Comparison of Different Local and Improved Post Harvest Technologies in the North of Mozambique

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Acknowledgments

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List of abbreviations

CBA	Cost and benefits analysis
CIAM	Centro de Investigação Agrária de Mapupulo (National Agricultural Research Institute)
CIMMYT	International Maize and Wheat Improvement Centre
MZN	Mozambican Metical (1CHF = 32 MZN)
NPV	Net Present Value
IIAM	Instituto de Investigação Agrária de Moçambique
IRR	Internal return of interest
LGB	Larger Grain Borer
PHL	Post-harvest losses
SAAN	Segurança Alimentar e Agro-Negócios (Food Security and Value Chains)
SDC	Swiss Development Cooperation
SSA	Sub-Saharan Africa

CONTENTS

Abstract

This study presents a trial done in the North of Mozambique, implemented with farmers and the centre of the National Research Institute of Mozambique. The objective of the trial was to see the effectiveness of a silo named the Tethere silo, promoted by HELVETAS Mozambique. It is made with local materials and was compared with other local (Epitha and Clay pan) and improved (plastic bottle, Superbag, metal silo) storage technologies, especially in regards to the losses during the storage. Statistical, economic analysis and evaluations with the farmers were used in order to know which technologies are more appropriate for the smallholder farmers of this region.

The results for maize showed that the Tethere silo is effective, depending on the insecticide treatment used. After five months storage, the Tethere silo with the chemical treatment Actellic presented low post-harvest losses (0.97%), the Superbag with Actellic 0.3%, the metal silo with Actellic 1.24%, the plastic bottle without insecticide treatment 0.2% and the Eptiha (local technology) 1.8%. The Tethere silos with chilli peppers presented high losses (29.57%) and were significantly less effective than other technologies, except with the clay pan (local technology), which also presented a significant level of losses (31.45%). The losses were caused by the maize weevils *Sitophilus zeamais.* No infestation of Larger Grain Borer (LGB) was found.
For beans, the clay pan and the Tethere silo with chilli pepper presented the highest level of losses after five months storage. Reaching 35.54% of losses in the sample for the Tethere silo with chilli pepper and 21.59% for the clay pan. The infestations of bruchids were also more present in these two technologies. The other technologies tested didn't present significant differences regarding the level of losses. An important aspect for this crop is the care given to the grains/seed during the harvesting and the drying time.
The cost and benefit analysis (CBA), done in order to determine if the metal silo can be a profitable storage technology for small farmers in the North of Mozambique, shows that unless there is a high financial subsidy (at least at 71%) by HELVETAS, the technology is not viable for small farmers.
During the evaluation with the farmers, the Epitha, the clay pan and the Tethere silo were especially cherished because of their availability, low cost and the local knowledge to the construction of these three technologies. In terms of conservation capacity, the Superbag, the Epitha and metal silo were the most appreciated by the farmers.

For small farmers from Mozambique to conserve the maize seeds, traditional technologies such as Epitha, Superbag or silo Tethere with appropriate insecticide treatments are recommended. The metal silo was too expensive. It is more suitable for large farms, which produce a larger harvest and generate a higher income. The clay pan for maize and beans did not present good results. The plastic bottle was not appreciated by the farmers because of the difficult accessibility to the material.
An important point, which must be improved, is the process in between harvesting and storage. This includes choosing the right harvest time and drying methods, as well as the cleaning of the storage silo in order to prevent initial infestations.
A central contributor to the success of the project implemented by HELVETAS is the farmer's access to the market. They must have access to the product, the chemical treatment and the Superbags.

Post-harvest losses were not of importance to the farmers. However, this topic is a key point in order to reduce poverty in rural areas. The importance of keeping the grains for a longer period of time is a concept, which still needs to be instilled in the farmer's mindset.

1. Introduction

For smallholder farmers in Sub-Saharan Africa (SSA) cereal grain is essential for food security and is an important aspect in families' livelihoods. The topic of post-harvest losses has gained importance in recent years because of the soaring cost of food prices in 2006/8 as well as the risk of food shortages in the future. Post-harvest losses are important to consider, not only because of the physical losses (weight and quality), which are caused during the post-harvest handling, but also because of the loss of opportunity for the producers to sell their products in the market place. An example of this is the lack of infrastructure due to lower market prices (due to sub-standard quality grain or inadequate market information) (Rembold 2011, 176).

At the regional level (Eastern and Southern Africa), estimated yield losses can vary from 2% to 10% in maize which has been stored for over 6 months, to 30% if the Larger Grain Borer *P.truncatus* is present (Kimenju and De Groote 2010). In Mozambique, the weight losses of smallholder farmers' maize grain were reported as high as 10% to 12% with, the principal pest, *Sitophilus zeamais.* In regions where the LGB has been found, mostly in the center of the country, the losses can reach up to 61.5% (Sitoe 2005).

HELVETAS Swiss Intercooperation has been working in Mozambique for more than 30 years. This report overlaps with two Helvetas projects, "The Food Security & Agribusiness (SAAN)" and the initiative financed by the SDC: "Reducing Food losses through post-harvest management in Sub-Saharan Africa" projects. This initiative was selected as a country pilot in Benin and Mozambique.
The SAAN project already has experience in the topic of post-harvest management. Over a period of more than 10 years, Helvetas Mozambique, has been promoting a silo named Tethere silo, a replication made with local materials of the metal silo, which was a big success in Central America. Despite the long promotion of this silo, it was not clear how much more effective the Tethere silo is in comparison to local storage techniques. Both projects implemented by Helvetas looked at the effectiveness of the Tethere silo in comparison with improved hermetic storage methods, such as the metal silo and the Superbag, which have presented good results in Asia.

The following two research questions were asked in order to respond to this problem:

Is the Tethere silo more effective than the traditional techniques of seed storage?

Is the Tethere silo more effective than other improved techniques of seed storage?

This hypothesis is founded on three pillars: the effectiveness of the technologies, the economical aspect and the social acceptation by the farmers.
In order to test this hypothesis, a trial was implemented with the participation of farmers from the district of Chiure, province of Cabo Delgado and in a centre of the National Research Institute of Mozambique. Six storage techniques, the Tethere silo with two local (clay pan and Epitha) and three improved techniques (plastic bottle, metal silo and Superbag) were implemented. The trial was done with maize and beans, two important crops for the food security in this region and with the insecticide treatments, Actellic and chilli pepper.
The economic aspect is an important point for the establishment of a technology. A cost and benefit analysis was implemented in order to determine if the metal silo can be a profitable storage technology for small farmers in the North of Mozambique, and to know how much HELVETAS would have to subsidise the silo in order for it to be profitable for the small farmers.

A technology or a treatment can be efficient but can be not accepted by the farmers for diverse reasons. In order to know if theses technologies are socially accepted, an evaluation for the participating farmers was implemented at the end of the trial, with special consideration given to the aspect of gender.

2. Materials and methods

2.1. The experimental design and method used for sampling

The trial compared the Tethere silo with local and improved storage containers. It was done using six different technologies with two crops (maize and beans) and three insecticide treatments. In total eighteen treatments were implemented.
The trial took place in the Province of Cabo Delgado in two different districts, namely Chiúre and Montepuez (see map in annexe I). A total of four repetitions were implemented. Three of them took place with different associations as on-farm trials. A total of four counts were made during a period of 21 weeks. The first count was completed during the setup of the trial. There were approximately 7 weeks between the first and the second count, 5 weeks between the second and third count and 8 weeks during the third and the fourth counting (see the chronogram in annexe II).

