Agriculture + Food Security Network Brief No 4
Post-harvest losses of dry grains in North Western Benin

The A+FS Network has identified the issue of post-harvest management as one of its focus areas.
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Introduction

Although the Republic of Benin is self-sufficient in roots, tubers and cereals (with the exception of rice) and despite various aid programmes aiming at ensuring food security in the country, access to diversified food remains problematic for the rural population. Food insecurity is particularly related to food availability – unequally distributed across the country – and to the high rate of poverty in the global context of rising prices for staple food (FAO 2011). In the primary sector, the problems faced at the level of food storage (in particular the storage of dry grains) are considered more serious than the insufficient agricultural production. The post-harvest losses of maize are estimated to be between 15 and 30%, due to precarious and archaic storage conditions (LARES 2000). The present study shows that the conditions are not different in the area around the Atacora mountain range, where cereals and dry leguminous crops constitute the major part of the people's diet (picture 1).

Picture 1: Yellow maize stored in cobs

According to the producers, just over half of the food produced by a rural household should be sufficient to prevent hunger among the rural population, excluding the reserve. However, 59% of the producers of dry grains interviewed reported difficulties in bridging their household needs in dry grains until the next harvest. Most of them have to buy dry grains during the hunger gap. The problem of food shortage becomes more severe during last the two months before the next harvest, and the situation may become very critical in the last few weeks. This observation led us to investigate in more depth the issue of storage losses, their causes and means of improving food conservation in the long term.

Between February and July 2012, a quantitative survey was conducted with 105 farmers in the commune of Boukombé. In this area, agriculture is the main source of income. The objective of the survey was to study the storage techniques of dry grains and the main problems encountered at the stage of storage.[1]

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[1] Another article based on this same study (Rochat 2012) was published under the title "Climate change: farmers' perceptions and strategies".

Importance and use of dry grains

In the study area, dry grain crops have a vital importance for the surveyed population, more than roots and tubers. The area allocated to dry grain crops is 0.8 hectare on average per household, for an average farm size of about 3 hectares, i.e. 26% of the available area (LARES 2000). The most popular crops (both for production and for consumption) are four cereal crops (sorghum, maize, fonio and rice, in order of importance) and two legumes (beans and Bambara groundnuts) (figure 1). Among these crops, beans are sold in comparatively large quantities, more than maize, rice or sorghum. In addition to home consumption (on average 56% of the production) and sales on the local market (24%), the remaining 20% of the crops harvested are allocated to a "reserve". This reserve, which is used as seeds for the next season, is not taken into account for the coverage of the family needs before the new harvest. However, if the hunger gap is too severe, the reserve may be used, which will have negative consequences on the seed availability for the next cropping season.

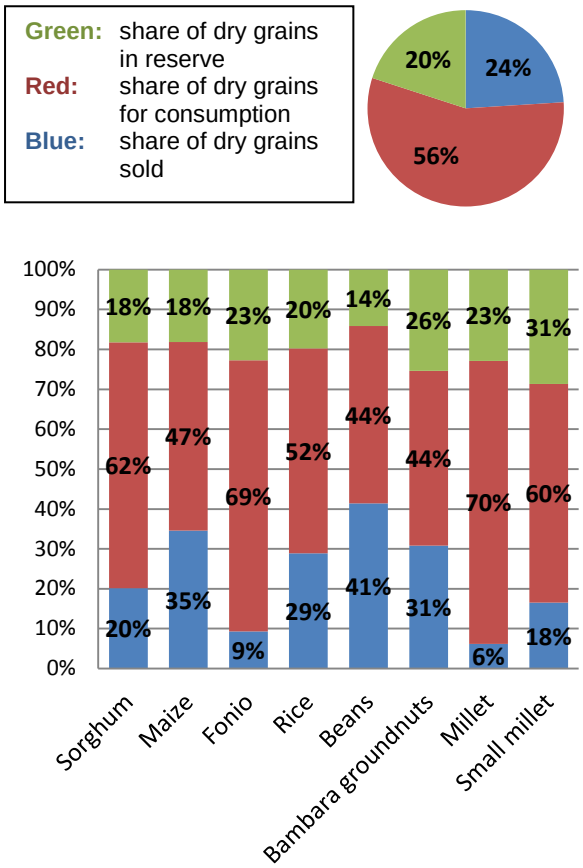

Figure 1: Use of the main dry grain crops. Pie graph on top = overall average; histograms = average for each dry grain crop (n=398)

