Journal of Agriculture and Ecology Research International

18(3): 1-14, 2019; Article no.JAERI.48735
ISSN: 2394-1073

Perception and Farmer Know-How on Conservation Techniques for Cereals and Pulses in the Far North of Cameroon

Mala Carine[1*], Kekeunou Sévilor[2], Lendzemo Venasius[3] and Nukenine Elias[4]

[1]Department of Biological Sciences, Faculty of Sciences, University of Maroua, Cameroon.
[2]Laboratory of Zoology, Faculty of Sciences, University of Yaoundé I, Cameroon.
[3]Regional Center, IARD Baboui, Cameroon.
[4]Department of Biological Sciences, Faculty of Sciences, University of Ngaoundéré, Cameroon.

Authors' contributions

This work was carried out in collaboration among all authors. Authors MC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KS, LV, and NE managed the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2019/v18i330060
Editor(s):
(1) Dr. Daniele De Wrachien, Department of Agricultural and Environmental Sciences, State University of Milan, Italy.
Reviewers:
(1) Daniel Kosini, Saint-Jérôme Catholic University, Cameroon.
(2) Arom Jantasorn, Srinakharinwirot University, Thailand.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48735

Original Research Article

Received 22 February 2019
Accepted 05 May 2019
Published 13 May 2019

ABSTRACT

Introduction: The storage and preservation of agricultural products remain the only conditions ensuring the almost permanent availability of foodstuffs. However, infestations due to insects and microorganisms are very often noted.
Objective: This present work aimed at understanding farmers' constraints, perceptions, and know-how on the post-harvest conservation of cereals and pulses.
Place and Duration of Study: A survey was conducted from March 2017 to March 2018 among 320 producers in the Far North region (Cameroon).
Methodology: The questionnaire consisted of closed and open questions which mainly related to the principal stored grains, the main constraints, and the usual means of control of stocks. The interview was conducted in a local language (Fulfulde), Arabic and/or French during 25 minutes for

**Corresponding author: E-mail: hadassaraymonde@gmail.com;*

each participant. Insect stock photos were also presented to the participants for confirmation of the information given.
Results: The results show that producers in our study area are aware of the post-harvest damage and adopt stock control techniques according to the nature of the products, the fate of the grain and the storage structure. The main food crops grown are sorghum (44.4%), cowpea (24.1%) and maize (15.60%). Six main types of storage structure; three methods of storing foodstuffs, five modes of packaging and, six usual methods of control were identified but store maintenance and warehouse monitoring (56.25%) was the most used. According to respondents, insects are the main causes of post-harvest losses. 11 species belonging to four orders were recorded.
Conclusion: The producers in our study area are aware of the post-harvest damage and adopt stock control techniques according to the nature of the products, the fate of the grain and the storage structure. But this control would be more efficient if all producers had access to training on storage techniques, isothermal bags or the use of resistant varietal genotypes.

Keywords: Cereals, pulse; storage structure; storage methods; postharvest.

1. INTRODUCTION

Cereals, as well as legumes, account for 75% of the staple food of people in developing countries, making them the main food source in the world [1,2]. In this respect, cereals in addition to representing 8 to 12% on average of daily protein intake; are very rich in glucose (starch), mineral salts including phosphorus and are the main source of vitamin B [3]. Legumes, on the other hand, are of triple dietary, ecological and economic interest [4,5,6]. Also, if food self-sufficiency means to produce enough, it also implies good conservation of this production for consumption as and when needed. Some authors share this view when they say that: "To counter food insecurity in the underdeveloped countries in the tropics and more specifically in sub-Saharan Africa; Africa must either reduce its population growth, increase its agricultural production by increasing crop yields and areas, or reduce losses before and after harvest" [7]. However, stored products are subject to deterioration of all kinds, which is caused by many agents including insects and stock pathogens that often damage much of the stored product [8].

Globally, losses of agricultural products caused by stored-product pests are 25 to 40% on average, ie 1.3 to 1.9 million tonnes and represent an annual monetary value of nearly $ 58 billion [9, 10, 11]. This percentage is even higher in developing countries in general and in sub-Saharan Africa in particular, where the rapid population growth and the food requirements it entails are the highest, underlining the importance of the problem to solve and constituting a persistent challenge.

In the face of these post-harvest losses, different control methods have been developed. These include physical methods (hermetic storage, drying), chemical control based on the use of synthetic pesticides, the use of plant material, the use of essential oils and varietal resistance [12, 13,14,15]. The excessive use of chemicals in the preservation of foodstuffs against their pests has serious consequences for the health of users, consumers and the environment, and often causes the development of resistance phenomena in certain insect pests [16,17]. Based on this observation and on the basis of observations on the involvement of the population in Western development aid [18], a survey of farmers' constraints, perceptions and know-how on the post-harvest conservation of cereals and legumes in the region of the Far North of Cameroon has been undertaken with the aim of looking for peasant know-how, capable of helping us to develop long-term integrated control strategies taking into account the sustainable protection of the environment.

2. MATERIALS AND METHODS

2.1 Study Site

Our study was conducted in 36 villages in the six divisions of the Far North region: 3 villages in the Highlands; 10 in the foothills; 10 in the Flood Plain and 13 villages in Dry Plain. This region is submitted to a Sudano-Sahelian climate characterized by two seasons: A short rainy season (June to September) and a long dry season (October-May) [19].

