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Grain Storage and Pest Management by Smallholders in Some Localities of North-West Region, Cameroon

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Abstract: Cereals and legumes grains are sustainable crops and major source of proteins, energy and fibre. Their storage is essential, since, their cultivation is done in the short period while consumption and marketing are carried out along the year. A survey in eight localities of North-West Region Cameroon with 366 respondents was carried concerning smallholder's knowledge on storage activity regarding stored commodities, storage facilities and protection methods. The survey showed that women were the most involved in storing grain with the group's age from 25-45 years old representing the most involved ages. Maize (43.2%) was the most stored grain followed by beans (18.3%) and groundnut (18%). Different types of storage facilities were reported but bag was the most used (45.9%). During the same survey it was found that smallholders use many protection methods and the use of chemicals or insecticides was the most common in all the eight localities. However, it has been found that the chemical application has some harmful effects with regards to their handling and management. Some smallholders stored their grain without any protectant (13.1%). The storage of grains in these localities allowed the availability of grains for meal, income and seed. The results of this study would help to address the problems linked to grain storage and find out the necessary measurements to improve this activity in turn to insure the quality and quantity of stored grains.

Key words: Cereals, legumes, storage, smallholders, North-West Region Cameroon, protection methods

INTRODUCTION

The food production remains a major preoccupation in the developing countries, especially, in Sub-Saharan Africa (SSA) where agriculture is not enough mechanized like Cameroon. Food grains have been the critical component of human diet for thousands of years and have played very important role in shaping human civilization. Legumes and cereals are at the basis of diet of the majority of the world population even entirety. Over 50% of world daily caloric intake is derived directly from cereal grain consumption (Yang, 2018).

Cereals and legumes are sustainable crops and major source of proteins, energy and fibre which human beings particularly rely on. Pulses offer many benefits for nutrition, health and chronic disease prevention. As a result, there has been increased interest from food companies in using pulse for product formulations (Yang, 2018). These seeds are valued worldwide as an inexpensive meat alternative and are considered the second most important food source after cereals (Kouris-Blazos and Belski, 2016). Legumes are nutritionally valuable, providing proteins with essential amino acids, complex carbohydrates, dietary fibre, unsaturated fats, vitamins and essential minerals for the human diet (Rebello *et al*., 2014; Bouchenak and Lamri-Senhadji, 2013).

Legumes and cereals have proven to be a cheap source of nutrients as well as a potential source of income for subsistence farmers who cultivate legumes at household level. In some parts of the world it is still regarded as the prime source of energy (56%) (Partil). Cereal consumption provides a significant amount of energy to human body as cereals are a rich source of starch and protein; nearly 50% of the world's cereal production is used for human consumption

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(Brennan *et al*., 2012). Cereals also contain dietary fibre and resistant starch which have been linked to beneficial nutritional profiles.

The cultivation of these staple foods is done during the rainy season whereas its consumption and marketing are carried out along the year. Therefore, the storage of these grains is an imperative. In order to provide food, the storage permits farmers to keep quantity of grain that will be used as seeds for the next agriculture campaigns. Then to be effective, storage management requires a supply chain approach, since, the crop is still in the field (preharvest) until the stored seed or grain is removed from storage for utilization. In North-West Region of Cameroon, cereal and legume crops are grown seasonally mostly during the rainy season and after harvesting, theirs grains are stored for short or long period as food reserves and as seeds for next season. Stored grains are subject to damage by many factors such as insect's infestation, fungi attacks and rodent damages. This situation is very common in the tropical zone which is characterized by the grain loss. Postharvest loss accounts for direct physical losses and quality losses that reduce the economic value of crop, or may make it unsuitable for human consumption (Kumar and Kalita, 2017). According to, the World Bank report, Sub-Saharan Africa (SSA) alone loses food grains worth about USD 4 billion every year (Zorya *et al*., 2011).