Storage techniques in the Atacora region

As both the storage period, which lasts seven to eight months, and the hunger gap of four to five months are longer in the north of Benin than in the south, the conservation of dry grains is key to food security (FAO 2011). The most popular among the traditional storage systems encountered in northern Benin is the banco granary (figure 2).

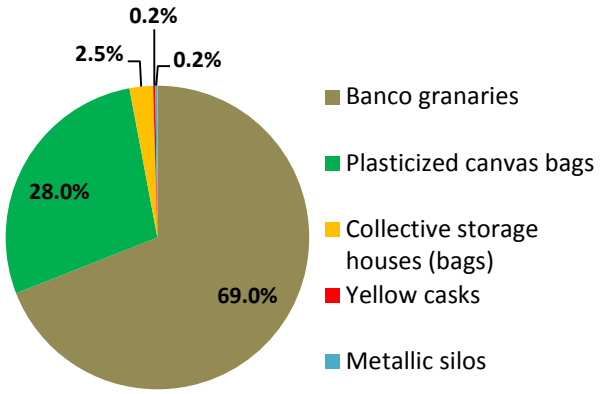

Figure 2: Main storage structures for dry grains (n=439)

The banco granary is one of the architectural characteristics of Boukombé housing – the tatas – with compartments inside and roofing with sorghum straw (picture 2).

Picture 2: Traditional "banco" granary in Western Atacora

Each household builds its granaries within the housing compound (picture 3).

Picture 3: Traditional house: Tata with two "banco" granaries at the upper floor

Traditionally, a granary is built for the harvest of the chief of the household, another one for his wife or for each of his wives, and a last one for the reserves or surplus. When opening the granaries for consumption, the one belonging to the chief of the household is usually opened first, followed by those of the wife or wives. Ideally, the last granary contains the reserves. At present, other storage methods are being used, such as plasticized canvas bags, air-tight yellow plastic casks and large metallic barrels. These methods are used especially for the crops intended for sale (maize, beans) or for smaller quantities of grains that are intended for immediate consumption (Bambara groundnuts) (picture 4). These containers are stored in the rooms, in mezzanines, in the kitchen and sometimes in collective storage houses.

Picture 4 : (l.) Plasticized canvas bag (r.) yellow casks used for fuel, water or seeds

Losses during storage

On average, 89% of the interviewed producers suffer losses during storage. Some storage structures are more affected than others and the share of destroyed grains depends on the crops. On average, 53% of the stocks of the seven dry grains analysed in the present study are affected by losses. The stored grains can be entirely destroyed in cases of a severe attack. This is frequently the case, especially for Bambara groundnuts for which 24% of producers reported a total loss. In the case of sorghum, maize and beans storage, 10% reported a total loss.

Losses by storage method

The producers reported losses mainly from the banco granaries and from storage in bags (figure 3). This is unsurprising as these two storage techniques are the most widespread in the study area. The granaries are used for long-term storage therefore they are prone to insect attacks and humidity. The efficacy of storage in bags largely depends on where they are kept. If they are exposed to rain or not well sealed, insects and water may enter, causing damage to the grain. Collective storehouses are not much used, on the one hand because there are not so many in the community, on the other hand because they are mostly in a rather bad shape. Moreover, producers do not have much trust in collective storage. There are much fewer losses in plastic or metallic casks, but their use is not widespread and is mostly for short duration storage. Air-tight storage seems to work well.