2.2 Questionnaire and Survey

The choice of villages and participants was facilitated by the support of the agricultural

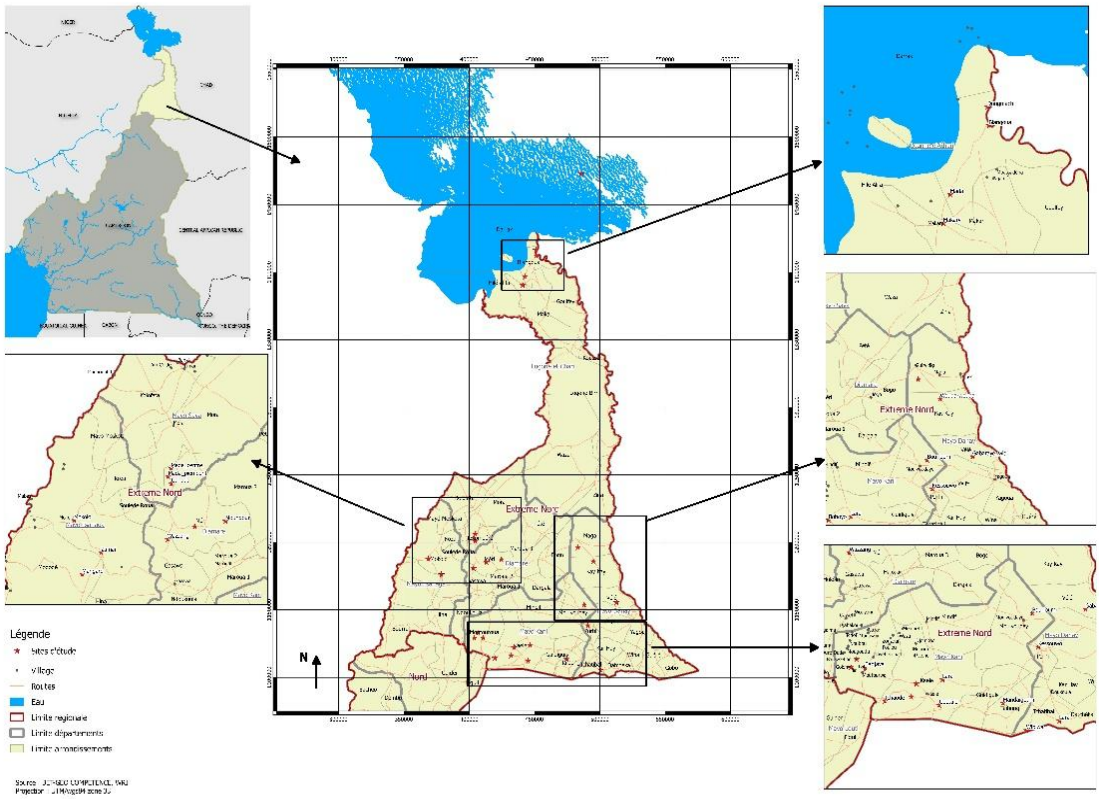

Fig. 1. Map of the study site presenting the 36 villages

agents on the basis of the production, availability, and diversity of the stocks. A semi-structured individual interview questionnaire was used in the survey [20]. A total of 320 farmers (241 men and 79 women) 38 in Diamaré, 99 in Logone et Chari, 38 in Mayo Danay, 28 in Mayo Sava and 28 in Mayo Tsanaga were interviewed separately within their farming areas or around their residence. The interviews were done in the local language (Fulfulde), Arabic and/or French and lasted approximately 25 minutes for each participant. The questionnaire consisted of 30 questions grouped into 4 main parts which sought to know: (1) the types of crops and cultural techniques carried out; (2) the products stored (nature, duration of flow, quantity and destiny) and grain conditioning modes; (3) the main storage structure; (4) the main constraints of stocks and the usual means of control. Data were also collected on the socio-demographic characteristics of respondents. Insect stock photos were also presented to the respondents for confirmation of the information given. The counting of the number of respondents by the flat-sorting technique made it possible to highlight the information sought.

2.3 Data Analysis

The qualitative and quantitative data were summarized as contingency tables and analyzed using the chi-squared test by SPSS 18. The separation of the averages statistically significant has been achieved using the test of Student Newman-Keuls at the probability level of 5%.

3. RESULTS

3.1 Socio-Demographic Characteristics of the Surveyed Population

Table 1 below gives the general characteristics of the 320 producers surveyed. Our results show that the age of participants ranged from 19 to 84 years with an average age of 42.60 ± 13.75 years. The most active population was recorded in the age groups that of over 50 years in all divisions (25.56%). Moreover, our study reveals that 42.5% of participants can neither read nor write. Furthermore, the main activity of the participants is agriculture (42.5%) and the main secondary activities practiced are also agriculture (47%).

Table 1. Distribution of respondents according to demographic characteristics in a different division

Variable	Category	Diamaré (n=38)	Logo. et Cha. (n=99)	Mayo Dan (n=38)	Mayo Kani (n=94)	Mayo Sava (n=28)	Mayo Tsana. (n=23)	χ^2 Value	*P*-value
Gender	Female	3.45	5.96	2.19	9.72	0.94	2.19		
	Male	8.46	25.08	9.72	19.43	7.84	5.02	9.92	.08ns
Age	Young (<25 years)	4.23	2.71	2.75	2.23	6.36	1.88		.21ns
	Middle age 25-35 years	20.95	20.46	20.64	17.32	28.14	18.16		
	35- 40 years	31.90	19.73	21.95	31.53	28.14	28.07		
								35.89	
	Old > 50 years	42.92	57.08	54.65	48.40	37.36	51.89		
Marital Status	Divorce/Widowed	7.90	6.06	2.64	8.51	3.57	4.35	28.52	.28ns
	Married	89.47	91.92	89.47	86.17	96.43	86.95		
	Single	2.63	2.02	7.89	5.32	0.00	8.70		
Education level	Illiterate	36.84	74.75	21.05	31.91	7.14	34.78	112.24	.0001***
	Primary	23.68	14.14	55.26	31.91	71.43	43.48		
	Secondary	31.58	4.04	18.42	32.98	21.43	21.74		
	Post secondary	5.26	7.07	0.00	0.00	0.00	0.00		
	Uuniversity	2.63	0.00	5.26	3.19	0.00	0.00		
Main activity	Public Salaried	5.26	1.01	2.63	2.13	7.14	0.00	52.99	.0009***
	Private samaried	5.26	2.02	28.95	6.38	7.14	4.35		
	Self-employment	26.32	39.39	13.16	44.68	25.00	60.87		
	Farmers	47.37	43.43	39.47	41.49	42.86	30.43		
	Others	15.79	14.14	15.79	5.32	17.86	4.35		
Secondary activity	Farmers	44.74	53.54	60.53	39.36	28.57	52.17	84.50	.0003***
	Livestock	13.16	18.18	15.79	8.51	46.43	21.74		
	Farmers and Liv.	7.89	1.01	18.42	11.70	14.29	8.70		
	Other	34.21	27.27	5.26	40.42	10.71	17.40		

