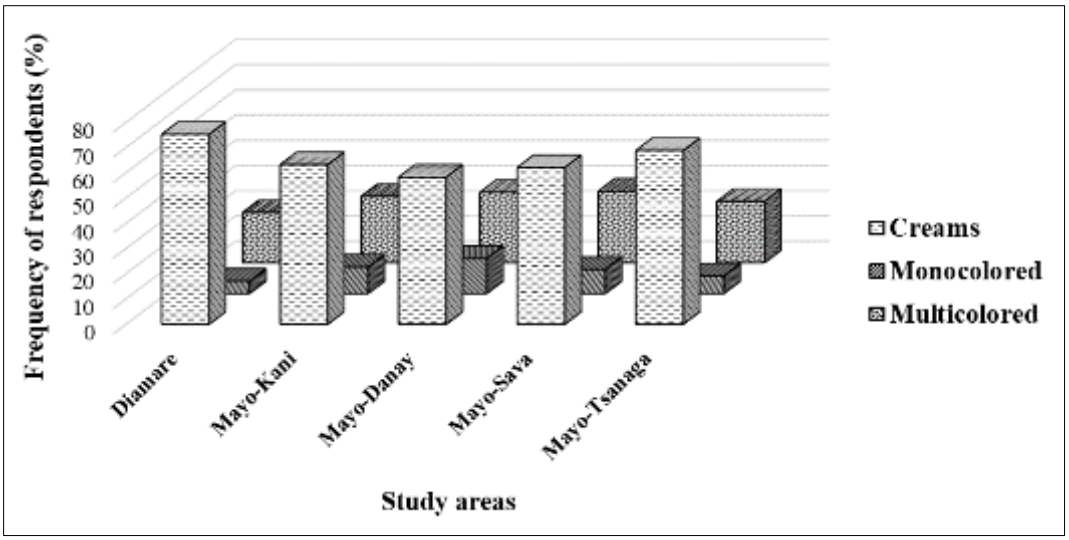

Figure 4 Choice of Bambara groundnut accessions by farmers in the study areas

3.7. Bambara groundnut seed supply

Seeds intended for sowing come from previous harvests, followed by markets and other sources of supply (Figure 5). The most common method of obtaining seeds is collection from previous harvests : Diamare (66.7 %); Mayo-Kani (56.5 %); Mayo-Danay (50 %); Mayo-Sava (62.9 %) and Mayo-Tsanaga (66.3 %). No producers claim to obtain their supplies from approved structures. This is explained by the non-existence of varietal improvement programs for Bambara groundnut in research institutions. The same observations were made by [39] and [23] in Burkina Faso, who showed that the most widespread method of seed supply is collection from previous harvests. [40], showed that the majority of African farmers currently produce only a quarter of their production potential because of poor seed quality. This corroborates the observations of [41] and [42] who showed that current accessions give low yields. Thus, the management of Bambara groundnut seeds remains traditional and cannot respond to the new conditions linked to climatic variability [41,42,31].