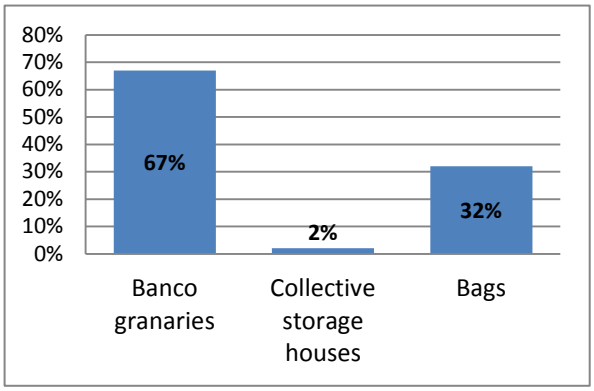

Figure 1 : Average harvest losses 2011 (%) by storage method (n=249)

Losses by types of dry grains[2]

The crops with the most losses during storage are beans, Bambara groundnuts and millet (figure 4).

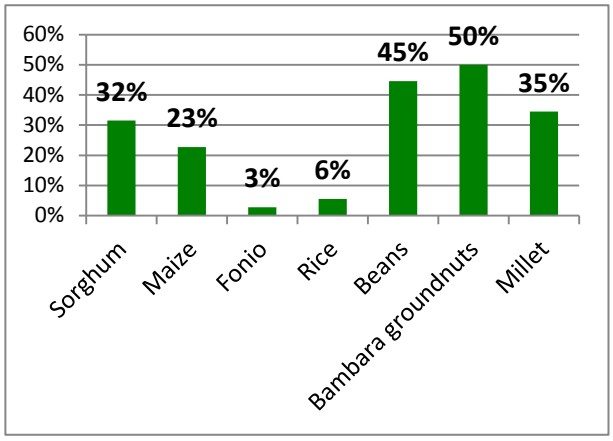

Figure 2: Average harvest losses 2011 (%) per crop (n=366)

Conservation is particularly difficult for Bambara groundnuts: this is the most attacked by insects and the most damaged crop with half of the harvest lost in 2011. Maize and sorghum are also heavily damaged, but less frequently than Bambara groundnut. Rice and fonio are the most resistant to insects, therefore the losses are lower. In the literature, reported post-harvest losses of dry grains in Western Africa show large fluctuations depending on the crops, on the storage technique (for maize storage in whole cobs, with or without husks or in grains), but also according to the method of calculation. Losses tend to increase over time; the highest losses appear after 6 months of storage (see for example FAO 1994, APHLIS 2012, GTZ 1997).

Causes of losses during storage

As considerable losses occur in the different storage structures and for different types of grains, it is important to identify their causes precisely. The producers know quite well the threats for their harvest and can easily assess the share of the harvest lost as well as the causes of the losses (table 1).

Analysis of the causes of losses

Picture 5: Wheat weevil

Surprisingly, rodents do not cause any problems. This may be due to the fact that the stores are elevated above ground. Weevils (picture 5) *(Sitophilus spp)* and other insect pests are responsible for 78.5% of losses. They attack the stores in general from the lower part of the container and eat the grains from the bottom, out of sight. Some pests lay their eggs in the store. Larvae as well as water infiltration cause

	Causes of losses	Dry grains and share of causes								
		Sorghum (n)	Maize (n)	Fonio (n)	Rice (n)	Beans (n)	Bambara groundnuts (n)	Millet (n)	*Total (n)*	**Cause (%)**
1	Wheat weevil	44	37	2	2	17	17	12	*131*	**61.2**
2	Rotting due to insects[1]	12	10	1	0	6	5	3	*37*	**17.3**
3	Rotting due to bad drying	6	5	1	0	2	0	1	*15*	**7.0**
4	Larger grain borer	5	2	2	2	0	0	1	*12*	**5.6**
5	Theft	3	1	1	2	1	1	0	*9*	**4.2**
6	Perforation by insects	1	1	0	0	1	1	0	*4*	**1.9**
7	Parasites	1	2	0	0	0	0	0	*3*	**1.4**
8	Infiltration with water	0	1	0	1	0	0	0	*2*	**0.9**
9	White grubs	0	1	0	0	0	0	0	*1*	**0.5**
	Total responses (n)	*72*	*60*	*7*	*7*	*27*	*24*	*17*	*214*	**100**