† *Logo. et Cha.: Logon et Chari ; Mayo Dan. Mayo Danay ; Mayo Tsana: Mayo Tsanaga ; Farmers and Liv. : Farmers and Livestock*

Table 2. Distribution of percentage respondents according to culture system, principal and secondary cultures, quantity stored and area cultivated in the different division

Variable Division	Culture system (monocrop)	Principal culture (Sorghum)	Secondary Culture (Cowpea)	Quantity stored (1t-3t)	Area Cultivated (1ha and more)
Diamaré	9,4 (30)	8,8 (28)	14,8 (38)	7,8 (25)	11,3 (29)
Logone et Chari	17,8 (57)	0,6 (2)	27,2 (71)	12,5 (40)	34,8 (89)
Mayo Danay	10,9 (35)	6,2 (20)	12,1(31)	4,7 (15)	14,1 (36)
Mayo Kani	21,2 (68)	17,2 (55)	28,5 (73)	13,8 (44)	19,1 (49)
Mayo Sava	7,2 (23)	7,5 (24)	8,6 (22)	3,1 (10)	9,0 23)
Mayo Tsanaga	5,3 (17)	4,1 (13)	8,2 (21)	4,1 (13)	5,1 (13)
Valeur du χ^2	29.11	18.79	31.87	5,80	85.78
P-value	0.0012	<0.0001	<0.0001	0.001	<0,001

† The numbers in parentheses correspond to the number of participants in each division that responded for a variable considered

3.2 Characterization of Agricultural Holdings

3.2.1 Area exploited

The results show that 35.00% of respondents have farms of less than 1 hectare (ha) and 42.19% have 3 ha or more. The distribution by sex shows that 23.44% of men and 11.56% of women have a cultivated area between 1 and 2 ha while 36.88% and 5.31% respectively of men and women have an area of exploitation of more than 3 ha (Table 2).

3.2.2 Cultures realized and cultural techniques

The main food crops grown in this region were millet/sorghum (44.4%), maize (15.6%), and cowpea (24.1%). To these crops were added onion, cotton, sesame, groundnut, peanut, potato, Bambara groundnut, and market gardening. With regard to cropping techniques, respondents said 71.88% practice the monoculture against 28.12% who make the polyculture (cereals/market gardening). The most common crop-growing systems are cowpea or Bambara groundnut or groundnut with Sorghum or Millet, on the one hand, groundnut, market gardening (okra, vegetables) with Maize or Millet on the other hand.

3.3 Characterization of Stored Products: Nature, Quantity, Destiny and Flow Time

3.3.1 Nature of grain and quantity of stocks

A total of 09 types of grain were identified in the storage structures. The analysis of our results reveals that there is a significant difference in the nature of the grains stored in each division ($\chi 2$ = 655.76, *P*-value = 0.0001). Sorghum/Millet is the main storage commodity followed by cowpea and maize respectively 49.7%, 26.56%, and 18.13%. According to the quantities, the most important stocks are in order of decreasing Sorghum, Maize, Cowpea, Groundnut, Sesame, Bambara groundnut, Rice, Millet, and Soy (Fig. 2).

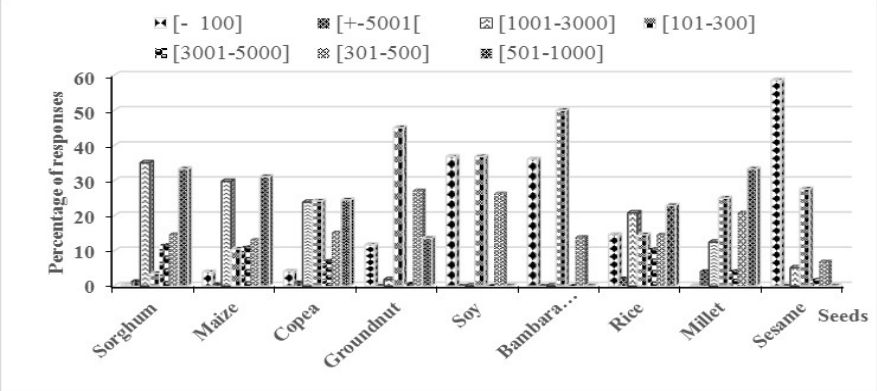

Fig. 2. Distribution of quantities of stored seed in the Far North region

3.3.2 Destiny of stocks

From a total point of view, the cereals stored in this region are according to our sample and independently of the division considered, intended mainly for the consumption whereas the legumes are primarily intended for the sale and oilseeds for sale and consumption. In fact, 58.04%, 55.90%, 66.66% and 27.66% of the stocks respectively of Sorghum, Maize, Millet and Rice on the one hand and on the other hand, 5.81%, 15.76%, 34.29% of the Cowpea, Soy and Bambara groundnut stocks are destined for self-consumption. Similarly, 6.25%, 6.55% 4.17% and 21.28% of the stocks of Sorghum, Maize, Millet and Rice for 55.80%, 63.15% and 37.14% of stocks. Cowpea, Soy, and Bambara groundnut are for sale. Despite the almost familiar fates of each commodity, it has been reported that, depending on the needs, consumer goods may be sold and vice versa. The seeds of these producers came for the most part from previous harvests.

3.3.3 Running time of stocks

The duration of disposal of stocks depends mainly on the destination of the commodity and its nature and secondarily on its quantity and the type of storage structure. In fact, cereals are kept for a relatively longer time than legumes (Fig. 3). The analysis of these results shows that among the cereals Sorghum and Millet appear to be the foods that are kept longer with an average duration of twelve months, followed by Bambara groundnut and Soy (7-9 months), then corn, peanut, sesame and rice (about 6 months) and finally cowpea which has an average shelf life of fewer than 6 months.