The level of postharvest losses in grain supply chains varies significantly, depending on the economy, agricultural conditions and practices and climatic conditions of the locality. While grain loss in developed countries range between 5-10% of the total commodities stored, it is considerable in the developing countries with about 50% loss within short storage time (Adam *et al*., 2006). This grain loss during storage leads food insecurity and precariousness. That situation is exacerbated in the SSA where the majority of population is poor and the agriculture is not mechanized enough. Cameroon is not an exception to this situation. Cameroon still satisfies only about 28.8% of demand via. local production. In order for the country to have a sustained growth and achieve its goal of agricultural production; there is need for proper management of pre and post harvest losses (Bime *et al*., 2015).

The availability of grains can be improved in vulnerable regions not only by increasing production but also the storage. A good storage reduces the pressure on the environment that can be induced by increasing agricultural production. Then many strategies are used to overcome grain losses during storage. This study shows the strategies used by the smallholders in order to bring out the lacks for insuring good grain storage in the surveyed localities.

The main goal of this study was to determine the smallholder's knowledge in grain storage in some localities of North-West Region of Cameroon. Therefore, the study intended to investigate on the types of stored grains, the perception of peasants on pest infestation and bringing out the strategies used to reduce stored grain loss.

MATERIALS AND METHODS

Study sites: The study was carried out in eight (08) localities in North-West Region of Cameroon; four in Ngoketunjia and four in Mezam divisions (Fig. 1). The North West Region of Cameroon is located between 5°4' and 7°15' Latitude North and 9°30 and 11°15 Longitude East. It covers a total area of 17 910 km^2. The North-West Region is composed of 7 divisions including: Mezam (Bamenda being the capital), Boyo (Fundong), Bui (Kumbo), Ngoketunjia (Ndop), Donga Mantung (Nkambe), Menchum (Wum), Momo (Mbengwi). North-West Cameroon is limited in South by West, East by Adamaoua and West by South-west Regions of Cameroon and the North by Taraba State of the Federal Republic of Nigeria. The region is characterized by accidental relief of massifs and mountains (Innocent *et al*., 2016). The soil is constituted by basalts, granitic sandy soils.

According to the 2005 census, the population of North-West was 1,728,953 inhabitants with a density of 97 inhabitants/km^2 (BUCREP). Mean monthly temperature range from about 15°C on the highlands to about 27°C in low-lying regions (Abia *et al*., 2016). Rainy season lasts for 7-8 months and the annual rainfall is 1500-1770 mm.

Sampling method and data collection: Multi-stage sampling was employed in selecting smallholder farmers in the area of study. Eight localities were chosen, four for each division of the region; Babungo, Bamali, Bamessing and Bamunka from Ngoketunjia divion and Agiati, Mambu, Mforya and Nsoh from Mezam division. The questionnaires were administered to the participants were chosen because of their availability in each locality. The questionnaires were focused on social characteristics, stored products and perception on storage activity (pest, damage, pest control methods and their effects). The data collected were analysed by using descriptive statistics and Chi-square test was used in some cases to test the relation some the variables. All statistic analyses were carried out by using SPSS package Version 20.0 (IBM Corporation, 2011).

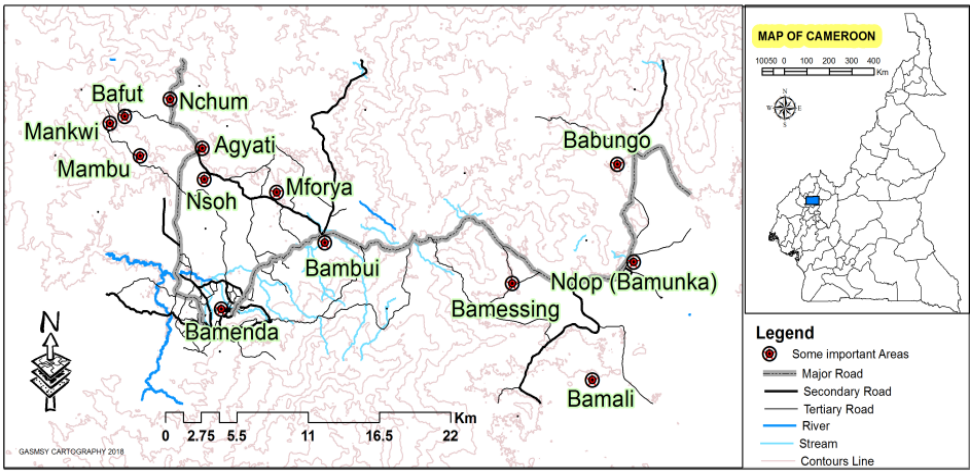

Fig. 1: Map presenting the surveyed localities in the North-West Region, Cameroon