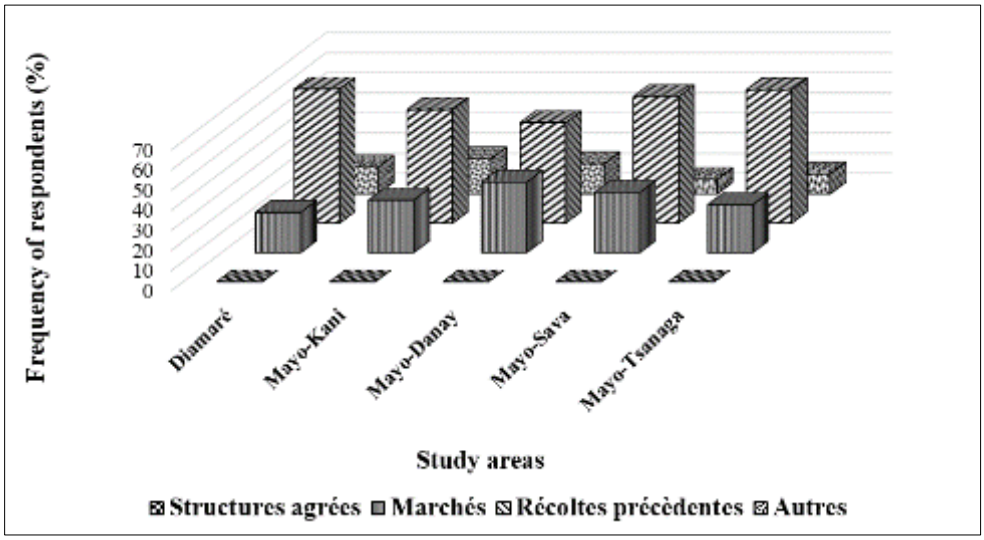

Figure 5 Mode of supply Bambara groundnut seeds

3.8. Surfaces sown with Bambara groundnut cultivation

Figure 6 show that less than 1/16 of a hectare of land (625 m^2) is used by 60 % of producers in Diamare, 56.5 % of producers in Mayo-Kani and 55 % of producers in Mayo-Danay. The fact that Bambara groundnut is cultivated mainly by women who are not landowners in most households would explain the small land observed. This corroborates the observations of [43] who showed that the small land reserved for Bambara groundnut cultivation would be partly due to less value and priority given to women in land allocation. In the five production zones, the cultivated land vary from

less than a sixteenth of a hectare (1/16 ha) to more than one hectare (1 ha). [23] in Burkina Faso showed that the land devoted to the cultivation of Bambara groundnut vary between one hundredth of a hectare (1/100 ha) and one hectare (1 ha). [28] in Benin explain these small land by the fact that Bambara groundnut is neglected and even underused crop. The exploitation of land of more than one hectare (1 ha) is observed in Mayo-Sava (27.8 %) and in Mayo-Tsanaga (22.8 %). This is explained by the demand for Bambara groundnut in the markets of these two zones which border neighboring Nigeria.

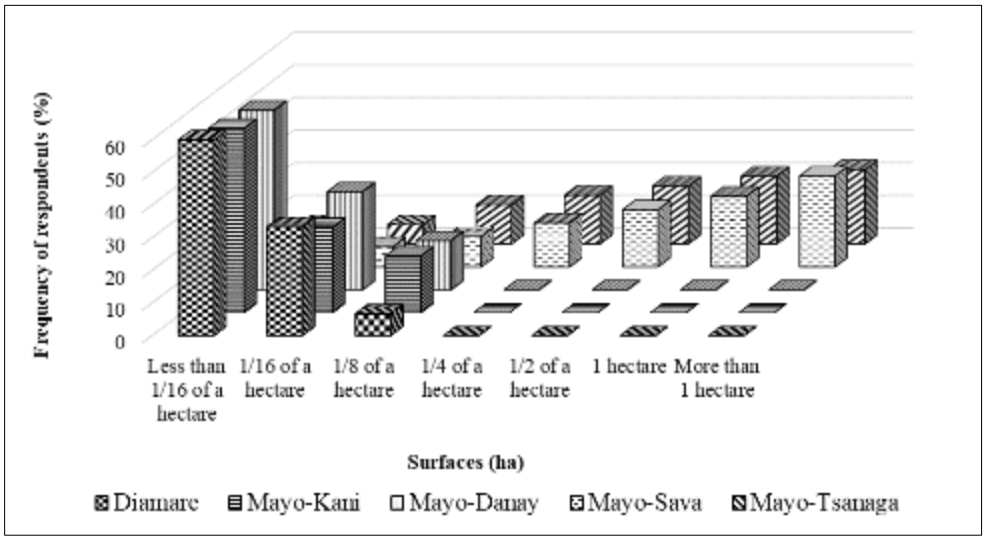

Figure 6 Land sown with Bambara groundnut cultivation in the five study areas

However, Figure 7 shows that the land sown with Bambara groundnut cultivation have changed from 2010 to 2015. In Diamare, 63.3 % of producers reduced their cultivable land, fallow by 60 % producers in Mayo-Danay, and 56.5 % of producers in Mayo-Kani. In these three zones, no producer claims to have increased their cultivable land from 2010 to 2015. This is explained by the lack of outlet for this crop in these three zones where it is mainly cultivated for subsistence. [35] made the same observations in Ivory Coast. In Mayo-Sava, 56.7 % of producers increased their cultivable land while in Mayo-Tsanaga, 55.4 % of producers also increased their land. In these two zones, no producer claims to have reduced their land from 2010 to 2015. This confirms the strong demand for Bambara groundnut in the border markets of these two zones with neighboring Nigeria. This would have led producers to increase their land.