Description of the experiment
For a better uniformity of the results, the experiment took place using seeds and not grains. The improved variety of Tsangano was chosen for maize and IT16 for beans. The moisture content of the maize was 12% at the beginning of the storage and that of the beans 11%.
The experiment consisted of six storage technologies with three different treatments:

For maize:		
T1	Metal silo with Actellic	100kg
T2	Metal silo with chilli pepper	100kg
T3	Tethere silo with Actellic	100kg
T4	Tethere silo with chilli pepper	100kg
T7	Superbag with Actellic (hermetic technology)	50kg
T8	Superbag without treatment (hermetic technology)	50kg
T9	Superbag with ageless treatment (hermetic technology)	50kg
T13	Epitha without treatment (local technology)	25kg
T15	Clay pan without treatment (local technology)	5kg
T17	Plastic bottle without treatment (hermetic technology)	1.5kg
For beans:		
T5	Tethere silo with Actellic	100kg
T6	Tethere silo with chilli pepper	100kg
T10	Superbag with Actellic (hermetic technology)	50kg
T11	Superbag without treatment (hermetic technology)	50kg
T12	Superbag with ageless treatment (hermetic technology)	50kg
T14	Epitha without treatment (local technology)	25kg
T16	Clay pan without treatment (local technology)	5kg
T18	Plastic bottle without treatment (hermetic technology)	1.5kg

(See annexe III for a detailed description of the technologies and the insecticide treatment)

In order to facilitate the statistical analysis, and to permit a real comparison between the storage technologies, Actellic was used in all improved technologies except in the plastic bottles. The Epitha and the clay pan were the two technologies used by local farmers and were used as a control. This was done because the farmers traditionally conserve their seeds using these methods without using pesticides. The metal silo and the Tethere silo presented the same treatments (Actellic and chilli pepper). The Superbags had three different treatments. Since the Superbag is a hermetic storage option, normally no treatment is necessary but this was to be proved with the Actellic treatment. The ageless treatment was to be tested for its positive influence on the reduction of the insect population (see

photographs of Ageless treatment in annexe XV). The plastic bottle is a hermetic storage and was used without treatment. Designs of the trial can be found in annexe IV.
The main limitations for the trials were the number of available metal silos. Only 8 were to be found in the region. The limited number of farmer communities prepared to implement this trial was the second limiting factor. In the end only three of the eight selected communities could be motivated to take part in the project trial.

2.1.1. Description of the sample

The process of collecting the data was organized as follows: for every treatment four handfuls of seeds were taken from two different places in the storage container (two from the top and two from the bottom). The same method was used for both the beans and maize. For each two handfuls, two hundred seeds were counted, selected and weighed with a precision weighing machine of 0.01g. For each storage container a total of four hundred grains were selected. The percentage of humidity was also measured (with mark Farmnex). Then, the healthy, diseased and perforated grains were graded, counted and weighed by category. Finally, the dead and live insects were counted from the four handfuls of seeds (see the figure to the methodology in annexe V).

2.2. Variables and Parameters

2.2.1. Response variables

The variables to assess the effectiveness of different storage technologies were the following:

- Weight loss of the sample
- Number of maize weevils for maize and bruchids for beans.
- Moisture content
- Number of grains infected with mould or damaged by insects
- Germination rate

All of these variables together help to determine the effectiveness in reducing post-harvest losses. The formula to determine the percentage of a damaged sample is illustrated in table 1.

Table 1: Formula of percentage sample damage (d= damaged grain, nd=non damaged grain)

Percentage sample damage: $\{[weight\ grains\ (d)]/[weight\ grains\ (d+nd)]\} * 100$

Source: Raboud 1984

In the damaged grain the perforated seeds attacked by insects and with moulds were counted.

2.3. Data analysis

The data from the maize was analysed separately from the data of the beans. In order to have an overview of the results, an analysis of all the treatments in a time period (in the stage of the different weeks) for all the response variables was completed. An ANOVA with two-ways (week and name of technology) was used in order to do this analysis. Data were subjected to One-way analysis of variance (ANOVA) using the NCSS program.
If all assumptions were accepted, a normal parametric test was carried out. In the case where the Probability Level was inferior to 0.05, a Scheffe's Multiple-Comparison Test was used in order to see where the significant differences were.
In the case, where the conditions of normal repartition were not filled, a non-parametric test was used namely: Kruskal-Wallis.
In the cases where the conditions of the equality of variance were not accepted, a transformation of the data with a square root was done.

2.4. Method used for the Cost and Benefit analysis (CBA)

The CBA is a systematic process for calculating and comparing benefits and the cost of a project. It was used to calculate a CBA for a metal silo in order to know how much an organization such as Helvetas Swiss Intercoorporation would have to subsidize the silos, so that they could be cost effective and profitable for a smallholder farmer.
This CBA was done looking at the conditions of small farmers from Cabo Delgado. The CBA looked at the storage and the selling of maize grain and not of seeds.
The size of the silo used for the CBA had a capacity of 250kg, which accords to the average production levels of the smallholder farmers in this region, who are unable to store a larger quantity of grain for a long time. The price of the silo (8050 MZN) was based on the price given by a local company, which already makes metal silos in the region (annexe VI). The price was then adapted for a silo with a smaller capacity.

Three scenarios were analysed. The changing factor was the level of losses for the metal silo:

1. **The metal silo presents 2% of losses and the Tethere silo 8%**

This level of loss is possible if the silo is sealed hermetically and the grains are cleaned and selected before storage.

2. **The metal silo presents 7% of losses and the Tethere silo 8%**

7% is a more realistic level of loss for the farmers under the assumption that the silo is not completely hermetic.

3. **The metal silo presents 0% of losses with the purchase of phostoxin and the Tethere silo 8%**

If the silo is well maintained and if the phostoxin is applied properly it is possible to reach 0% of losses.
(See annexe VII for more detail about the methodology of the CBA)

2.5. Method used for the storage technologies' evaluation with the farmers

The exercise was done with the two associations of farmers from Namawowo and Nauauane. All technologies were drawn on a separate sheet of paper and placed in a line on the floor. In the first evaluation the question put to the farmers was, "Do you like this technology?" In order to respond to this question, every man received a certain number of grains of maize and every woman received a certain number of grains of beans. They placed these in front of the drawings of the different technologies:

- 0 grains meant that they didn't like the technology,
- 1 grain meant that they more or less appreciate the technology,
- 2 grains meant that they really liked the technology.

After they had placed all the grains, an open discussion took place in order for them to share their opinions regarding each technology. The criteria were selected depending on what were the advantages or the disadvantages for them in regards to each technology.
For the second phase, the same process was implemented. The men and women were separated throughout the evaluation process to avoid influencing each other. The criteria chosen for the evaluation were effectiveness, economic viability, availability of equipment, local construction capacity, acceptability of the technologies and resistance to mice attacks (see the criteria of evaluation of the farmers in Annex VIII and interview semi-structured in annex IX).