RESULTS AND DISCUSSION

Characteristics of respondents and their perception on pest infestation during storage: In the eight localities, there were observed that the number of women (60.4%) involved in storage activities was greater than that of men (39.6%) (Table 1).The same tendency was found for each locality (Fig. 2). Different groups ages were recorded, their implication varied, according to, the locality. But the age ranges of 25-35 and 35-45 were the more involved (Fig. 3). As the observation was done, the age from 55 years old and above was the less represented in storage activity.

Two main activities regarding storage were determined, trade and farming (Table 2). In general, those who are mainly farmers represented 53.3% and traders 46.7%. In the different localities the number of farmers was greater than that of traders (Fig. 4). In Mforya and Nsoh, the number of farmers was practically the double of that of traders. Whereas in Bamali, Bamessing and Bamunka, the two groups were almost equal.

Types of stored commodities and facilities: Six grains were found as the stored foodstuffs in the eight surveyed localities (Table 3, Fig. 5). The smallholders in these localities stored beans, groundnuts, cowpea, soya bean, maize, rice and some others products which included dried cassava, some plant's seeds. In general maize was reported as the most stored grain (43.2%) followed by beans (18.3%) and groundnuts (18%). Cowpea (0.8%) and soya bean (3.3%) constituted the less stored products. Maize remained the most stored in the different localities except in Mambu where it was reported as beans were the most stored (42.5%). Rice was reported as the third most stored grain in the different localities except Bamessing, Mambu and Nsoh.

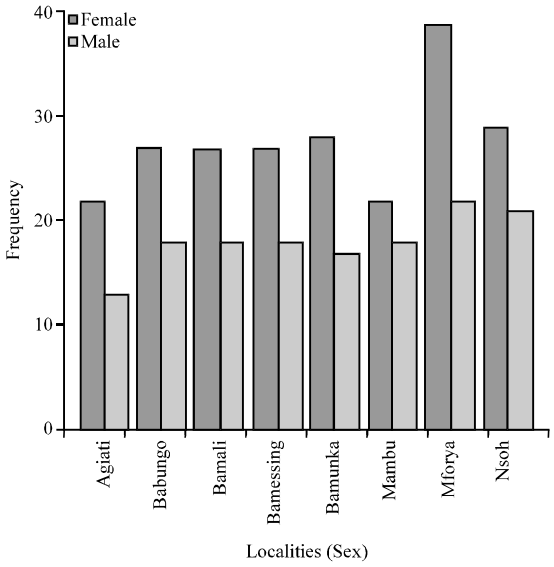

Fig. 2: Repartition of the respondents in the eight surveyed localities, according to the sex

Table 1: Distribution of respondents according to the sex

Sex	Frequency	Percentage
Female	221	60.4
Male	145	39.6
Total	366	100.0

Table 2: Repartition of the population according to the two main activities concerning grain storage activity

Activity	Frequency	Respondents (%)
Farmer	195	53.3
Trader	171	46.7
Total	366	100.0

Many facilities were reported as used for storage of different foodstuffs. In the eight surveyed localities, the

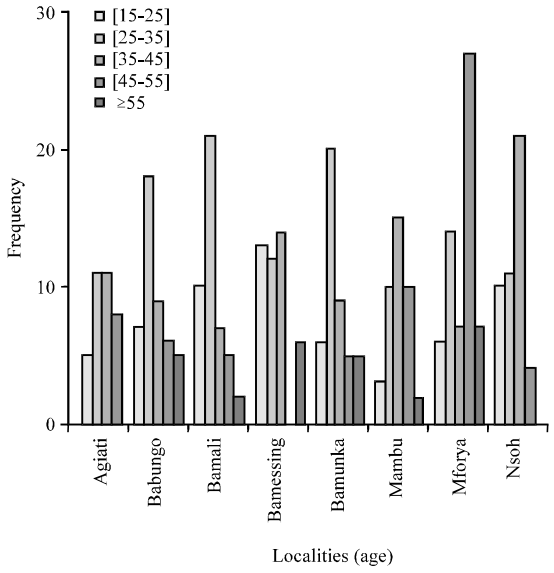

Fig. 3: Distribution of the respondents, according to the age in the different locations