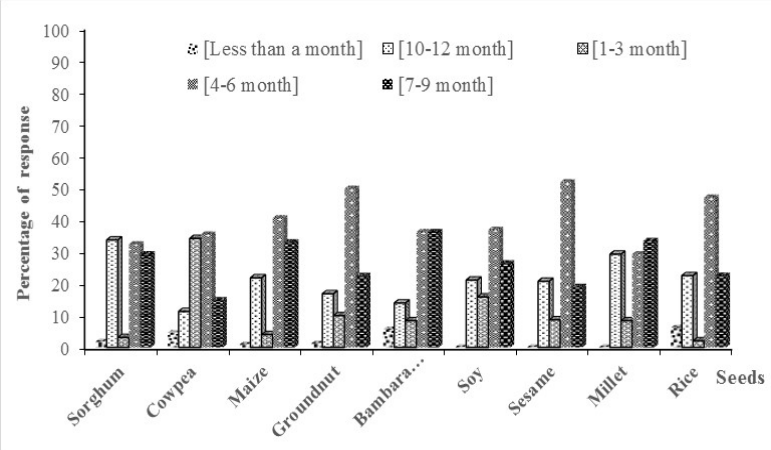

Fig. 3. Distribution of the average duration of disposal of stocks of food stored in the Far North region

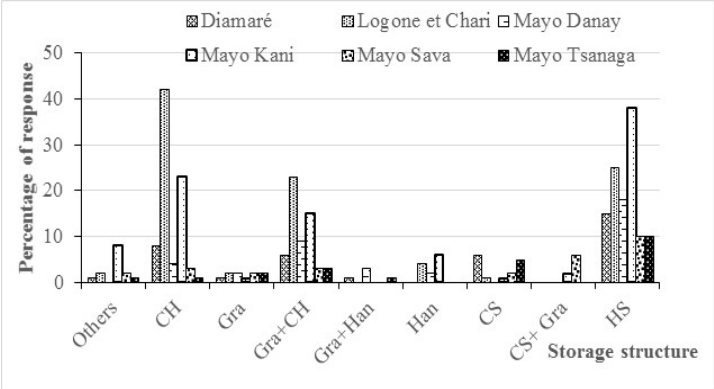

Fig. 4. Distribution of the different storage structures used in the Far North region

Legend: CH: Corners houses; Gra: Granaries; Gra+CH: Granaries+Corners Houses; Gra+Han; Granaries+Hangar; Han: Hangar; CS: Community Store CS+Gra: Community store+ Granaries; HS: House Store

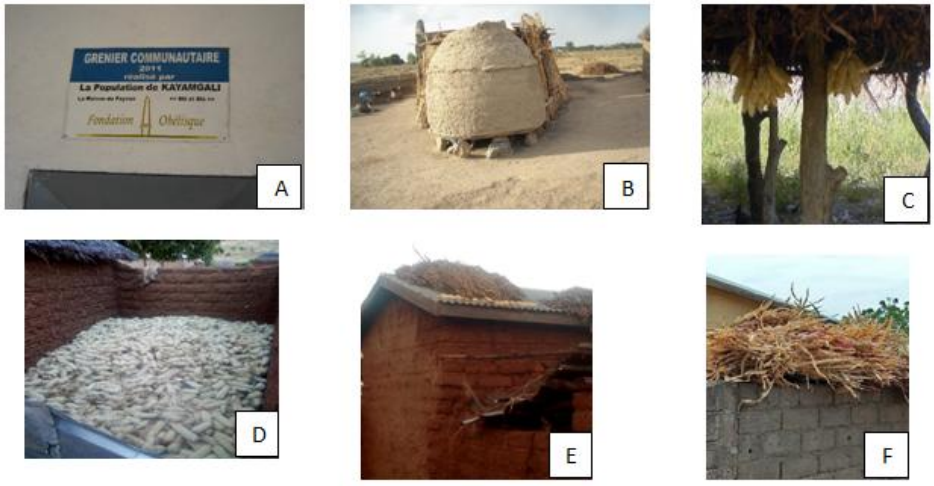

Fig. 5. Images of some grain storage structures in the far north region (Mala, 2017)

Legend: A. Community store; B. Granary; C. Hangar; D. Bulk storage at concession corner; E. Rooftop storage of houses; F. Storage racks

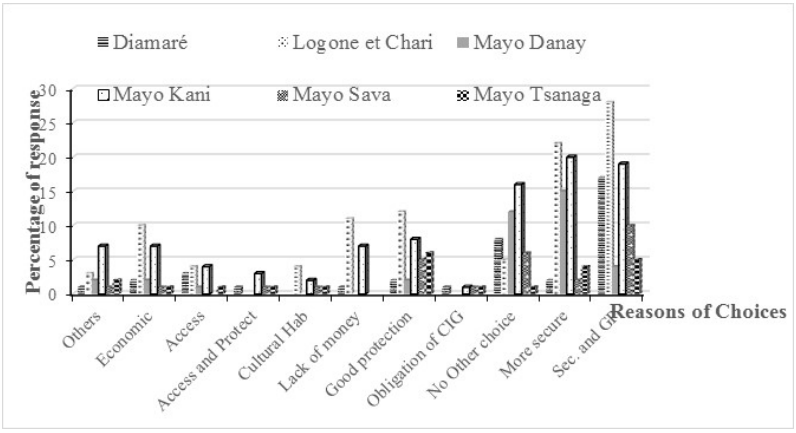

Fig. 6. Distribution of the various reasons advanced justifying the choice of the storage structure

Legend: Assess: Accessibility; Access and Protect: Accessibility and Protection; Cultural Hab: Cultural Habits; Sec and GP: Security and good protection