3. Results and discussion

3.1. Resulting statistics for the maize

Percentage of sample loss

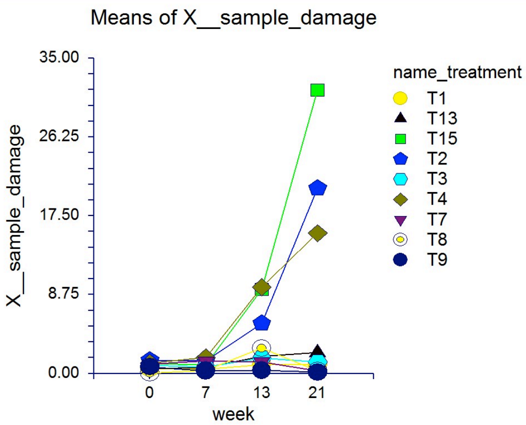


Figure 1: Means of % of sample damage for maize. With T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment

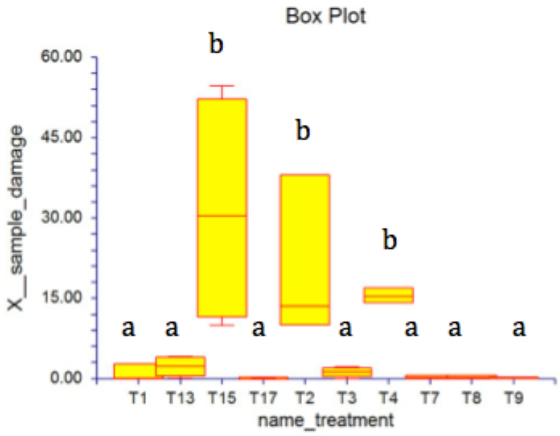


Figure 2: Loss in the sample after 21 weeks of storage for all the technologies with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment; T17 plastic bottle without treatment

The percentage of sample damage represents the weight of the perforated and infested grains in relation to the healthy grains in the sample. In the first count the percentage was the same for all the samples with a maximum of losses of 1.5%. In the second count, there were no notable differences. However, the maximum loss in the sample came to 2%. After 13 and 21 weeks it can clearly be see that the three technologies, T4 (Tethere silos with maize and chilli pepper), T15 (Clay pan with maize) and T2 (metal silo with maize and chilli pepper) stood out from the others (figure 1).

Figure 2 shows the loss in the sample for maize after 21 weeks of storage. After this period, the treatment T15 (clay pan without treatment), T2 (silo metallic with chilli pepper) and T4 (silo Tethere with chilli pepper) presented high losses in their sample. These three treatments (b) presented significant differences (Prob. Level = 0.002355) to the other treatments (a). The clay pan (T15) presented the highest level of losses with 31.45% of damage. Followed by the metal silo with chilli pepper (T2), 20.57% of losses and the Tethere silo with chilli pepper with 15.55%. All the other treatments presented losses fluctuating from 0.07% to 2.29% of losses. The fully hermetic plastic bottle presented the best results with only 0.07% of losses, followed with the three Superbags: with ageless (0.12%), with Actellic (0.37%) and without treatment (0.38%). The metal silo with Actellic (T1) presented a loss of 0.97%, followed by the Tethere silo with Actellic 1.24% and the Epitha without treatment with 2.29% of losses.

Humidity

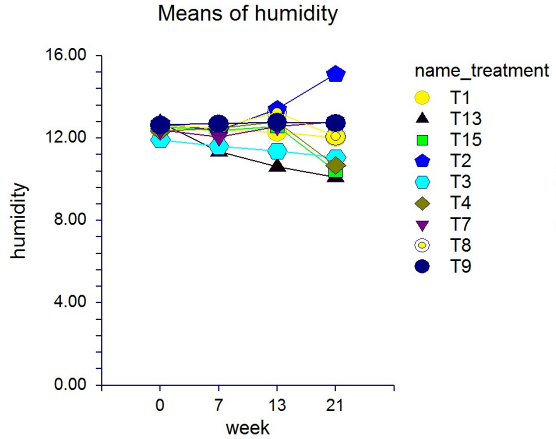


Figure 3: Means of % humidity for treatments with maize T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment.

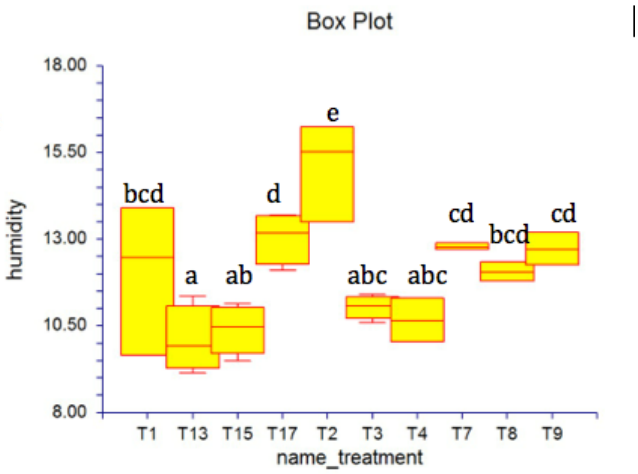


Figure 4: Box plots of the humidity rate after 21 weeks of storage with: T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan without treatment; T17 plastic bottle without treatment

In the first count, seed moisture was between 11.85% and 12.75%. After 21 weeks, the humidity of the grain was lower than at the beginning, except for the metal silo with chilli pepper, which presented an increase in humidity up to an average of 15.1% and the plastic bottle with 13.05% (figure 3).

After 21 weeks, it was possible to see significant differences (Prob. level = 0.000145) between the technologies. The metal silo presented the highest level of humidity with 15.01% and a significant difference to all the other technologies (e). The second technology that presented a high level of humidity was the plastic bottle with a mean of 13.05%. This technology presented significant differences (d) to the treatments T1, T15, T4, T3. The other technologies presented a normal rate of humidity between 10.1 and 12.8%. The two local technologies, the Epitha (a) and the clay pan (ab) were the technologies that presented an inferior humidity rate of 10.1% and 10.4% of humidity respectively. The Tethere silo with chilli pepper had in mean a humidity rate of 10.6%, and with Actellic 11.05%. The metal silo and the three Superbags presented significant differences to the Epitha (bcd/cd), with a humidity rate for the silo of 12.01%, for the Superbag without treatment of 12.07%, the Superbag with ageless 12.7% and the Superbag with Actellic 12.8%. The Superbag with ageless and Actellic presented also significant differences (cd) to the clay pan, the metal with Actellic and the Tethere silo with Actellic and chilli pepper (figure 4).

Germination rate:

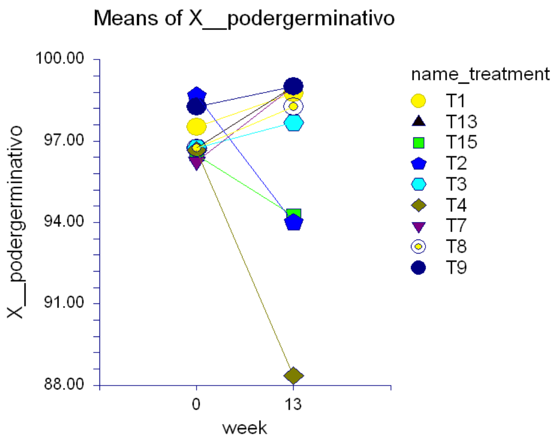


Figure 6: Means of germination power with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment

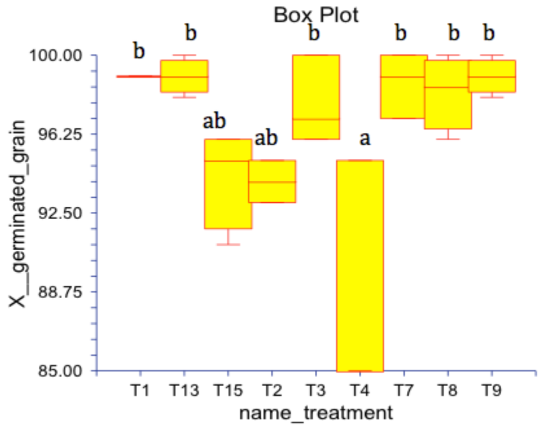
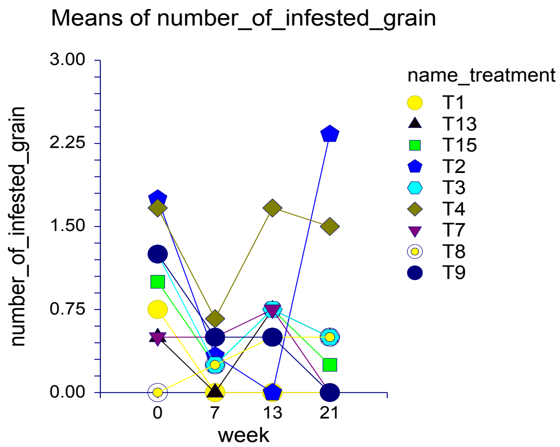


Figure 5: Box plot germination power after 13 weeks storage with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment; T17 plastic bottle without treatment

In the first count the successful germination was rather good for all technologies, with a variation of percentage ranging between 98.8 and 95.8. Thirteen weeks later, a lower successful germination was noted for three technologies: T4 (Tethere silos with maize and chilli pepper), T15 (Clay pan with maize) and T2 (metal silo with maize and chilli pepper). The T4 (a) treatment presented a significant difference (Prob. Level = 0.013556) with the T3, T8, T7, T1, T9 and T13 (b) (figure 5, figure 6).