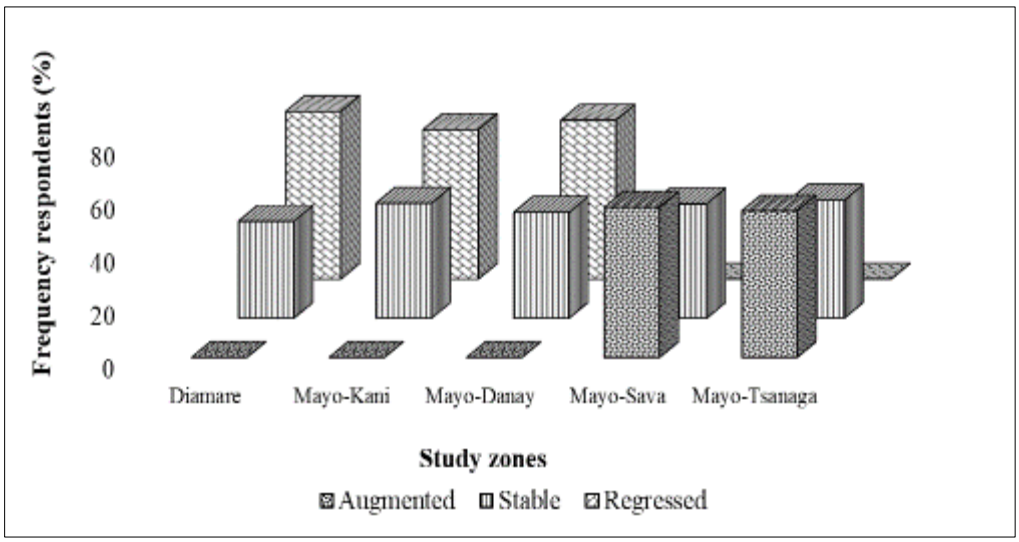

Figure 7 Evolution of land sown with Bambara groundnut in the five study areas

3.9. Cropping system practiced in the five study areas

Figure 8 presents the Bambara groundnut cropping systems in the five study zones. The majority of producers cultivate Bambara groundnut in association with other crops : Diamare (68.3 %), Mayo-Kani (73.9 %) and Mayo-Danay (72 %). Pure cultivation is found in Mayo-Sava (79.6 %) and Mayo-Tsanaga (81.4 %). The predominance of mixed cultivation in the first three areas (Diamare, Mayo-Kani and Mayo-Danay) stems from the little interest that producers have in Bambara groundnut unlike other legume species such as peanuts, cowpeas, soybeans, etc. which are practiced in pure cultivation. In these three areas, Bambara groundnut is cultivated more for self-consumption than for marketing. The high rate of producers who practice pure cultivation in Mayo-Tsanaga (81.4 %) and Mayo-Sava (79.6 %) is explained by the promising markets of these two zones. [44] reported that in Swaziland, monoculturer represents 98 % of the plots occupied by Bambara groundnut. Similarly, [45] in Burkina Faso also reported that Bambara groundnut is practiced in pure and to a lesser extent in association with other crops. Producers in the five study areas integrate crop rotation into their cultural practices: Diamare (76.7 %), Mayo-Kani (78.3 %), Mayo-Danay (75 %), Mayo-Sava (70.1 %) and Mayo-Tsanaga (70.3 %). Anikwe et Atuma [13] and [14] showed the importance of incorporating Bambara groundnut into rotation and crop rotation systems with cereals. [30] in the savannah zone of Ivory Coast showed that the rotation of Bambara groundnut with cereals is recurrent. For these authors, the incorporation of Bambara groundnut into crop rotations makes it possible to meet the nitrogen fertilizer needs of subsequent crops. [46] in Benin showed to this effect that in the face of declining soil fertility and rising prices of imported fertilizers, rotations including legumes such as Bambara groundnut constitute an important alternative for sustainable soil fertility management.