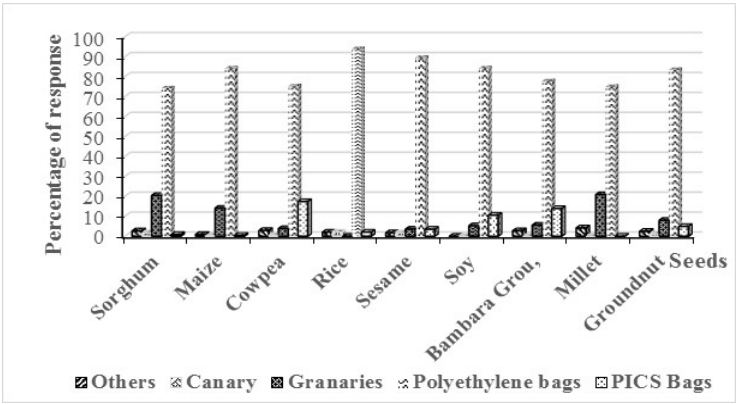

Fig. 7. Distribution of packaging stocks according to the nature of the grains

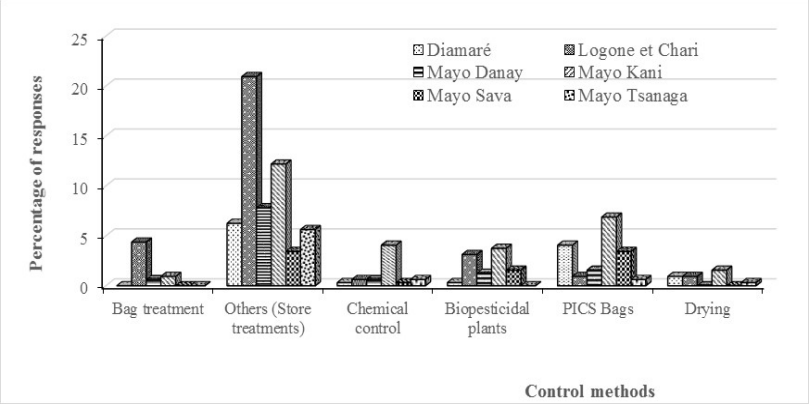

Fig. 8. Distribution of usual means of stock protection in the Far North region

Table 3. Diversity of industrial chemical insecticides, their active ingredients in northern Cameroon and their classification according to the standards of the joint meeting for pesticides management FAO / WHO (WHO, 2009)

Trade names	Actives ingredients	Families*	Classe**
Phostoxin	Aluminum phosphide	PI	Ia
Thioral	Heptachlor	OC	O*
Marshall	Carbosulfan	CA	II
K-Optimal	Lambda-Cyhalothrin 15 g/l + Acetamiprid 20 g/	Pyr Néo	II
Rambo	Permethrin	Pyr	III
Pia-pia	Dichlorvos	OP	Ia
Malagrain	Deltamethrin	OP	III
Calthio	Chlopyrifos-méthyl + thiram	OP	III
Optimal	Acetamiprid 200 g/kg	Pyr	II

*Legend: * OC: organochlorine; OP: organophosphorus; PI: inorganic phosphide, Pyr: pyrethroid; CA = carbamate; Neo: Neonicotinoids ; † The three classes observed among the five possible classes are: class Ia: Extremely dangerous; class II: Moderately dangerous; class III = Not dangerous; O*: Obsolete because this active ingredient is no longer registered in Cameroon*

3.4 Characterization of Storage Structures and a Reason for the Choice

Six main types of storage structure were identified in the participants (Fig. 4), depending on the nature of the commodity, the fate and the quantity χ^2 = 57.74, *P*-value = 0.03). The storage structures most often favored by farmers are home stores (36%) and house corners (25%).

About 18% of participants say they store their food simultaneously in attics/sheds and house corners, depending on the nature of the grain and its intended purpose. In fact, legumes and oilseeds (groundnut) are placed on the roofs of houses ("Dankins" / sheds) and grain cereals in the attics or on racks in the houses. In the absence of attics, the grains are ginned and put in bags and stored in corners of houses or shops. Some storage structures encountered in the study site were illustrated in Fig. 5 (A to F). 63.1% of respondents say that they choose one storage unit according to the nature of the grain, safety, and accessibility (χ^2 = 83.46, *P* = 0.002) (Fig. 6).

3.5 Main Constraints of Stocks and the Usual Control

The main storage constraints reported by participants are, in order of importance, insects, rodents, mold/moisture and birds. Insects alone can cause losses of more than 50% of the harvest over an average of 4 months. The largest losses are recorded on cowpea while the lowest losses are recorded on Millet, Soy, and Sesame

(less than 25% over an average duration of 7 months).

The evaluation of the entomaufaune subservient to inventoried stocks reveals a great peculiar wealth of pests. A total of 11 species in four different orders were identified by the producers. They are Coleoptera, Lepidoptera, Hymenoptera (family *Pteromalidae*) and *Blattoptera*. From this inventory, species of economic importance due to the damage caused were according to the participants: *Callosobruchus maculatus* (37.20%) stock pests (legumes), *Sitophilus* sp. (30.30%), *Tribolium* (10.20%) and Lepidoptera (4.4%). The damage from mildew, rodents, and termites is not the least.

In the face of the qualitative and quantitative damage caused by these insects, various protection techniques are carried out on the commodities to be stored as soon as they are lightened. These are drying, packaging and storage. In fact, all the foodstuffs intended for storage once collected from the fields will be dried beforehand (at least 3 hours) and then preserved according to three main storage methods: ears (cereals), pods (legumes) and grains (cereals and cereals). legumes) and 6 methods of packaging. Depending on the nature of the foodstuff to be stored, participants say that their food is mainly packed in polythene bags (69.5%), PICS bags mainly for legumes (16.90%), and granaries / Hangars / Roofs of houses (in ears or pods) (Fig. 7).

In total, 6 main usual means (traditional and modern) of stock protection were mentioned by the participants in this survey. This is the chemical control (6.56%), the use of plant derivatives (barks, roots, oils, leaves or ashes) (10%), the use of PICS bags (17.50 %), bag processing (5.94%), drying / bagging (3.75%), and store maintenance and warehouse monitoring (56.25%). In the same way, several parental techniques continue to be applied by the farmers are mainly the storage of the crops in the lofts, the hangars, and the Canaries after drying is 36.99% of the techniques mentioned. It should be noted that some producers claim to introduce chemicals into granaries prior to storage and plant material during shelf life. 85.75% of people who use the maintenance of the stores say they do it with chemicals that they apply on the bags, the soil or in the enclosure of the structure of storage. In the same vein, 87.75% of participants using chemical control say they do not perform contact treatments on grains compared to 12.25% who practice them. And anyone who says they treat the bags says dip them in a chemical-based solution before introducing the grains. From a total point of view, the participants in this survey mainly use chemicals with regard to modes and forms of application.

In addition, we find that there is a significant difference between the means of controlling selected stocks and the divisions. Indeed, the Mayo-Kani division is the one where the producers have the most recourse to modern methods like the spraying of chemicals in warehouses, introduction of tablets of phostoxin into bags and use of PICS bags. Similarly, producers in the Logone and Chari division use the most traditional methods such as the maintenance of warehouses, introduction of plant material derivatives into bags, salt and soaking of bags in macerations plants (Fig. 8).

