

## Lao Upland Rural Advisory Service (LURAS)

### ACTION RESEARCH

## On-farm trial of drying and storage of maize for postharvest loss prevention

June 2020



# Contents

- Executive Summary ..... 4
- Introduction..... 5
- Objective..... 7
- Location ..... 7
- Materials and methods ..... 7
- Analysis .....14
  - Dryers .....14
  - Cleaning .....15
  - Measurement of temperature and moisture .....16
  - Laboratory analysis .....18
  - Cost-benefit analysis .....19
- Observations/Lessons learned .....20
- Recommendations – moving forward .....21

## List of Tables

Table 1. Average moisture content and weight of maize type of storage.....	17
Table 2. Average moisture content, percentage of damaged grains and germination rates of stored maize .....	18
Table 3. Gross margins on maize production, post-harvest and storage.....	19

## List of Figures

Figure 1. Traditional way to keep maize after harvest .....	5
Figure 2. Damage suffered by maize after harvest.....	6
Figure 3. Small-scale dryer .....	8
Figure 4. Metallic dryer .....	9
Figure 4. Cleaning dry maize.....	10
Figure 5. Building a hermetic metallic silo .....	10
Figure 6. Filling a hermetic metallic silo with dry and clean maize.....	11
Figure 8. Module with hermetic silo, hermetic bag and polypropylene bag .....	12
Figure 9. Polypropylene bags with maize placed inside a GrainSafe bag.....	13
Figure 11. Small dryer being filled .....	14
Figure 12. Small drier in operation.....	14
Figure 13. Small portable dryer being emptied .....	14
Figure 15. Cleaning maize grains.....	15
Figure 16. Maize stored in Polypropylene bag.....	18

## Acronyms

CIMMYT	International Maize and Wheat Improvement Center
DAFO	District Department of Agriculture and Forestry
DTEAP	Department of Technical Extension and Agro-Processing
F2F	Farmer-to-Farmer learning
HB	Hermetic bag
LURAS	Lao Uplands Rural Advisory Service
PAFO	Provincial Department of Agriculture and Forestry
PB	Polypropylene bag
SDC	Swiss Agency for Development and Cooperation
SNV	Netherlands Development Organisation

## Executive Summary

Action research was conducted in Kham district, Xieng Khuang province to test new drying and storage practices and technologies. The objective of the trial was to provide farmers and the LURAS project with information on the potential benefits of adopting new drying and storing practices. The expected potential benefits include farmers being able to sell their maize when the prices are higher and/or farmers using their maize for other purposes such as preparing feed for animals.

Action Research and Farmer-to-Farmer learning (F2F) are essential elements of the Green Extension approach being promoted by LURAS. This approach recognizes that sustainable agricultural practices must be adapted to local conditions, and that these conditions are both diverse and dynamic in the uplands of Lao PDR. Therefore, Green Extension supports groups of producers in analysing local problems and opportunities, testing alternative practices and sharing the knowledge they acquire with other farmers.

In close cooperation with farmers, the research team introduced new ways of threshing and drying maize, and introduced new or improved storage practices at selected farmers' households, including metallic hermetic silos, and small and large hermetic bags. Local welders were closely involved in the construction of metallic hermetic silos and farmers were trained in the use of the new equipment introduced. Farmers were also closely involved in the monitoring of progress and results.

This study was conducted by SNV in the framework of the LURAS project implemented by Helvetas Swiss Intercooperation and funded by the Swiss Agency for Development and Cooperation (SDC), in close collaboration with DTEAP, MAF XKH and DTEAP Kham. A partnership was agreed with the International Maize and Wheat Improvement Center (CIMMYT) to provide technical assistance.

The research found that both the metallic hermetic silos and the hermetic bags were able to preserve the quality of the maize grains (moisture and temperature) and avoid any damage due to pests. A cost benefit analysis found that gross profits per ton are highest when farmers sell undried and uncleaned grain at "low season", this is around December or January, where prices of this type of grain increase to around 1,700 LAK per kilo. Gross profits are almost as high if maize is stored in a hermetic metallic silo, and sold around April/May on the following year when prices for clean and dry maize reach around 2,200 to 2,300 LAK per kilogram. The gross profits per ton of maize grain stored in a GrainSafe bag decrease considerably, given the higher cost of the bag, while gross profits for maize of grain stored in small hermetic bags are slightly higher than those of grain stored in Grain Safe bags.

Based on the finding of this research the following recommendations are made: i) test with farmers new techniques for harvesting maize, so that the maize is peeled at the field and maize leaves are left in the field to be used as compost; ii) test the use of cribs for storage of maize on the cob before it is being threshed and dried in order to reduce losses due to pests and potential high moisture; iii) test the use of a mechanical cleaner, to reduce the heavy workload of cleaning grains; iv) conduct a second round of researcher trying the same technologies in different environment and conditions; iv) support the development of supply chains of the tested technologies to be sold locally, including the support to metal workers to manufacture silos, the development of supply chain of hermetic bags, the support to young agripreneurs interested in providing drying and cleaning services.