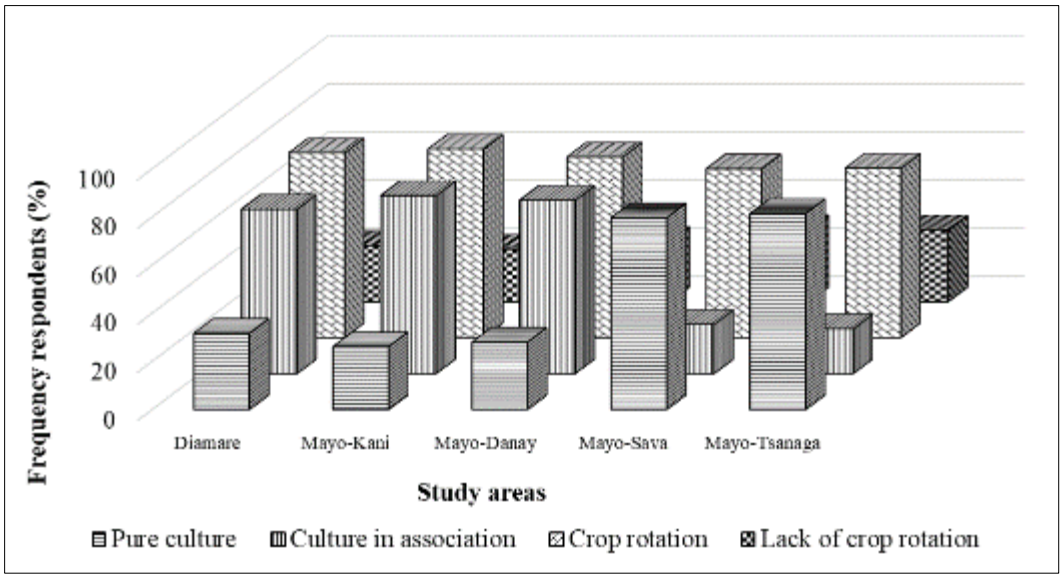

Figure 8 Cropping system and crop rotation in the study areas

3.10. Soil preparation

Two soil preparation techniques for cultivation are used : ploughing and no ploughing. Flat ploughing is the most widespread method of soil preparation : Diamare (84 %), Mayo-Kani (87 %), Mayo-Danay (86.7 %), Mayo-Sava (87.4 %) and Mayo-Tsanaga (86.2 %). Kew [47] showed that this type of ploughing allows the plant to bury its pods well at the time of fruiting. Similarly, [39] and [48] reported that some producers grow Bambara groundnut on ridges. No ploughing once unknown to producers, has gradually become integrated over the years into the cultivation practices of Bambara groundnut producers in view of numerous experiments observed on other crops. This corroborates the observations of [29] on peasant practices of Bambara groundnut production in the northern regions of Cameroon.

3.11. Sowing densities

The majority of producers have no knowledge of the seeding density applied to Bambara groundnut cultivation : Diamare (86.7 %), Mayo-Kani (88 %), Mayo-Danay (90 %), Mayo-Sava (86.4 %) and Mayo-Tsanaga (88.2 %). This is explained by the lack of data from support services and research institutions. Several authors have shown in various parts of the world that crop production can be improved by cultivation techniques such as spacing between plants [49,50]. Seeding density has a significant effect on crop growth and yield parameters [51,52]. Kouassi and Zoro Bi [53] in Ivory Coast showed that the best yields are obtained at high seeding densities.