This non-exhaustive analysis of the usual means of stock control allows us to understand that farmers in the Far North region of Cameroon have developed several strategies for the conservation of their foodstuffs. However, it should be noted that the traditional methods (drying, plant material, ash) of storage are effective for small quantities, for short duration and for foodstuffs intended for consumption. Therefore, these methods will have several limitations when it comes to producers of large quantities primarily for sale. Also given the quantitative, qualitative and organoleptic losses that insects cause on commodities with the effect of falling prices, large producers will tend to practice chemical control which offers better management of stocks over a relatively long period with better financial impact but with repercussions on the health of consumers, traders and the environment.

A total of eight products and 10 active ingredients belonging to 06 families divided into 3 Organophosphates, 3 Pyrethroids, 01 Organochlorines, 01 Neonicotinoids, 01 Carbamates, and 01 Aluminum Phosphides were cited by producers in our study area (Table 3).

4. DISCUSSION

This study has allowed us to understand the conservation conditions of cereals and pulses in the Far North region of Cameroon and to

determine the level of technicality of the producers as regards the conservation of their harvest. From the demographic characteristics, it can be seen that the respondents involved in the survey have a low level of formal education and more than 78% depend on agriculture or self-employment for their survival. This could be one of the factors limiting the ability of the respondents to adopt and/or use improved or popularized storage techniques and the equipment made available to them by the various support structures. These results are similar to those obtained in Kwara state in Nigeria and in southern Africa (Malawi and Zambia) [21,22]. Furthermore, 71% practice a monoculture with 3 main crops. These results are similar to those obtained by some authors who claimed that sorghum, millet, and cowpea were the main crops in the Guinean and Sudano-Sahelian savannah areas of Nigeria [23]. Certain authors report that in Mali and around the Lake Chad Basin cowpea monocrop is increasingly practiced as a bargaining chip for agricultural inputs [24, 25]. These results are contrary to those obtained in South Cameroon zone where 69% of farmers practice polyculture in the cropping systems to solve the problem of declining soil fertility and pests [26].

On the other hand, the harvest of cereals is intended for the consumption and the legumes for the sale. These results corroborate those of some authors who reported that cereals, especially millet, maize, and sorghum are the staple foods of the Sahelian populations in Africa [27,28]. It had already been noted out in earlier work reports that in the different farming systems of the Far North, sorghum and millet were the main food crops that were widely grown and consumed by the rural population while maize, groundnuts rice, and cowpea are classified as cash crops and self-consumption [29]. These cereals are kept longer time than legumes. This could be due to the storage mode (ears or spikes) of cereals. Also, the storage in spikes ensures better conservation [30].

Two predominant types of storage structure were identified among the six home stores (36%) and house corners (25%). These results are similar to those obtained by some authors on legumes and on cereals [31,32]. These modalities are due in large part to the fear that producers will have their crops stolen.

The Main storage constraints reported by respondents are consistent with those of several authors who claim that in the Sahelian zones, the risks of stock degradation come mainly from insects and rodents [31,33,34].

Pest entomofauna associated with stocks identified by respondents is similar to that of several authors on cereals and pulses. Eight species on Bambara groundnut seeds in the southern half of Togo were recorded [35]. In the High Bassin region of Burkina six species have identified on the grains of Bambara groundnut and cowpea [31]. On cereals stocks, i11 species were identified of the southern Sudanian zone of Burkina Faso [32]. The presence of 18 species in northern Cameroon, including *Sitophilus zeamais*, S. oryze, *Callosobruchus maculatus, Tribolium castaneum, Sitotroga cerealella,* and *Ephestia elutella* has been reported [36]. In contrast to the studies conducted by these authors, we observed *Prostephanus truncatus* (Horn), *Rhyzopertha dominica* F., *Caryedon serratus* (Oliv.) and Isoptera (termites) in the storage structures of our study area. Several authors have reported the presence of *P. truncantus* on corn on the cob or seed and *R. dominica* on legumes [31,33,37,38,39]. The presence of *P. truncatus* in our area could be attributed to the multiple movements of refugees in recent years. *Dinarmus basalis* observed in these stocks has the status of a natural enemy of beetles pests stocks.

In fact, the Larger grain borer is an important pest of cereals [40] and its absence in Cameroon was once attributed to the release at various points of the continent of its predator *Teretriosoma nigriscens* which would have caused its scarcity or absence during surveys [10]. However, its presence was reported in Nigeria in 1992 when no inoculation of *Teretriosoma nigriscens* had been made [41]. Also, the different displacements observed for a few years on the northern borders of Cameroon with Nigeria could have allowed an accidental reintroduction of the pest in Cameroon.

Several methods were identified by the respondents as means of controlling their stocks including chemical control, plant material used, packaging methods, and warehouse maintenance. These results corroborate those of [42]. Also, seven of the eight products used by growers are likely to cause insect resistance, particularly on Stitophilus species [43, 44]. To these resistances are added the risks of intoxication emanating from the non-respect of

the doses, the ignorance of the products and the fragility of the ecosystems of this zone. Indeed, the 'Phostoxin insecticide' formulated from aluminum phosphide and class Ia product (extremely dangerous) is among the products approved by Cameroon [45] and is the most used on stocks of legumes. In addition, producers say they use cotton products (Optimal) or rodents and other insects (Rambo) on commodities. Similarly, Pia-pia and Marshall pulverized by producers in warehouses or on bags are banned products on the markets of Cameroon [46] because of their strong persistence in the environment, their high lipophilicity, their non-biodegradability and their potential for bioaccumulation in adipose tissue as well as throughout the food chain up to breast milk with impacts on male fertility [17].