Number of fungi



Generally the numbers of fungi were not more dominant in the first count in compared to subsequent counts. In the seventh week the number was inferior but it may have been due to the random sample. Up until twenty-one weeks, a fungus attack was not a problem for any of the technologies. The maximum average percentage of attack was 2.33% with the metal silo. No significant differences (Prob. level 0.168923) were found between all technologies after twenty-one weeks of storage (figure 7).

Figure 7: Number of seeds attacked by fungi with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment

Number of maize weevils in the sample

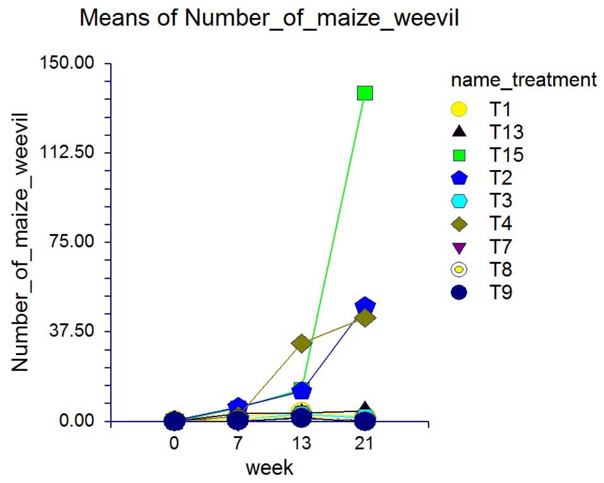


Figure 9: Means number of maize weevils in the sample with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment

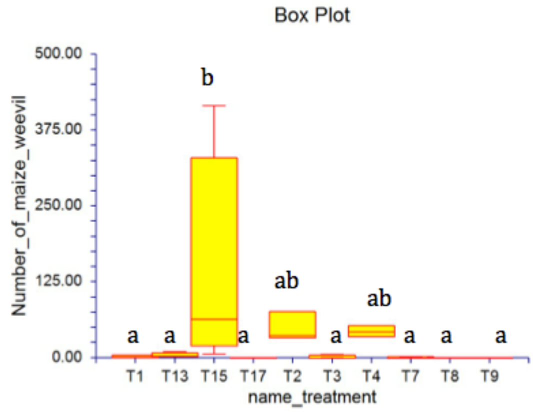


Figure 8: Box Plots number of maize weevils after 21 weeks of storage with T1 metal/Actellic, T2 metal/chilli pepper, T3 Tethere/Actellic, T4 Tethere /chilli pepper, T7 Superbag/Actellic, T8 Superbag/without treatment, T9 Superbag/ageless, T13 Epitha/without treatment, T15 Clay pan/without treatment; T17 plastic bottle without treatment

At the beginning there was no infestation of maize weevils in any of the samples. After 7 weeks the T2 (metal silo with chilli pepper) and the T15 (Clay pan) presented a small increase of maize weevil population with an average of 6 insects in each storage container. After thirteen weeks the treatment T4 (Tethere silos with maize and chilli pepper), demonstrated a very high increase in maize weevil numbers with a population almost thirty times higher than seven weeks prior. Treatments T15 and T2 had continued insect growth (figure 8).
After 21 weeks (figure 9) the clay pan without treatment presented a high elevation of population with a mean of 137 insects in the sample. Significant difference (Prob. Level = 0.003643) has been found between the T15 (b) and the T17, T8, T9. T7, T3, T1 and T13 (a). The metal silo T2 (ab) and the Tethere silo T4 (ab) presented no significant results with 48 insects and respectively 43 maize weevils in the sample. The rest of the technologies already presented a low population of maize weevils. The plastic bottle, and the 3 Superbags presented a means of insect inferior or equal to 0.5, the T3, T1 and T13 also presented a low number of maize weevil in the sample with respectively in mean 1.5, 2 and 4.5 insects in the sample.

3.2. Confirmation of the hypothesis for maize

The research hypothesis is the comparison between the Tethere silo with local and improved technologies. One important aspect is to distinguish the Tethere silo with Actellic or with chilli pepper. In fact, the Tethere silo with chilli pepper presented twelve times more losses than the one with Actellic (15.55% of losses compared to 1.24%) after 5 months of storage.
Most of the losses were caused by maize weevils, while very few were also caused by fungi found on the seeds. The larvae of the maize weevil nest inside the grain and cause damage to the embryo. This is the reason why there is a link between the number of insects, the number of damaged grains and the percentage of germination.

Effectiveness of the Tethere silo with the traditional storage technologies

The Clay pan presented the highest level of losses in the sample with 31.45% after five months storage. It was attacked by the maize weevils with an average of 137 insects in the sample. It is thus less efficient than the Tethere silo with Actellic (1.24%) but presented no significant difference to the Tethere silo with chilli pepper (15.55%). The clay pan is not recommended for the conservation of maize seeds. After 13 weeks this technology already presented a high level of losses (9.35%). The Epitha, the other local technology, presented results with a low percentage of only 2.29% losses after 5 months storage and a low maize weevil infestation of only 4.5 insects average in the sample. It is not clear if the Epitha was less infested because of the efficiency of the natural insecticide (the possible effect of the bark of the tree), or because of where the Epitha was situated. The temperature during the day can be extremely high which prevents the insects from multiplying. The germination rate was also high, with an average 98%. This technology is therefore very effective for farmers to conserve their seeds of maize. Epitha is recommended to conserve grain, but need special care again rodent attacks.

Effectiveness of the Tethere silo with the improved storage technologies

Counting as the improved technologies, are the Superbags with the three different treatments (ageless, without treatment, Actellic), the metal silo with Actellic and chilli pepper and the plastic bottle.

With the same treatment, the metal silo Actellic, the Tethere silo Actellic, and the Superbag Actellic did not present significant differences. The Superbag presented the best results with a loss of 0.3%, followed by the metal silo with 0.97% of losses and finally, the Tethere silo had 1.24% losses. With Actellic, the metal silo and the Superbag were as efficient as the Tethere silo. The plastic bottle presented the best results with 0.07% of losses in the sample. This technology was fully hermetic.

The Tethere silo with chilli pepper did not present good results, with the percentage of losses of the sample reaching 15.55%. The metal silo with the same treatment also presented a high level of losses with 20.57% of losses in the sample. There were no significant differences between the two silos with the treatment of chilli pepper. Both of these two technologies with this treatment were not effective after five months storage.

The Superbag, regardless of the treatment, is more effective than the Tethere silo with chilli pepper and is as effective as the Tethere silo with Actellic.