3.12. Diseases and pests

Bambara groundnut is attacked by both diseases and pests. Damage caused by pests is most cited : Diamare (86.7 %), Mayo-Kani (78.3 %), Mayo-Danay (80 %), Mayo-Sava (85.6 %) and Mayo-Tsanaga (82.2 %). This is the result of the combined effects of delayed rains or early cessation of rains. Insects are the main pests that degrade seeds in the field and during storage [54,55,56]. The presence of diseases is cited in the five study areas : Diamare (13.3 %), Mayo-Kani (21.7 %), Mayo-Danay (20 %), Mayo-Sava (14.4 %) and Mayo-Tsanaga (17.8 %). These low rates are explained by the hardiness of the plant and the short period of humidity which is not conducive to the proliferation of diseases in the fields. This corroborates the observations of Baudoin and Mergeal [2] who described that Bambara groundnut is little attacked by diseases. Ouoba [57] and Nadembèga [33] have indeed shown losses of Bambara groundnut dements due to diseases in southern Burkina Faso. Similarly, [58] have shown serious damage caused to the plant by diseases and pests.

3.13. Internal factors in the five study areas in the Far- North

3.13.1. Strengths and weaknesses in the production environment of Bambara groundnut

The existing strengths and weaknesses is presented in Figure 9A. The presence of Bambara groundnut producers constitutes the main strength in Mayo-Tsanaga (54.5 %) and Mayo-Sava (45.4 %). This is explained by the existence of growth markets and the high demand for Bambara groundnut. The existence of consumers constitutes the main strength in Diamare (53.33 %), Mayo-Kani (52.17 %) and Mayo-Danay (55 %), while the existence of management structures also constitutes a strength, despite their inertia [59]. According to weaknesses (Figure 9B), the lack of knowledge on controlling diseases and pests is more perceived : Diamare (36 %), Mayo-Kani (39.5 %), Mayo-Danay (36 %), Mayo-Sava (46.7 %) and Mayo-Tsanaga (45.3 %); followed by the non-existence of innovative cultivation technique : Diamare (30 %), Mayo-Kani (26.1 %), Mayo-Danay (30 %), Mayo-Sava (30.7 %) and Mayo-Tsanaga (25.8 %). These results are explained by the unavailability of reliable data from the management and research services. [23] in Burkina Faso showed that diseases and insects are the main biotic constraints contributing to the decline in Bambara groundnut yields. [22] in Benin showed that the lack of mastery of cultivation techniques contributes to the decline in crop yields. The non-existence of Bambara groundnut value chain in the five study areas : Diamare (22.3 %), Mayo-Kani (21.7 %), Mayo-Danay (21 %), Mayo-Sava (22.6 %) and Mayo-Tsanaga (23 %) is explained by the absence of a policy for the valorization of Bambara groundnut in Cameroon. [22] in Benin proposed a strategic plan for valorization and promotion of the Bambara groundnut culture. The low involvement of young people is observed in Diamare (11.7 %), Mayo-Kani (12.7 %) and Mayo-Danay (13 %). This is explained by the lack of opportunity offered by this culture in these three areas.