5. CONCLUSION

This study shows that the low standard of living of the populations, the low access to inputs (quality seeds, fertilizers) and the damage caused by the pests during storage in our study site constitute a drive for food security. In spite of the fact that each family applies to its exploitation, the climatic hazards amplified by the losses caused during storage constitute the two main constraints to the production and the reduction of the famine. Indeed, cereal crops stored for long periods are also those so inflation alters very little or almost no portfolio of the producer especially when we know that the cultivation of sorghum against season can overcome the lack of cereals. However, legumes, the main sources of vegetable protein and thus products of inflation is remarkable during the lean season are the most attacked storage and therefore the fastest sold. In addition, the fact that growing legumes requires very little means, many producers diversify in this sector to the detriment of cereal cultivation without benefiting from it for lack of good conservation techniques respectful of human health and health. environment. The finding is therefore that the weakness of food supplies is reinforced by the lack of grain stocks and the shortage in the markets of certain staple foods such as millet and sorghum causing destocking as well as the almost systematic sale of the main legumes. The cash crop character of legumes and mainly cowpea suggests a food imbalance in this population that leads to malnutrition. To remedy this situation and thus allow the production of each family to reduce famine in the region, we recommend techniques of protection of stocks typically biological and less expensive.

ACKNOWLEDGMENTS

The authors warmly thank the Regional Center for Agricultural Research of Maroua (RCARM) for facilitating travel in the various departments. We are also very grateful to the Departmental Delegates of Agriculture and Agricultural Heads of the constituency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gueye B, Schoonmaker FK. Introduction à la méthode accélérée de recherche participative (MARP), Quelques notes pour appuyer une formation pratique, Pub. IIED, London (UK). 1991;69.
2. Adjalian E, Noudogbessi JP, Kossou D, Sohounhloue D. État et perspectives de lutte contre *Sitotroga cerealella* (Olivier, 1789), déprédateur des céréales au Bénin: synthèse bibliographique. J. Appl. Biosci. 2014;79:6955–6967.
3. Shewry PR. Improving the protein content and composition o cereals grain. J. Cereal Sci. 2007;46:239-250.
4. Lienard V, Seck D. Revue des méthodes de lutte contre Call*osobruchus maculatus* (F.) (Coleoptera: Bruchidae), ravageur des graines de Cowpea *(Vigna unguiculata* (L.) Walp) en Afrique tropicale. Insect Sci. *Applic.* 1994;15(3) :301-311.
5. Langyintuo AS, Lowenberg-DeBoer J, Faye M, Lambert D, Ibro G, Moussa B, Kergna A, Kushwaha S, Musa S, Ntoukam G. Cowpea supply and demand in West and Central Africa. Field Crops Res. 2003; 82:215-231.
6. Duc G, Mignolet C, Carrouée B, Huyghe C. Importance économique passée et présente des légumineuses: Rôle historique dans les assolements et facteurs d'évolution. Innovations Agronomiques. 2010;11:1-24.
7. Delobel A, Tran M. Les coléoptères des denrées alimentaires entreposées dans les régions chaudes. Faune Tropicale XXXII. ORSTOM/ CTA Eds, Paris. 1993;424.

8. De groot I. Agrodok 18: Protection des céréales et des légumineuses stockées. Fondation Agromisa, Wageningen; 2004. [ISBN : 90-77073-88-4]
9. Kumar R. La lutte contre les insectes ravageurs. Karthala et CTA: Paris. 1991; 10- 311.
10. Ngamo LST, Hance TH. Diversité des ravageurs des denrées et méthodes alternatives de lutte en milieu tropical. Tropicul. 2007;25(4):215-220.
11. Goergen. Petit manuel d'identification des principaux ravageurs des denrées stockées en Afrique de l'Ouest, l'Institut International d'Afrique Tropicale (IITA), Benin. 2008;20.
12. Dabiré C. Étude de quelques paramètres biologiques et écologiques de *Clavigralla tomentosicollis* STAL., (Hemiptera: Coreidae) punaises suceuses des gousses du Cowpea (*Vigna unguiculata* L.) dans une perspective de lutte durable contre l'insecte au Burkina Faso. Thèse de Doctorat d'état, Université de Cocody, Cocody. 2001;179.
13. Isman MB. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu Rev Entomol. 2006;51:45-66.
14. Ketoh GK, Koumaglo HK, Glitho AI. Inhibition of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) development with essential extracted from *Cymbopogon schoenanthus* L. Spreng. (Poaceae) and the wasp *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae). Journal J. of Stored Products Prod Research Res. 2005;41:363-371.
15. Ngamo LST, Ngassoum MB, Mapongmetsem PM, Malaisse F, Haubruge E, Lognay G, Hance T. Current post-harvest practices to avoid insect attacks on stored grains in Northern Cameroon. Agr. J. 2007;2(2):242-247.
16. Pazou EYA, Boko M, Van Gestel CAM, Ahissou H, Lalèyè P, Akpona S, Van Hattum B, Swart K, Van Straalen NM. Organochlorine and organophosphorous pesticide residues in the Ouémé river catchment in the Republic of Benin. Environment Environ. International. 2006; 32(5):616-623.
17. Kanda M, Wala K, Batawila K, Djaneye-Boundjou G, Ahanchede A, Akpagana K. Le maraîchage périurbain à Lomé: pratiques culturales, risques sanitaires et dynamiques spatiales. Cahiers Agri-cultures. 2009;18(4) :356-363.
18. Bouvier N. L'usage du monde. Librairie Droz; rééd. Petite bibliothèque Payot/Voyageurs, Lausanne, Suisse 1992; 349.
19. Jebkalbe P. Les agriculteurs face aux enjeux de la conservation de l'environnement dans la région de l'extrême-nord du Cameroun. ISDA 2010, Montpellier, France. Cirad-Inra-Sup Agro, hal-00525957; 2010;20.
20. Gueye B, Schoonmaker FK. Introduction à la méthode accélérée de recherche participative (MARP), Quelques notes pour appuyer une formation pratique, Pub. IIED, London (UK). 1991;69.
21. Segun FB, Olubunmi OA, Zainab AT. An economic survey of cowpea (V*igna unguiculata*) storage practices in Kwara state, Nigeria. Bangladesh J. Agril. Res. 2014;39(1):47-57.
22. Kamanula J, Sileshi GW, Belmain SR, Sola P, Mwumi BM, Nyirenda GKC, Nyirenda SP, Stevenson PC. Farmers' insect pest management practices and pesticidal plant use in the protection of stored maize and beans in Southern Africa. International Inter. Journal J. of Pest Management Manag. 2011;57(1):41–49.
23. Zhang W, Kato E, Bianchi F, Bhandary P, Gort G, Van der Werf W. Farmers' perceptions of crop pest severity in Nigeria are associated with landscape, agronomic and socio-economic factors. Agriculture Agric, Ecosystems Ecosy and Environment Environ. 2018;259:159–167.
24. Coulibaly O. Factors affecting the adoption of agricultural technologies in sub-Saharan Africa: The case of new varieties of cowpea around the agricultural research station of Cinzana, Mali. MSc thesis, Michigan State University, East Lansing, Michigan, USA; 1987.
25. Pedune-Cameroon. Production ecologi-quement durable du niébé. Annual country report. Cameroon. International Institute of Tropical Agriculture, Cotonou. Benin; 1999.
26. Atemkeng MF, Neba NA. Assessing farmers' knowledge on the role of cowpea in improving soil fertility in cropping systems in southern Cameroon Asian Journal J. of Agricultural Agric Extension, Economics & Sociology. 2017;19(3):1-8.