The insecticide treatments

The chilli pepper, was only active for 7 weeks. After this period the treatment was no longer effective, as seen by the heavy increase in the insect population (figure 8). The effective action time of the chilli pepper is, therefore, limited. An example of this can be seen in the results obtained in a previous trial implemented by the CIAM (Irenio, 2012), where there was with a regular repetition of the treatment in the Tethere silo. The chilli pepper treatment had to be renewed every 6 weeks in order to kill or repel the insects. Ideally, the farmers would renew the treatment with chilli pepper, but in reality it was noted during the trial that the farmers were not motivated to ground and manipulate the chilli pepper because of the side effects the chilli pepper has on skin and eyes. The chilli pepper is largely available in rural areas but, because of the reluctance to handle it, other organic repellents are recommended, such as neem leaves (*Azaterachta indica L.)* or Brazilian ironwood seeds *(Caesalpina ferrea)*, both of which also presented good results in the previous trials**.** Other studies would need to be done with these organic repellents in order determine if they can be easily sourced in rural areas, their effectiveness and the social acceptation of the treatments.

The treatment with Actellic was efficient and resulted in a low rate of losses in the sample with only 1.24% after five months storage for the Tethere silo. The Actellic is also very practical, as it only has to be applied at the beginning of the grain storage. It not being necessary to reapply the treatment is a considerable advantage for the farmers. The bigger problem with Actellic is that it is very difficult to acquire and is very expensive for the smallscale farmers. At the beginning of the season (April-May) it can be found in the rural shops for a reasonable price. But often the farmers take the opportunity to buy things of first necessity at that time and worry about storing the grain later. The period of availability of the product at a reasonable price didn't correspond to the storage period of small farmer.

The metal silo with Actellic, with 0.97% sample losses, presented better results than the treatment with chilli peppers, with 20.57% sample losses. The fact that the treatment had an influence on sample losses in the metal silo concludes that there was air inside the silo. The reason for there being air in the silo is that it was not completely full (only 100 kg of seeds for a 250 kg capacity). A large amount of air in the silo can facilitate the proliferation of the insect population. If the farmers use this technology, it is important that they choose a silo size capacity corresponding to their needs, making sure the silo is full at the beginning of storage. In a trial done by the CYMMIT (2010), there were little differences between the metal silo without treatment, with Actellic or with phostoxin. In this case the silo was hermetic, since the treatment didn't have a big influence. Of course the treatment with phostoxin always gave good results with a maximum of 0.5% of losses (CYMMIT 2013 and Raboud 1984).

The Superbag/Actellic presented losses of 0.3% The Superbag/without treatment (0.3%) and the Superbag/ageless gave the best results with a loss of 0.12%. It is possible that the treatment ageless had a positive influence on the air contained and permitted a lower percentage of loss in the sample. However no significant differences were noted between the three treatments. The metal powder for the ageless is not easily available for farmers in rural areas because normally the artisans are based in the towns. Because of the low accessibility of the material, this treatment is not recommended.
It has been noted that the opening of the bags for the counts could have influenced the results. In the farmer's context, the Superbag once closed must remain so until the grain is needed to avoid air circulation and the elevation of the humidity rate. In a trial implemented by the CYMMIT (Kimenju and De Groote 2010) in Kenya, the Superbag presented good results (below 2.5% of losses) for up to 5 months storage. In the sixth month, the losses began to increase considerably reaching losses of 6.3%. It is thus safer to recommend the use of this technology for a period of 6 months or less.

3.3. Resulting statistics for the beans

Percentage loss in the sample

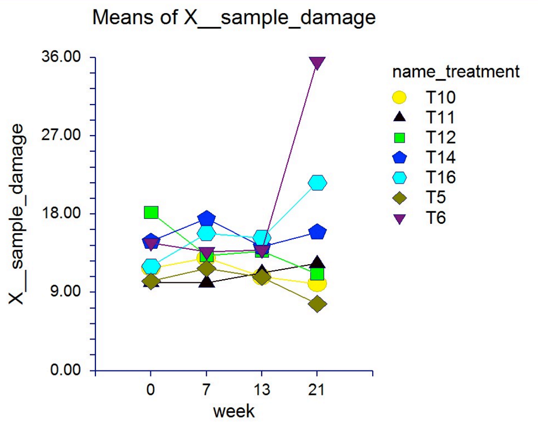


Figure 10: Average % of sample damage with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment

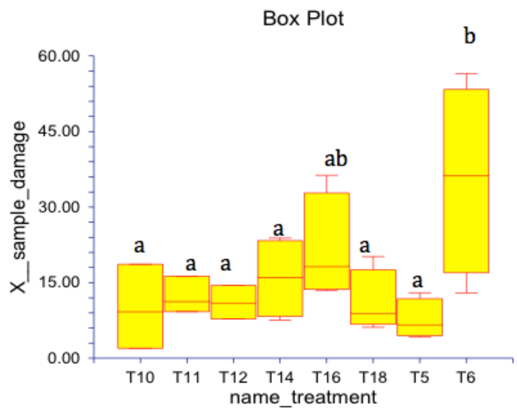


Figure 11: Box Plot % of the losses in the sample after 21 weeks of storage with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment, T18 plastic bottle without treatment

In figure 10, it becomes apparent that already at the beginning of the trials some samples were more damaged than others. Between the first and the third counts, there was not a general increase in grain damage. After 21 weeks (figure 11), the Tethere silo with chilli pepper and the clay pan presented a higher level of losses. The T6 (b) presented a significant difference (Prob. Level = 0.017599) to all the other technologies (a), except the T16 (ab), with a level of losses of 35%. The T16 presented a level of losses of 21%. The silo Tethere with Actellic (T5) presented the best results with 7.67% of losses, followed by the T10 Superbag actellic (9.99%), T12 Superbag with ageless (11.1%), T18 the plastic bottle (11.11%), T11 Superbag without treatment (12.3%) and the Epitha with 15.92%.

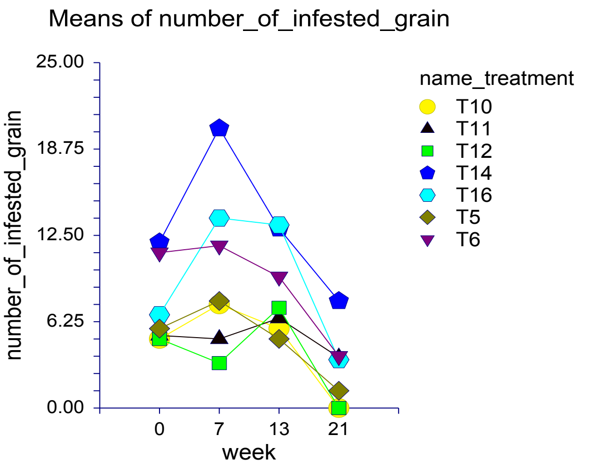


Figure 13: Number of seeds infested by a fungus with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment

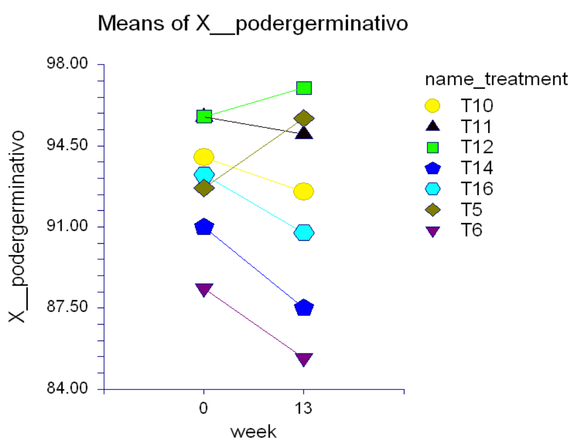


Figure 12: % of germination of the sample with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment

Number of seeds contaminate by fungi

In the first count, the grains were not homogenous, but no significant differences were found. After 21 weeks, the fungi were of lesser importance than at the beginning. No significant differences (Prob. Level = 0.103214) between the technologies were found (figure 12).