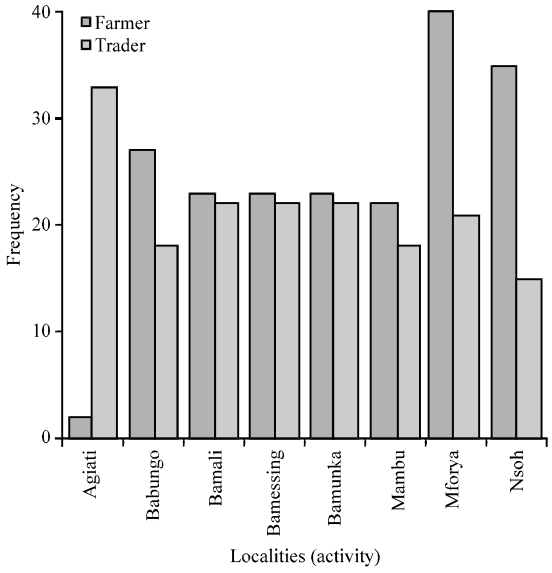

Fig. 4: Distribution of the respondents, according to their main activity following the village

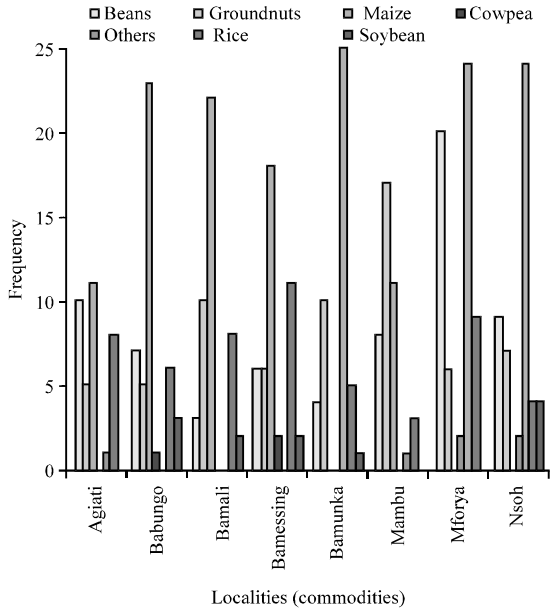

Fig. 5: Frequency distribution of the different stored grains, according to the smallholders in the eight surveyed localities

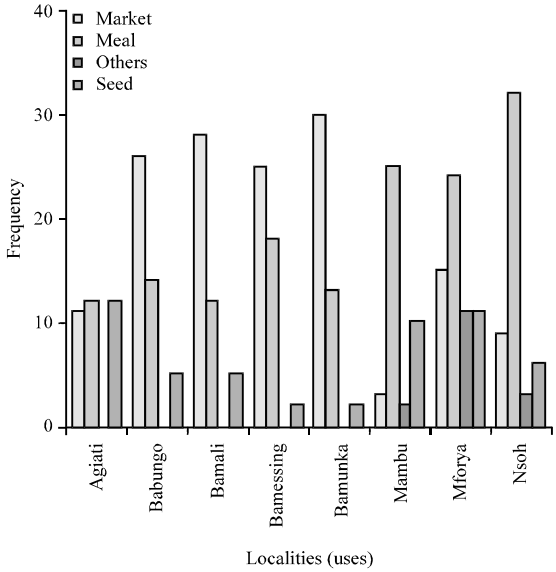

Fig. 6: Distribution of the population concerning the uses of stored products in the different surveyed locations

famers use bags, barns, buckets, cans, containers, cribs, drums, plastic and tins as storage facilities (Fig. 6). The bags constituted the most used storage facilities and that in all the surveyed localities followed by barns and buckets. There was reported that not all the types of storage facilities were used in the different localities. The types of storage facilities varied, according to the village. For example, in Agiati locality, four types (bags, barns, buckets and tins) out of 10 reported in the survey. The smallholders in Bamali and Nsoh localities reported using seven types of facilities which represented the highest diversity of storage facilities. The other localities except the three previously cited used six different types of