Table 1: Causes of losses during storage

[2] Note for the interpretation of the results: the data about losses indicated in the present study are semi-quantitative and they refer to frequencies of mention in the survey (losses yes or no) and to the share of harvest lost by crop (in % of the stored quantity)

mould and rot. Another observation is that the grains are often not dried well enough during the rainy season. The relative air moisture prevents optimal drying and causes damage to the grains. The larger grain borer (*Prostephanus truncatus* (Horn)) is another threat for the quality of maize in the traditional storage system. Finally, theft is also a problem: neighbourhood conflicts are often due to theft of grains, and this is the reason why collective storage is not popular. It is also a motive for the inhabitants to hide their grains in bags, in their rooms or their kitchen.

> *"During the connecting period, hunger drives people to come by night to the granaries that are outside the Tata to steal something to eat"*

The grains that are mostly affected

Rice and fonio are more resistant, in particular to the attacks of weevils, than other grains. The presence of weevils in rice, for instance, does not seriously affect the quality of the grains for consumption, except for the taste that is slightly altered. Fonio is also seldom attacked by weevils. Only the larger grain borer can damage it (Hinvi 2012).

Most grain losses of sorghum, maize, beans and millet are due to weevils and other insects which suck and chew grain or cause them to rot. As farmers were not able to identify the insect pests for the category "rot due to insects", we assume that these could be, among others, the rice moth *(Corcyra cephalonica)*, the grain beetle *(Tribolium castenum)* and / or the grain borer *(Phizopertha dominica)* (FAO 1994).

Strategies for improved grain conservation

The issue of conservation of dry grains is not new in Benin, and many techniques – biological, chemical or mechanical – have been available in regional and communal centres (CeRPA/CeCPA) for about a decade. The producers interviewed apply many new and traditional methods, promoted through extension or personal experience, to prevent losses during storage (table 2). Only 4% of the producers interviewed do not apply any conservation methods.

Type	Conservation technique of seeds	Number of producers indicating the technique	Dry grains concerned
Biopesticides	Ashes	**31**	L
	Neem oil and leaves	**24**	C + L
	Bitter plants	**24**	C + L
	Bark of cailcedrat trees	**6**	C + L
	Ground chilli	**2**	C
Techniques and construction	Drying (simple)	**7**	C + L
	Drying in smoke, sterilizing seeds	**1**	L
	Re-drying after rainy period	**4**	C + L
	Store in ears, cobs or non-threshed	**3**	Maize + Sorghum
	Regular replacement of the granary lid	**1**	C + L
	Protection against theft and humidity in collective storage houses	**2**	C + L
	Construction of granaries above ground	**3**	C + L
Chemicals	Sophagrain	**28**	C
	Diverse chemicals	**6**	C + L
	Attelic Super Dust	**1**	C
	Total (n)	157	

Table 2: Applied conservation techniques for dry grains (n=157)
L = leguminous grains ; C = cereals

Biopesticides

Biopesticides are the most widespread means of controlling insect pests in grain storage. Mixing ashes with beans or Bambara groundnut is a well-known technique, but only 20% of the interviewees apply it. Farmers have a deep knowledge of the plants growing in their fields and use them expertly. The most widely used are neem (Azadirachta indica), in the form of oil or dried leaves, the latter of which are ground and added to the grains (picture 6 on the left). This tree is very common in the region and its fruit, bark and oil are used in many insecticide preparations. The bark of cailcedrat trees (Khaya senegalensis), ground and mixed with the grains in the store, is another well-known technique (picture 6 on the right). However, this tree is not very common in the region and it is difficult to cultivate. Otherwise, many bitter plants exist (more than ten species quoted in local language), most of them found in backwaters. These plants, after drying and grinding or left on branches, are added in layers in the stores.

Picture 6: (l.) Neem fruit and leaves; (r.) Young cailcedrat tree

Storage techniques and construction

Special attention is paid to drying. Some farmers take the harvest out of the granaries during the dry season to observe the health status of the grains and to dry them a second time if needed. Grain sterilization and smoking are mainly used for legume grains. Cereals such as maize, sorghum and rice are stored with their ears, cobs or unthreaded. For better conservation, it is important to properly maintain the straw roofs. Constructing granaries above ground is the most common practice, allowing space for the poultry underneath. The interviewees did not mention these architectural features, probably because they were too obvious to them.