Germination rate:

For all treatments except the T12 (Superbag with beans and ageless) and the T5 (Tethere silos with beans and Actellic), the germination levels were smaller after thirteen weeks compared to the beginning of the trials but no significant differences (Prob. Level = 0.358786) were found between the technologies (figure 13).

Percentage of humidity content of the seeds:

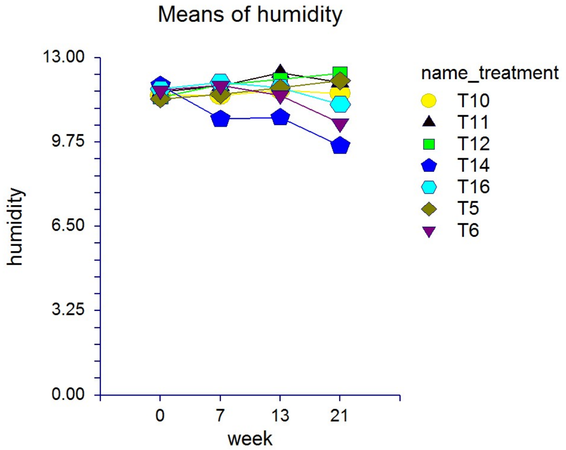


Figure 14: Mean of humidity content of the seeds with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment

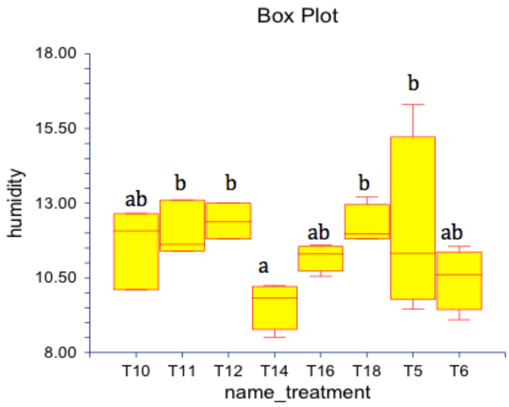


Figure 15: Box Plots humidity of the beans and seeds after 21 weeks storage with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment. T17 plastic bottle without treatment

The technology that presented the highest reduction in humidity was the T14 (Epitha). The technology that presented the highest moisture content was the T12 (Superbag with beans without treatment). In general, the humidity content of the seeds was lower after 21 weeks than at the beginning. The Epitha presents a significant difference (Prob. Level = 0.046516) to the T11, T5, T18 and T12 with 9.6% of humidity. The humidity content ranged between 9.6 and 12.4% (figure 14 and 15).

Number of bruchids in the sample:

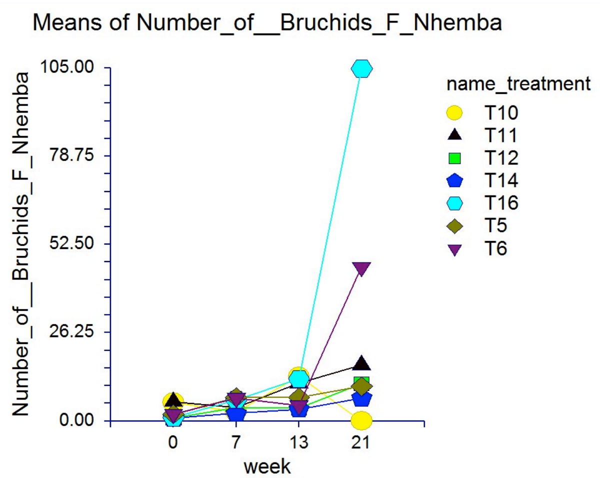


Figure 16: Number of bruchids in the sample with T5 Tethere/Actellic, T6 Tethere/chilli pepper, T10 Superbag/Actellic, T11 Superbag/without treatment, T12 Superbag/ageless, T14 Epitha/ without treatment, T16 Clay pan/without treatment

The number of bruchids was higher in the third count compared to the first one. After 21 weeks, the T16 (Clay pan), T6 (Tethere with chilli pepper) and T11 (Superbag with beans without treatment) presented the highest bruchid population. In the Clay pan and Tethere with chilli pepper, the highest increase was seen during the 13th and the 21st week. The Clay pan shows an elevation in the bruchids population. On average 139 insects were found in the sample. The silo Tethere with chilli pepper also contained a high level of insect population with 91.5 in the sample. Despite the high insect population in the T16 and T6, no significant difference was noted (Prob. Level = 0.190388) (figure 16).

3.4. Confirmation of the hypothesis for beans

During the first count and the setting up of the trial, it was noted that the pulses were already of a low quality containing fungi and perforated grains. These problems were seen in the fields and during the drying period. After 21 weeks of storage, the number of grain infested by fungi was lower for all technologies (figure 12). It is probably because all technologies promoted a favourable environment for seed conservation. The humidity content of the seeds presented good results because after 5 months of storage the humidity rate ranged from 9.6% to 12.4%. The safe moisture content for beans is 14% (Hodges and Stathers 2012, 248). It was interesting to note that the majority of the bruchids were dead when found; the reason being that the insects do not have a long life cycle (Hodges and Stathers 2012, 248). After 13 weeks, there were no significant differences regarding the loss in the sample for all technologies were found. All the technologies were ranked between 10.7 and 15.2% of losses.
After 21 weeks, despite no significant differences having been found, the Tethere silo with chilli peppers and the clay pan presented an elevation in bruchids infestation. The Tethere silo with chilli pepper, also presented a significant difference of losses in the sample in comparison with all technologies, except the clay pan with a level of losses of 35.54%. Ergo, to store for a period longer than 3 months, the Tethere silo with chilli pepper and the clay pan are not recommended, because of the high infestation of bruchids and the losses caused by this insect. The rest of the technologies presented satisfying results.
The treatment with chilli peppers only has a limited period of action against the bruchids. This period is slightly longer than for the maize weevils. In fact the population of bruchids growth began only after 13 weeks, whereas maize weevils began already after 7. The chemical treatment Actellic sufficiently killed both the maize weevils and the bruchids.
The Epitha when put in the sun, presented the highest loss of humidity content of the grains with 11.85%. This loss of humidity can influence the germination rate. The germination test was satisfying with 87.5% of grains germinating. Bad quality seed at the beginning of the trial possibly affects this result.
Proper management of beans in the fields and during the drying process is of vital importance, as the pulses are fragile during this period.
(See the detailed statistical results of the fourth count in the annex X for maize and beans, as well as of the three other counts in Annex XI for maize and beans)

3.5. CBA results

The objective of the CBA was to analyse if the metal silo is a profitable storage technology for small farmers, and how much the organization HELVETAS Swiss Intercoorporation would have to subsidise in order for farmers to be able to make a profit.
In order to reach this objective, an analysis was made with 3 different parameters:

1. The metal silo presented 2% of losses and the Tethere silo 8%
2. The metal silo presented 7% of losses and the Tethere silo 8%
3. The metal silo presented 0% of losses (but it was necessary to purchase phostoxin) and the Tethere silo 8% of losses

The CBA of the three different scenarios

The results show that the metal silo is not profitable for small farmers with a silo capacity of 250kg at the full price costs 8050 MZN. This is not viable for them and the investment is too high to be cost effective. The silo would have to be subsidized if this technology is to be promoted. This detailed analysis attempted to identify the highest payable price for the metal silo, so that the farmers could still make a profit with the storage of grains.

For a metal silo with 2% of losses, the silos must to be subsidized 71%. This means that the maximum metal silo price for the farmers to be able to make a profit is 2300MT. Table 2 shows a calculation where the net present value (NPV) is 38.45 and the internal return of interest (IRR) is higher than 10% with 10.18%. Under these conditions would the project be cost effective for the farmers.