Table 3: Variability of storage facilities, according to the types of stored grains in the surveyed localities

	Facilities (%)									
Commodities	Bags	Barns	Buckets	Cans	Containers	Cribs	Drums	Others	Plastic	Tins
Beans	61.2	7.5	9.0	10.4	1.5	0.0	3.0	0.0	0.0	7.5
Groundnuts	45.5	0.0	21.2	10.6	0.0	0.0	0.0	4.5	9.1	9.1
Maize	35.4	53.2	5.7	0.6	0.0	2.5	0.6	0.0	0.0	1.9
Cowpea	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0
Others	33.3	16.7	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
Rice	63.0	1.9	20.4	5.6	0.0	0.0	0.0	0.0	7.4	1.9
Soybean	25.0	0.0	25.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4: Repartition of the population, according to the use the stored products in the surveyed locations of North-West Region of Cameroon

Variables	Frequency	Percentage
Market	147	40.20
Meal	150	41.00
Others	16	4.40
Seed	53	14.50
Total	366	100.00

storage facilities. The use of facilities varied, according to the commodities (Table 3). The most stored products; maize, beans, groundnuts and rice were put in different facilities. Beans were stored for 61.2% in bags. Maize was stored by 53.2 and 34.4% of smallholders, respectively, in barns and bags 63 and 20.4% of people in the surveyed localities stored rice in bags and buckets. Groundnuts also reported to be stored in bags (45.5%) and buckets (21.1%).

Uses of stored commodities: The grains are stored for many uses in different surveyed localities in the North-West Region of Cameroon (Table 4). As reported by the survey, the grains are stored in majority for meal (41%) and market (40.20%). There were also reported 14.50 and 4.50% surveyed population stored the grains to be used as seeds and others purposes, respectively. There was found that all the eight localities stored mainly for meal, market and seed (Fig. 6). But market and meal remained the most reported uses of stored grains; it was reported by more than 80% of surveyed smallholders. In addition to the previously listed uses, there was reported that in Mambu, Mforya and Nsoh the smallholders stored grain for others uses. The importance of these uses varied from one locality to another.

Diversity of pests infesting stored commodities and importance of damage: The smallholders in the eight localities reported four groups of organisms as pests of stored their stored grains; insects, moulds, rats, birds and some unidentified organisms (Fig. 7). Insects were the most reported as pest followed rats. Birds represented the less reported pest. This tendency was common for all localities.

The different pests were reported to cause different damage levels on stored products (Fig. 8). The level of

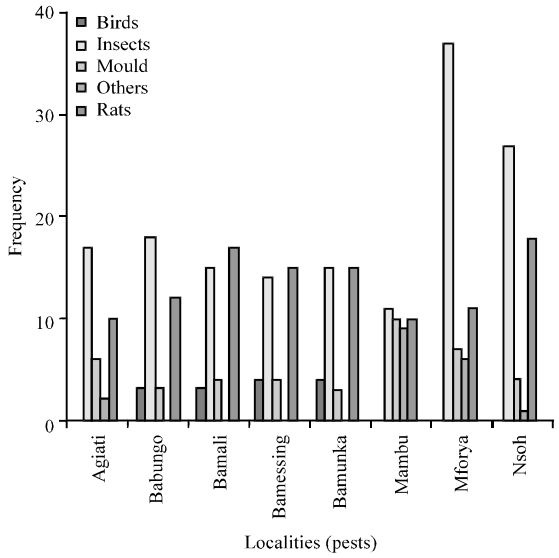

Fig. 7: Population knowledge on the diversity of pest infesting stored products following the different localities