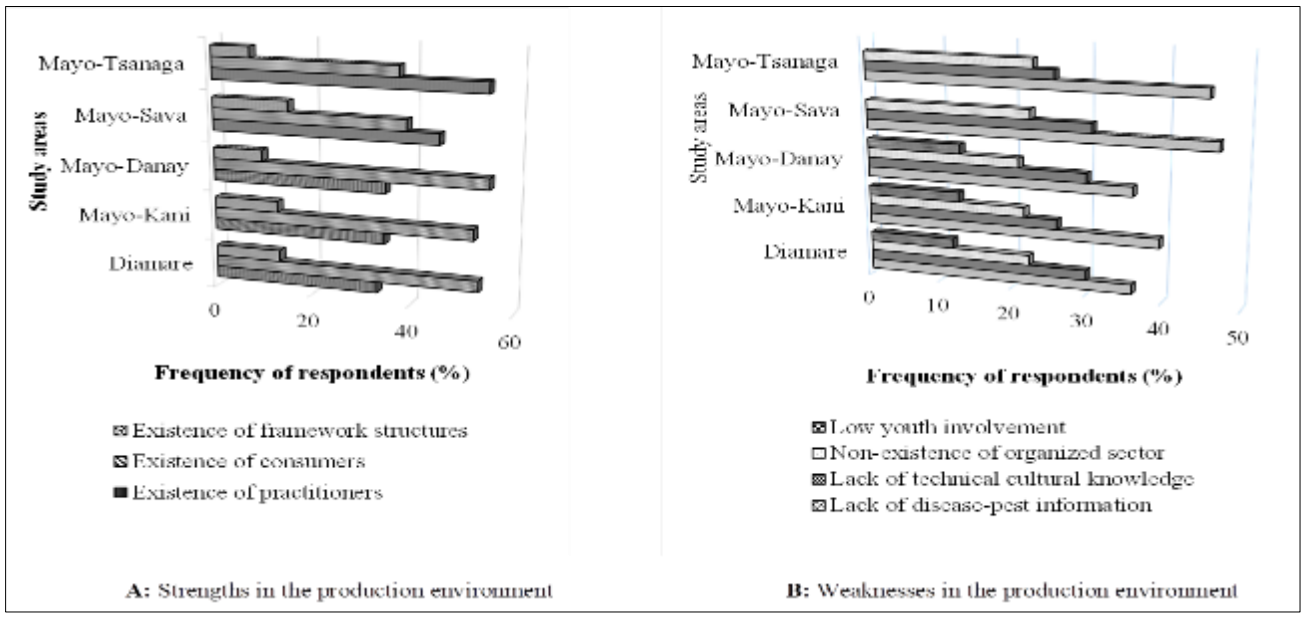

Figure 9 Strengths and weaknesses in the production environment of Bambara groundnut in the five study areas

3.14. External factors in the five study areas of the Far North

3.14.1. Opportunities and threats in the production environment of Bambara groundnut

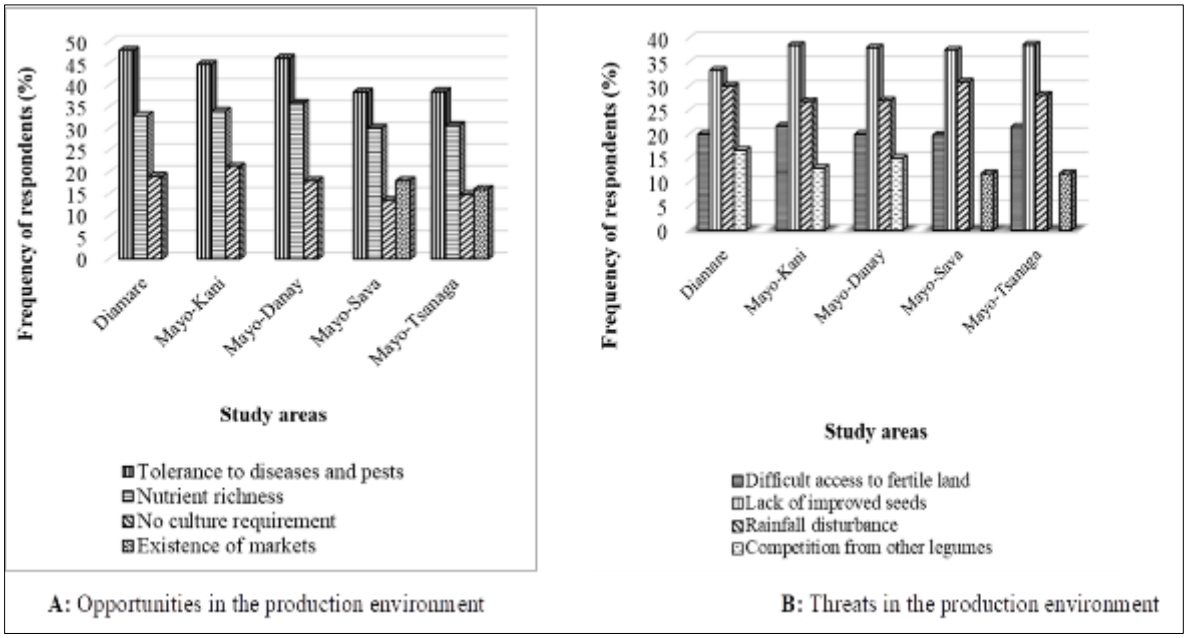

Figure 10 Opportunities and threats in the production environment of Bambara groundnut in the five study areas