Table 2: VAN and IRR of the first scenario

NPV	10%	38.45
IRR		10.18%

In the second scenario, the metal silos have 7% losses. In this case, to be cost effective, the metal silo must be subsidized to 77%. The highest price possible for the silo is 1900MZN. At this price, the NPV of the CBA is 185.45 and the IRR is 11.06% (table 3).

Table 3: NPV and IRR of the second scenario

NPV	10%	185.45
IRR		11.06%

In the last scenario, the silo presented no losses but the farmers had to buy phostoxin. In this case, the silo has to be subsidized to 71%. The farmers can buy the silo at a price of 2400 MZN. NPV would be positive with 32.13, and the IRR is 10.15% (table 4).

Table 4: NPV and IRR of the third scenario

NPV	10%	32.13
IRR		10.15%

(more detailed results in annex XII)

Conclusion of the CBA

The metal silo remains a very expensive technology for rural farmers in the north of the Mozambique. The second scenario would be most feasible. The third scenario is profitable only because the price of phostoxin is very low (one tablet 10 MZN) and the benefits that this treatment brings are high.
The CBA shows that this technology must be strongly subsidized at least to 65% by an organization to be viable. This percentage depends on the differences in losses between the normal way of conserving the grains and the metal silo. According to the DAI (2013) the metal silo is not profitable for small farmers in Malawi. In Mozambique the same conclusion was reached. Even with strong subsidies, this technology can only be a real benefit if the farmers are able produce larger quantities of grains.
The metal silo must be more focalised for farmer, which already has some condition and are then more able to make profit with this technology.

3.6. Results of the evaluation of the technologies and discussion with the farmers

Clay pan

The farmers were not satisfied with the clay pan with maize because they saw that there were high storage losses. However, the women could make the clay pan themselves and the local materials were readily available. The women said that it was not difficult to make it and that it did not take up too much time. They also said it was easy to remove the grains and was not expensive to make. The clay pan was also relatively effective against mice attacks.
The farmers from one community also made a surprising comment. They believe that the clay pan for maize is more likely to be damaged and attacked if it has been used to store cornmeal or if used for cooking the year before.

Plastic bottle
The plastic bottle was not very easily available in the rural areas. The farmers could only obtain them when they purchased oil in the town. Some farmers also said that they didn't trust this technology because they had already tried it with sesame and the seeds did not germinate as well compared to when the sesame seeds had been stored in another recipient. As the quantity stored with the plastic bottle is only small, it is easy to handle the technology but it can only be used for seeds.

Epitha
The farmers were happy to see the good quality of the maize and bean seeds after storage in the Epitha. Although the materials are easily available and most of the men can make Epithas, the technology is not really practical for the women removing the grains. The Epitha is placed under a roof or in a tree. It is more difficult for women to have access to the Epithas than for men. An advantage is that it is a local technology that can be made with no cost for the farmers and it can be made quickly. A disadvantage that the farmers noted, was that the Epitha is liable to mice attacks.

Superbag
The farmers noted that the Superbag was efficient because the seed conservation was good. The women liked the Superbag because the 50kg quantity is adapted to their needs. 50kg is the quantity used for a normal family's (5-6 people) food needs over a 2-week period. The women also appreciated the Superbag because it is easy to transport and to sell. Sometimes it was not very clear if what the farmers really liked was the plastic bag or the polypropylene bag used as a protection. The polypropylene bag is more or less available in the rural areas and is really appreciated. The farmers told us that the Superbag is not cheap but it is possible for them to buy some (price was 90MZN for the plastic bag + polypropylene bag). The major problem for them was that they had no idea where it is possible to buy it. In the trial, the Superbags were hanging. For the women this is not practical, as it is very heavy to hang it.

Tethere Silo
The advantages for the farmers are that they have the local knowledge and materials in order to make the Tethere silo. They noted that the silo, maize with Actellic and the silo with the beans, gave goods results. The farmers found that it was practical to remove the grain but some women also said that it was tedious to cover the opening hole with clay after each time it is opened. The majority of the farmers said that the Tethere silo had a good resistance against mice attacks.

The metal silo
The farmers were satisfied with the quality of the grains. They liked this technology but it was expensive for them (cost said 8050 MZN). They also did not know where metal silos were sold. Both women and men found that it was easy to remove the grains/seeds. The metal silos were very resistant against mice attacks.
(See the results of the evaluation with the farmers in annexe XIII)

Social acceptation of the technologies
In general, the farmers said during the evaluation, that they particularly liked the metal silo, the Epitha and the Superbag because of the good quality of the seeds. The other technologies presented other advantages. For example, the farmers have the know-how to construct the Tethere silo and the Clay pan. The majority of the farmers were in agreement that the Tethere silo presents an advantage, as it is easy to take out the grains. However, some women from Namawowo said that the fact that they had to cover the holes with clay after each use is a considerable disadvantage. In two communities the Tethere silos were not used. In one community one Tethere silo was used to store peanuts. The advantage with

this silo is that if it has been correctly made, it is possible to burn before to the new harvest to kill the adults and eggs of the insects. The problem was that the farmers didn't always take good care of the silos. The lack of maintenance can cause spoilage to the crops.

The metal silo has had good results in Central America according to the low level of losses and the widespread use of the silo (Raboud 1984). The context between Central America and the Mozambique is very different and had to be taken in account in order to see if the metal silo could also be a successful project in this region of Africa. The main difference is that, in Central America, the farmers have more grains to store than in Mozambique. On average a small farmer in Mozambique has 800kg of maize per year. This quantity signifies that they don't have enough grain to store throughout the year, contrary to Central America farmers. The metal silo is advantageous if the farmers want to store the grain for a very long time. In the Mozambique, the storage period is so short that this technology doesn't make sense for a small farmer. The second important point is that the materials to make the technology are more readily available in Central America than they are in the North of Mozambique. The price is too high for small farmers to be able to purchase it.

The farmers were not really satisfied with the clay pan because it generated high losses. The women considered it an advantage as they can make the clay pan themselves. They found the fact that it is very difficult to remove the seeds from the Epitha a disadvantage. It is important to remember that these two traditional technologies are made to conserve seeds. The Epitha is not very practical for the woman but, at the same time, it has to be opened only if the women want to control the seeds or when they are needed for sowing. Thus, it is not a huge disadvantage as it is only necessary to open the Epithas occasionally.

The farmers were very satisfied with the Superbag. This technology presented few losses. For the women, the quantity filled in the bag (50 kg) is practical because it represents 2 weeks of food for one family. The size is practical and it is easy to transport. It is possible that the farmers will not hang the Superbag (as shown in the trial) because it is heavy for the women to hang it. In this case, it is really important that the bag does not touch the floor because of contamination through humidity and/or mice. If the bag is perforated it is no longer hermetic. The farmers really need to take special care with these bags. The farmers said that they are ready to spend money to buy the bags, which cost 90MZN. If they take good care a bag can be recycled and used for 1 or 2 years (maximum).
Superbags present many advantages: no necessity to use pesticides, its practical size and few losses, etc. It has however one very important disadvantage, namely that the Larger Grain Borer can perforate it. In this case, the technology loses its hermetic quality and thus is no longer viable. The insect is not really present in the region of Chiure. During the trial only one LGB was found. According to Sitoe (2005), it is found more in the district in the North of Cabo Delago where it is more prolific. The infestation has come from Tanzania where this insect is a serious problem. The province of Nampula in the south of Chiure does not have a LGB infestation (ALPHIS 2013). The farmers must be aware that this insect can cause considerable damage to their maize crops during the storage period. It is important that they are able to recognise it in order to take the necessary precautions in case of infestation. According to Makondi (2013) the most efficient insecticide in order to kill this insect is the Actellic. According to Scheidegger (2012) it is easy to see if there are LGB by putting the grains in the plastic bag; the LGB will perforate the bag within one week. The farmer must check the bag for holes after one-week storage. If this is the case, the ideal solution is to put the grains in the sun for two days in order to kill the insects and, if possible, to treat the grains with Actellic. If the grains are infested by other insects (for example bruchids for the beans or maize weevils for the maize), the same process needs to be implemented for the other technologies.