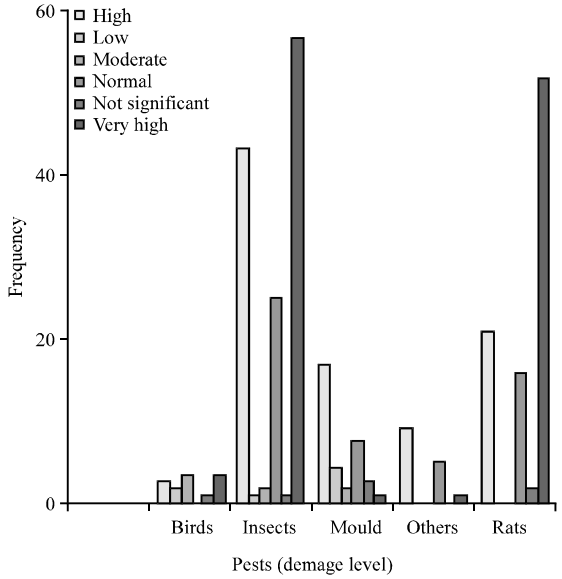

Fig. 8: Different levels of damage reported for different pest by the population in the surveyed localities

Table 5: Relation between damage levels and pests

Variables	Values	df	Significance
Pearson Chi-square	494.117	30	<0.0001
Likelihood report	315.493	30	<0.0001
No. of observations	366		

Df: degree of freedom

Table 6: Different types of treatment used reported by the smallholders in the some localities of North-West

	Respondents	
Treatments	Frequency	Percentage (%)
Chem+phys	19	5.50
Chem+phys+plant	6	1.60
Chem+plant	14	3.80
Chemical	110	30.10
No	48	13.10
Phys+plant	32	8.70
Physical	73	19.90
Plant	63	17.20
Total	366	100.00

chem+phys: combination of chemical and physical methods; chem+phys+plant: combination of chemical and physical methods and plant; chem+plant: combination of chemical method and plant; No: no treatment used; phys+plant: combination of physical method and plant

damage varied, according to the pest (Table 5). Damages reported for insects and rats were more considerable than those reported for the others pests. Insects remained the most detrimental as reported by the surveyed smallholders. Birds were reported as the less detrimental organisms. However, some farmers reported some damage level due to these organisms.

Different methods used to control infestation by stored pests: The smallholder farmers in the eight surveyed localities reported to use different methods or strategies to reduce damage caused by the different pests (Table 6). Chemical, physical methods and use of plant and sometimes the combinations of these methods were reported. Even some smallholders (13.10%) reported to do not use any method. The use of chemicals was the most reported (30.10%) followed by physical methods (19.90%) such as fire and Sun then plant materials (17.20%). The combinations of the methods were not too reported, however, the combinations of chemical and physical and plant and physical were reported by 5.50 and 8.70% of smallholders, respectively. The ternary combination was not practically reported. The same tendency was reported in the different surveyed localities (Fig. 9). In these localities, the ternary combination of the three methods (chemical, physical, plant) was hardly reported.

Efficacy of control methods (efficacy and frequency of treatments): The report made by the smallholders in the eight localities showed that the efficacy of the pest control varied, according to the method (Table 7, Fig. 10). The methods reported to be effective mostly between

Table 7: Relation between pest control methods and efficacy

Varibales	Values	df	Significance
Pearson Chi-square	199.920	63	<0.0001
Likelihood report	158.642	63	<0.0001
No. of observations	366		

Df: degree of freedom

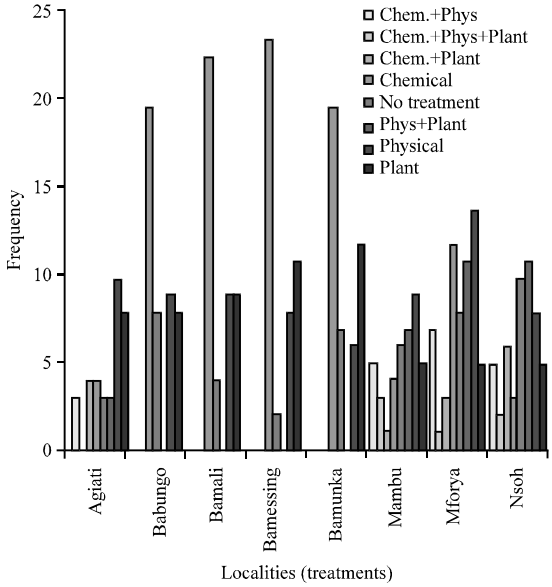

Fig. 9: Treatments reported to be used by the farmers in the surveyed localities (chem+phys: combination of chemical and physical methods; chem+phys+plant: combination of chemical, physical methods and plant; chem+plant: combination of chemical method and plant; No: No treatment used; phys+plant: combination of physical method and plant)