According to the opportunities (Figure 10A), the tolerance of the crop to diseases and pests ranks first in Diamare (48 %), Mayo-Kani (44.8 %), Mayo-Danay (46.2 %), Mayo-Sava (38.4 %) and Mayo-Tsanaga (38.5 %). The same observations were reported by Baudoin and Mergeal [2]. These authors showed that Bambara groundnut is a plant tolerant to diseases and insect pests. The richness in nutrients of the seeds also constitutes an opportunity in the five study areas: Diamare (33 %), Mayo-Kani (34 %), Mayo-Danay (35.8 %), Mayo-Sava (30.1 %) and Mayo-Tsanaga (30.7 %). Oparaeke and Bunmi [60]reported that Bambara groundnut seeds are rich in carbohydrates (63 %), proteins (10 %) and lipids (6.5 %). Minka and Bruneteau [3] and [61] showed that Bambara groundnut seeds are highly caloric with 387kcal/100g, rich in lysine, methionine and mineral elements. This shows that the incorporation of Bambara groundnut in malnutrition recovery foods could improve the nutritional status of populations [62]. The non-requirement of the culture in mineral matter constitutes an opportunity in Diamare (19 %), Mayo-Kani (21.2 %), Mayo-Danay (18 %), Mayo-Sava (13.5 %) and Mayo-Tsanaga (14.8 %). This is explained by the quantity of yields that Bambara groundnut producers continue to have on poor soils. These observations are in agreement with those of [11] who showed that Bambara groundnut provides yields in conditions that are submarginal for other crops. The flourishing marketing of Bambara groundnut seeds in Mayo-Sava (18 %) and Mayo-Tsanaga (16 %) is explained by the opening of these two areas on border markets with Nigeria which supplies itself with several tons. According to threats (Figure 10B), the lack of improved seeds is the main threat in the five study areas: Diamare (33.3 %), Mayo-Kani (38.5 %), Mayo-Danay (38 %), Mayo-Sava (37.5 %) and Mayo-Tsanaga (38.6 %). This is explained by the absence of an improved seed production program. [63] in Zimbabwe and [32] in Ghana showed that Bambara groundnut is one of the most neglected crops by research. As for climatic disturbances, they are felt in the five study areas: Diamare (30 %), Mayo-Kani (26.8 %), Mayo-Danay (27 %), Mayo-Sava (30.9 %) and Mayo-Tsanaga (28.1 %). This is the result of the combined effects of drought, delayed rains, early cessation of rains, floods, etc. which affect production. They constitute a serious threat to the sustainability of agricultural production systems [64]. [65] in Ontario-Canada showed that current climate change models predict significant effects on diseases that will affect plants in the coming years. Access to fertile land also poses a threat in the five production areas : Diamare (20 %), Mayo-Kani (21.7 %), Mayo-Danay (20 %), Mayo-Sava (19.8 %) and Mayo-Tsanaga (21.5 %). This is explained by the strong involvement of women who are unfortunately not landowners. These observations corroborate those of [43] in Burkina Faso who showed that small areas and less fertile land are allocated to Bambara groundnut cultivation because less value and priority are given to women. Price instability is observed in Mayo-Sava (11.8 %) and Mayo-Tsanaga (11.8 %). This suggests that prices are not stable and fluctuate over the course of the year. These observations corroborate those of [23], who showed that the price of Bambara groundnut varies from one region to another and from one period to another. Just after the harvests, the supply is high, which leads to a drop in prices. In general, when the supply is lower than the demand, prices experience a surge ; this case is observed as the agricultural seasons approach. The competition of Bambara groundnut with other grain

legumes (peanut, cowpea, soybean, bean) is observed in Diamare (16.7 %), Mayo-Kani (13 %) and Mayo-Danay (15 %). This is explained by the demographic mixing and the interest in other legume species given the very diverse eating habits of the populations in these three study areas.

4. Conclusion

Given the importance of Bambara groundnut for the populations of the Sahelian regions, it would be important for the public authorities to place emphasis on the promotion of this legume seed. Thus, the government incentive through the implementation provision of inputs to producers, strengthening and financing varietal selection programs, the possibilities of processing seeds of Bambara groundnut into other by-products and their valorization will make it possible to reverse the current trend of consideration of this legume.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the trend reported in this paper.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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