27. Fofana A, Mbaye DF. In: Production du mil au Sénégal: Contraintes et perspectives de recherches. ISRA Direction des Recherch sur les Cultures et Systèmes Pluviaux, Dakar. 1990;7.
28. Neethirajan S, Karunakaran C, Jayas DS, White NDG. Detection techniques for stored-product insects in grain. Food Control. 2007;18:157-162.
29. Njomaha C. Durabilité des systèmes de culture dans l'Extrême-Nord Cameroun. Actes du colloque, 27-31 mai 2002, Garoua, Cameroun. 2002;1-10.
30. Cruz JF, Troude F, Griffon D, Hébert JP. Conservation des graines en régions chaudes (2 édn). Coll. Minist. Fr Coop et Dév. Techniques rurales en Afrique, CEEMAT/CIRAD : Montpellier. 1988;545.
31. Sankara F, Gondé Z, Sanou AG, Somda I. Diagnostic participatif des pratiques paysannes post-récolte et des contraintes de stockage de deux légumineuses cultivées dans la région des Hauts-Bassins du Burkina: Cas du Cowpea, *Vigna unguiculata* (L.) Walp. et du Bambara groundnut (*Vigna subterranea* (L.) Verdc. International Intern. Journal J. of Innovation Inn and Applied App Studies. 2016;16(3):646-656.
32. Waongo A, Yamkoulga M, Dabire-Binso CL, MNBA, Sanon A. Conservation post-récolte des céréales en zone sudsoudanienne du Burkina Faso : Perception paysanne et évaluation des stocks. Int. J. Biol. Chem. Sci. 2013;7(3): 1157-1167.
33. Bosque-pérez NA. Insectes nuisibles du maïs entreposé : biologie et méthodes de lutte. Guide de recherche de l'IITA No. 30 Programme de la formation, Institut international d'agriculture tropicale (IITA), Ibadan, Nigéria. 1992;32.
34. Rajendran S. Postharvest pest losses. In Encyclopedia of Pest Management, Pimentel D (ed). Marcel Dekker, Inc: New York. 2002;654–656.
35. Nyamador SW. Influence des traitements à base d'huiles essentielles sur les capacités de reproduction de *Callosobruchus subinnotatus Pic.* et de *Callosobruchus maculatus* Fab. (Coleoptera : Bruchidae) : Mécanisme d'action de l'huile essentielle de *Cymbopogon giganteus* Chiov. Thèse de Doctorat, Université de Lomé, Togo; 2009.
36. Ngamo LST Deuxième rapport annuel (2000-2001). Grand programme de recherche universitaire. Développement et valorisation des ressources animales et végétales. Protection intégrée des denrées stockées. Université de Ngaoundéré. 2001;15.
37. Philogène BJR, Arnason JT, Lambert JDH. Facteurs contribuant à la protection du maïs contre les attaques de *Sitophilus* et *Prostephanus. Céréales en régions chaudes.* Paris: AUPELF-UREF, John Libbey, Eurotex; 1989.
38. Holst N, Meikle WG, Markham RH. Grain injury models for *Prostephanus truncatus* (Coleoptera: Bostrichidae) and *Sitophilus zeamais* (Coleoptera: Curculionidae) in rural maize stores in West Africa. J. Econ. Entomol. 2000;93(4):1338–1346.
39. Vowoter KA, Meikle WG, Ayertey JN, Markham RH. Distribution and association between the larger grain borer *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) and the maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) in maize stores. J. Stored Prod. Res. 2004;41:498-512.
40. Helbig J. Écologie de *Prostephanus truncatus* au Togo examinée notamment du point de vue des interactions avec le prédateur *Teretriosoma nigriscens*. GTZ, Eschborn; 1995.
41. GTZ. Propagation de *Prostephanus truncatus* et de son prédateur *Teretriosoma nigriscens* en Afrique GTZ, Eschborn; 1999.
42. Folefack DP, Sobda AG, Tengomo SO, Boukar, Tahirou A. Vulgarisation de la méthode du triple ensachage pour le stockage amélioré du Cowpea en zone sahélienne du Nord Cameroun: Enjeux et perceptions paysannes. Tropicultura. 2013;31(3):170-178.
43. Odeyemi OO, Ashamo MO, Akinkurolere RO, Olatunji AA. Resistance of strains of rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae) to pirimiphos methyl. 10th International Working Conference on Stored Product Protection. Julius-Kühn-Archiv. 2010;425(1):1-6.
44. Guèye MT, Seck D, Wathel JP, Lognay G. Lutte contre les ravageurs des stocks de céréales et de légumineuses au Sénégal et en Afrique occidentale : synthèse

bibliographique, Biotechnol. Agron. Soc. Environ. 2011;15(1) :183-194.

45. MINADER. Index phytosanitaire du Cameroun, édition 2014. Ministère de l'Agriculture et du Développement Rural Ed. Yaoundé. 2015;395.

46. MINADER. Arrêté N°27/09/A/MINADER/ SG/CNHPCAT/SEC du 23 mars 2009 portant interdiction d'utilisation des produits phytosanitaires contenant le Carbosulfan (Marshal 35 DS, Marshal 480); 2009.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/48735