from 3-8 months. However, some low smallholders reported the effectiveness of 12 months even more. A considerable number of surveyed people reported that the chemical used to protect stored grain up to 8 months. The most reported efficacy for physical control was 3 and 6 months, the same report was done for plant use and the combination of physical method and plant.

Harmful effects of grain storage methods: Some factors implied in the grain storage activity were found to be harmful to the smallholders (Table 8). Chemical products (OR = 46.34, p<0.0001), handling and management of these products (OR = 1480.07, p<0.0001) were reported to be the factors inducing harmfulness of stored products protection methods and that was varied, according to, the surveyed localities (OR = 0.71, p = 0.001). This perception concerning the noxious effect of the chemicals varied from one locality to another. In addition, the number of

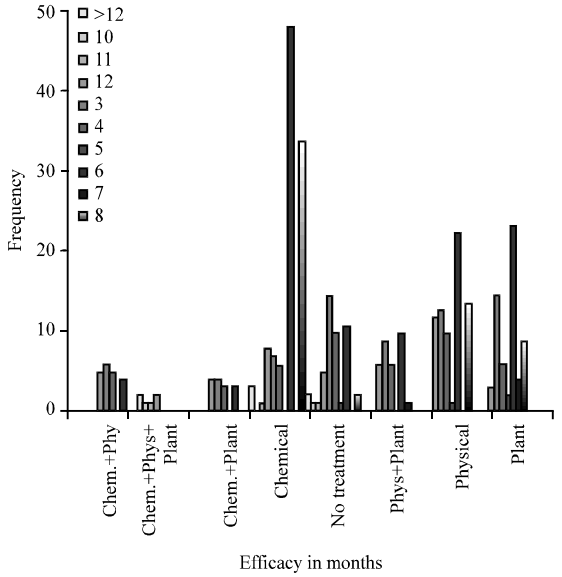

Fig. 10: Efficacy reported for the different treatments by the smallholders in the surveyed localities

Table 8: Estimates and odds ratios of grain protectant methods on treatment harmfulness in the different localities of North-West, Cameroon

			CI (95%)		
Factors	Estimates	OR	Lower	Upper	p-values
Area	-0.34	0.71	0.59	0.87	0.0010
Activity	-0.43	0.65	0.30	1.39	0.2660
Treatment before grain storage	-0.99	0.37	0.16	0.88	0.0250
Treatment during grain storage	-0.62	0.54	0.23	1.26	0.1540
Chemicals	5.05	156.07	46.64	522.27	<0.0001
Physical	0.09	1.09	0.47	2.51	0.8420
Plant usage	0.59	1.81	0.77	4.27	0.1750
Chemical handling and management	7.30	1480.07	259.20	8451.42	<0.0001

OR: Odds Ratio; CI: Confidence Interval

smallholders reported the negative effects of chemicals were greater than that of those who did not find any harmful effect.

The survey carried out in the eight localities of the North-West Region of Cameroon established that the storage activity implied people at the different active ages of both genders. Women are more involved in grain storage than men and the age intervals of 25-45 were the most represented. In rural area, women appear the most involved in livelihood agriculture in many African countries and in specifically, in Cameroon. According to 2008, census the number of women is greater than that of men, it represent more than 50% of Cameroon population (BUCREP). The majority of the respondents (97%) were male household heads in survey carried out in Kebbi State Nigeria by Iliyasu *et al.* (2013). The low number of female respondents could be due to the procedure used for selection of respondents as only the head of a household was interviewed. Whereas in the present study, any population implied in the storage was sampled not only the household. The African, especially, Cameroonian population is in general young that could partly justify the considerable number of people from 25-45 most involved in storage and in addition many of them are at same time responsible in the cultivation in these various stored grains. This range of ages constitutes the very active group of people which are the most concerned in agricultural activity, since, they exclusively have as activity farming and trading.