The plastic bottle presented good results in regards to the conservation of the seeds (0.07% sample losses for maize and 11.1% for the beans) and had a normal germination rate. The biggest problem with the plastic bottle is the distrust farmers have regarding this technology and its lack of availability. Consequently they were not interested in using this technology for maize or beans.

The commercialization

The farmers have a problem commercializing and selling for their crops. They really need to sell a part of their harvest at the beginning of the season (May-July) in order to have cash to purchase items of first necessity. They are afraid to keep the grains or a big quantity of grains for longer as they lack information regarding possible purchasers. When the grains are dry there is a company that goes to the villages to collect and purchase the grains directly. Once the price is higher, the company is less interested to collect and purchase the grains. Commercialization is a focal point for the success of the post-harvest project. It is important to know exactly which actors are playing in the process of the purchase of maize and beans and what the value chain of the product is.

Post harvest practices

In the province of Cabo Delgado, in the north of Mozambique, the small farmers produce enough maize or bean grains to store until December-January. They did not produce a large enough quantity to store until the next crop harvest (April-May). With the climate changing, the farmers already leave more of the grain drying in the dryer. In the two communities interviewed, they said that with the majority of the grain, they begin to store the grains only in October-November, which is the beginning of the rainy season. In this case, the higher quality grains are only stored in silos or granaries for two to four months. The farmers also said that in the dryer, the crops could be attacked by mice as well as by insects like maize weevils or bruchids. The levels of infestation in the dryer are not known. A study documenting losses in the dryer would be an important follow-up of this project. One known advantage of the dryer is that grains with a low humidity content are less susceptible to the insects' attacks. In this case, two solutions could be deemed possible:

1. If the farmer doesn't want to invest too much time or money in a post-harvest technology, as a first step to reduce post-harvest losses, the farmer could improve the dryer structure. At the moment, at the smallscale farmer's level, the dryers are very basic but it is simple to make some small improvements like protecting against rodents or a roof to avoid irregular rainfall. The dryer must be placed in a strategic position to benefit from the wind.
2. The second possibility for a farmer interested in a higher quality grains, is that after effective drying (August), the grains could be stored in an appropriate container.

In any case, for the seeds, special care needs to be taken. The germination percentage has to remain high. It is paramount that the grains have an optimal moisture content (not too dry) and have a good quality at the time of storage (July, August). The maize will be stored until December, for a period of five, six months.

4. Conclusion and recommendations

When asked, the farmers said they were not worried about post-harvest losses. For them the most important losses were in the fields because of climate change. However, minimizing post harvest losses is a key factor in reducing poverty in rural areas. The importance of keeping the grains for a longer period of time is a concept, which still needs to be instilled in the farmer’s minds. It will take time before the farmers realize that there is a real benefit in selling their grains at the end of the season. Of course, they have to have the confidence that there will be buyers who are prepared to buy their grains at the higher price.
In the trial, beans after 5 months in the Tethere silo with chilli pepper presented a high level of losses (35.54%) with a significant difference to all other technologies except the clay pan, which, with losses 21.59%, was also not recommendable In these two technologies, the population of bruchids were very high after 13 weeks of storage. The others technologies did not present significant differences regarding the losses or the insect population.
For the maize, some technologies like the Superbag, the Epitha and the plastic bottle presented a very low percentage of sample loss. The metal silo and the Tethere silo presented very good results with the chemical treatment Actellic, but had more losses with the biological treatment the chilli pepper. The local technology, the clay pan, presented a high rate of insect infestation and losses in the sample and is thus not recommended for maize storage. The Tethere silo and the metal silo are only effective if used with an appropriate treatment. If a biological treatment is used, it is really important that a systematic renewal of the treatment implemented. Without taking these precautions, both silos can present a high level of damaged grains.
The following general conclusions can be made:

1. **All technologies (except the Epitha) must remain in the shade**, otherwise the losses can be higher due to the elevated temperatures inside the container.
2. **All PHM technologies were effective with Actellic.** This treatment efficiently eradicated the insect population in the storage container.
3. **Hermetic storages are effective without storage pesticides** as long as the process of hermeticity is well applied: All the air in the container must be be removed before the sealing of the container. The technology cannot be perforated and the technology must remain closed as long as possible).
4. **The Silo Tethere alone is not effective.**
5. **Biological treatments, such as chilli pepper, are not effective unless reapplied every 6 weeks.**
6. **The availability of the appropriate technologies (with proper instruction to their correct usage), as well as ease of market access has the potential to increase the use of proper PHM.**
7. **The ageless treatment is effective but is not recommended because of the lack of access to the required materials.**
8. The farmers must also become more aware on the adequate drying time and post harvest management of their crops in general.

In order to continue the project to help farming in Mozambique as it is today, several studies are proposed below:

1. **Implement a study, which describes the post-harvest practices for the maize and bean grains**, with a special attention to the practices from the fields until storage, including the observation of the drying practices with a special focus on the differences between the local and the improved varieties. This study will give the principal information on where, when and how much are the losses. It would also be

interesting to see if it is efficient to let the crops dry for a long period of time instead of storing after a short drying time.

2. **Implement a further study of biological repellents** in order to know the action time, focusing on the social acceptation and the accessibility of the raw materials. This study will be particularly important in regards to the Tethere silo, which, without chemical or biological insecticide is not effective.

3. **Implement a study on market issues for maize and beans** in the region of the North of Mozambique. The topic of post-harvest losses is strongly linked with the market. It is important to understand the value-chain with its different actors.

4. **Improve the structure of the dryer. Reduce the losses due to mice and insect attacks in the dryers.**

5. **Explore further the acceptance and economic viability of superbags if LGB is absent.**

6. **In the case of infestation with LGB, a study must be implemented in order to know if the grains/seeds treated with Actellic beforehand can be stored in Superbags.**

7. **The possibility of creating a local, closed, joint storage unit using the phostoxin treatment.** This treatment is effective and practical, as the grain is stored in the same container it is transported in.

It would also be recommended for the organisation:

1. **To propose different technologies to conserve the grains or the seeds depending on the quantity of grains/seeds harvested, on how much time the farmer wants to conserve their grains/seeds and depending on the income of the farmer.**

For farmers with a low income, it could be recommended, for example, to store their seeds in an Epitha and in two or three Superbags (for the grain which would be used when all the stocks are finished). The rest of the grains can be stored in a silo like Tethere with an appropriate treatment. A farmer, that has a higher income and larger quantities of harvested grain, can use the metal silo with the phostoxin treatment or Superbags.
It is of utmost importance, that the technologies used are adapted to the needs of the farmers.

2. **To facilitate and encourage the farmer's access and the use of the chemical treatment Actellic and the Superbag with polypropylene bag**. This technology showed a real efficacy during the storage time.

3. **The metal silo should not be promoted for small farmers in this region.** It is too expensive and not adapted to the small harvest quantity common in this region.

In a general, the farmers were not aware of post-harvest management, for example, of the importance of drying the grain thoroughly, selecting the good quality seeds and of cleaning the technologies before filling them up with the new harvest.
In the North of Mozambique, the post harvest project is a real challenge because of the lack of awareness and knowledge of the farmers. However, this topic is very important. It is hoped that with time the farmers will realize that there is a real benefit for them and their families, if they take care to dry the grains/seed properly, store them in the most appropriate storage for their needs and sell the harvest at the most profitable time of year.

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