Chemical input for grain conservation

The most frequently used chemical is Sofagrain, a synthetic pyrethrinoid, which is packed in small bags that are spread in the granary. It is effective for three months, and the grains should not be consumed during this period. Sofagrain is the main chemical sold at CeCPA. Although Attelic super Dust, which has the same active ingredient, is seemingly more effective, it is more expensive and its application requires more labour. Farmers therefore prefer Sofagrain and they use it a lot.

Methods promoted by the extension services of Benin and availability

In July 2012, after the survey of producers had been completed, a meeting was organised with the person responsible for the promotion of storage methods at the extension services (CeRPA) of the Atacora Department (Assani 2012).

These services are responsible for the promotion of various storage techniques, including the use of ashes for leguminous grains, oil, oil cake and leaves of the neem tree. These techniques have been promoted for over 20 years.

CeRPA also has an extension programme for storage techniques. They sell chemicals for the storage of grains. Since 2010, the triple-bag technique has been added to the programme. This technique consists of three bags, one of which is of polyethylene, and is based on the same principle as the plastic casks: vacuum.

Lack of access to knowledge and means of improving conservation

The meeting with CeRPA highlighted the key issues of the poor availability of products and the lack of knowledge, especially in the most remote rural areas of the department. Indeed, the availability of the chemicals depends on the government, which sometimes supplies them late or not at all. On the other hand, some producers buy chemicals in communal centres (CeCPA) without knowing how to use them, with a high risk of poisoning for their families. Some innovations, such as the triple-bag technique, never reach the producers. Less than 20% of the producers

interviewed indicated that they had received information about this new storage technique. Due to this difficulty of governmental services to disseminate technologies that are likely to be effective against post-harvest losses, many producers in northern Benin continue to have significant losses.

Conclusion

Considering the major challenges of demographic growth and climate change, the storage of dry grains appears to be a key issue for food security in the Atacora, in northern Benin. Some improved storage techniques mentioned by the farmers have proven to be effective and have the potential to reduce the frequent seasonal food insecurity in Benin. However, the present study shows that they are not yet widely used. The fight against rotten grains due to excess humidity also raises questions, but it remains unclear whether this is a recurrent problem or whether the conditions that prevailed in 2011 were special in this regard: in which conditions were the grains stored in 2011 and were the granaries properly maintained? In addition, the “losses” related to non-agronomic factors (ceremonies, presents, theft,…) are difficult to quantify.

The study raises the question of the importance given to post-harvest losses in Benin’s political agenda, and thus the means available to reduce those losses. But it also raises the question of the adequacy of extension methods to promote effective conservation techniques, and it points to a problem of communication between the different stakeholders. The storage issue has been known to the governmental services and other development agencies for more than 50 years. Many projects and many non-governmental organisations have tried to propose or develop solutions that are adapted to the specific conditions of northern Benin. However, the results are not yet sufficiently tangible.

Today, the challenge is to encourage producers in distant, remote areas to use existing techniques that have proven to be effective over time, and to spread the knowledge about storage loss prevention. To optimize synchronization of the efforts of the extension services and to ensure long-term follow up of the producers, it is necessary to improve the collaboration between local NGOs, producers’ organisations and public services on a larger scale. Producers’ participation in the development of innovations seems to be the right approach in order to reach the target population. This approach will make them actors in their own progress.

A broad dissemination of metallic silos or triple bags could contribute to significantly improving food security in the Atacora department. However, this would require facilitated access for producers to those techniques, which raises the issues of funding, of profitability (ratio between the cost of equipment and the value of the stored products), of governance (especially for the management of community storage) and of sustainability (maintenance and replacement of the equipment at the end of their service life). The experiences of the Swiss Agency for Development and Cooperation in Central America as well as in Eastern Africa should feed the debate on the reduction of post-harvest losses, taking into account the lessons learned regarding the technical conception of the innovations and their economic constraints.

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