The smallholders for various reasons store different grains which can be cereals, pulses or seed oils. Maize was the most cultivated grain; this grain is adapted as part of traditional dishes in all localities of North-West Region and its cultivation is easily carried by the smallholders. In addition, it is less demand in term of technology and uses to have a good yield. The same observations were done for the main legumes such as groundnuts and beans. These seeds are the most cultivated in the Western part of the country, since, they are most used in the diet of the population in the many areas of Cameroon. The legumes are valued worldwide as an inexpensive meat alternative and are considered the second most important food source after cereals (Kouris-Blazo and Belski, 2016). Rice is also stored but not at the same level like maize, since, it is not cultivated in all the localities like maize. It is mainly cultivated in Ndop valley represented in the survey by the localities of Babungo, Bamunka, Bamali and Bamessing. However, it is considerably stored, since, it is also more used in the population for diet and for income generation. In most of the places, crops are grown seasonally and after harvesting, grains are stored for short or long periods as food reserves and as seeds for next season that in developing countries (Kumar and Kalita, 2017).

Bad storage practices or facilities may create a conducive environment for mould and pest proliferation that are responsible for significant losses at household level (Elmouttie and Hamilton, 2010). For a good storage, many facilities are used by the smallholders to conserve their commodities. In most developing countries, especially in Africa and South Asia, grains are generally, stored as bulk or bags in simple granaries constructed from locally available materials (straw, bamboo, mud, bricks) (Kumar and Kalita, 2017). The bags are most used, since, all the types of grains can easily be packed in and easily displayed in the different structures. The findings were done by Taruvinga *et al.* (2014), who observed that in traditional storage systems in Southern Africa, bags storage systems tend to predominate, although, bulk storage occurs quite often at farm level.

Many storage facilities appeared rudimentary because the storage in this area is carried out by smallholders for household consumption and to generate income to cover the basic needs such as school fees, health care etc. Whereas traders buy and collect the grain during harvest with farmers in order to sell out during lack period that permit them to obtain advantageous price. Then quantity stored by traders could be more important than that of farmers. Storage plays a vital role in the food supply chain and several studies reported that maximum losses occur during this operation (Bala *et al*., 2010; Majumder *et al*., 2016).

Different methods are used by the smallholders to protect their stored grains against pest which are insects, rats and sometimes birds. Insects were the most important common to all the surveyed localities. Postharvest grain losses during storage can be primarily attributed to two main natural drivers; the relative humidity in many Sub-Saharan African countries that fosters mold formation and damage from pests such as weevils, grain borers, birds and rodents (Yakubu, 2012). The pest insects may include a number of orders of insects that are associated with stored grains such as beetles (Coleoptera), moths (Lepidoptera), psocids (Psocoptera), bugs (Hemiptera) and parasitic wasps (Hymenoptera) (Rees, 2004; Hagstrum and Subramanyam, 2006). This group of pest induced serious damage to the stored cereals and pulses in this area. The application of synthetic pesticides was the most common compared to the other means such as physical control or the use of plant. Iliyasu *et al.* (2013) reported in a survey that over 30% of respondents use no control method probably due to cost or difficulty in accessing the commercial chemicals, similar, findings were also reported in the present study. However, in the different surveyed localities, populations reported the harmful effects due to the handling and management of these chemicals. This situation can be more serious because the smallholders sometimes do not have the necessary knowledge and techniques to handle the chemicals. In addition, some farmers stored grains with the non-appropriate insecticides due to the lack of mean and the unavailability.

CONCLUSION

The availability of low cost and effective storage structures can motivate farmers to store their grains and obtain high prices instead of selling right after harvesting when there is an abundant supply of grains. A farmer survey is a valuable tool for gaining an overview of the problems associated with preserving harvested grain (Iliyasu *et al*., 2013). The survey brought out the importance of grain storage in the different localities of North-West Region of Cameroon and the difficulties that those smallholders facing in this activity. The results of this survey would help to address the problems linked to grain storage and find out the necessary measurements to improve this activity in turn to insure a quantitative and qualitative storage.

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