## Introduction

Farmers in the Northern Uplands of Lao PDR cultivate maize as a cash crop during the months of April and September-October. Maize is grown by a large number of farmers in an unsustainable way as has been described widely.

This maize is sold shortly after harvest to traders that then sell it to large buyers in Vientiane, Vietnam, Thailand and China. Because most farmers sell right after harvest, they sell at a low price and have very limited bargaining power. Farmers have poor post-harvest and storage techniques, which prevents them from selling later in the season when prices are higher. Furthermore, maize is heavily affected by insect pests during the short period of storage. The dominant insect pests that attack stored maize are the larger grain borer and the maize weevil.

Figure 1. Traditional way to keep maize after harvest



Farmers do not use any fumigants to protect their maize. Furthermore, they do not dry the maize to an appropriate moisture level of 12%-13% before storing. Farmers estimate losses of between 10% and 30% of their total crop from the field until sold to the trader.

Figure 2. Damage suffered by maize after harvest



Hermetic storage technologies such as super grain bags, metallic hermetic silos, cocoons and others have been promoted as a cost-effective way to control storage insect pests and conserve the quality of the grain in Latin America, Africa and Asia. The use of hermetic storage was identified as a potential technology to help farmers

Action research was conducted in Kham district, Xieng Khuang province to test new drying and storage practices and technologies. The objective of the trial is to provide farmers and the LURAS project with information on the potential benefits of adopting new drying and storing practices. The expected potential benefits include farmers being able to sell their maize when the prices are higher and/or farmers using their maize for other purposes such as preparing feed for animals.

Action Research and Farmer-to Farmer learning (F2F) are essential elements of the Green Extension approach being promoted by LURAS. This approach recognizes that sustainable agricultural practices must be adapted to local conditions, and that these conditions are both diverse and dynamic in the uplands of Lao PDR. Therefore, Green Extension supports groups of producers in analysing local problems and opportunities, testing alternative practices and sharing the knowledge they acquire with other farmers.

In close cooperation with farmers, the research team introduced new ways of threshing and drying maize, and introduced new or improved storage practices at selected farmers' households. Local welders were closely involved in the construction of metallic hermetic silos and farmers were trained in the use of the new equipment introduced. Farmers were also closely involved in the monitoring of progress and results.

This study was conducted by SNV in the framework of the LURAS project implemented by Helvetas Swiss Intercooperation and funded by the Swiss Agency for Development and Cooperation (SDC), in close collaboration with DTEAP, MAF XKH and DTEAP Kham.

A partnership was agreed with the International Maize and Wheat Improvement Center (CIMMYT) to provide technical assistance. As part of this partnership, three CIMMYT technicians and one experienced producer of silos travelled to Lao PDR in October 2019 to

train local metal workers in the production of hermetic metallic silos and in farmers in the use of the silos.

## Objective

This study was conducted to test the effectivity of a number of technologies and practices in controlling insect infestation, rodents, degradation (moisture and fungus) and preserving the quality of maize in smallholder farm conditions. The assumption was that practical and affordable drying and storage technologies can help farmers reduce losses of stored maize and obtain better value for a better quality maize. Finally, the expectation is that by reducing losses and preserving the quality of their maize, farmers will be less inclined to continue cutting down forest in order to maintain the high yields necessary to get a reasonable income from maize cultivation.

## Location

Two villages in Kham district, Xieng Khuang province, namely Sai and Hang Nieng villages were selected to participate in this research. The villages were selected because they grow maize and expressed an interest in participating in this trial. In each village, five households were selected by the villagers themselves to participate in the research. Households with different characteristics were selected to reflect the different socio-economic situation of households in the village. An assessment of post-harvest practices was conducted to understand their general characteristics and practices.

An agreement was made with farmers prior to starting the trial. Consent to participate in the trial was sought after the farmers had clearly understood the risks and potential costs of participating in the trial, as well as a clear explanation of how the equipment bought by the project for this trial was to be used.

The trial of storage lasted for 6 months, from October 2019 to April 2020. However, further activities were developed based on the ongoing findings and identified needs.

## Materials and methods

To test improved post-harvest handling of maize, the following activities were conducted:

1. Maize was bought from farmers at market price.
2. Maize was threshed at the village before drying and storing.
3. Threshed maize was dried in one of two dryers, i) a small portable dryer with an estimated capacity of 400 kg, ii) a dryer with a capacity of 800 kg.
4. Cleaning. Dry maize was cleaned from impurities before being stored. Cleaning was done manually, using a screen made with a metal sheet.
5. Dried seeds were stored in four different storage technologies:
  - a. Metallic hermetic silos with a capacity of up to 600 kg.
  - b. GrainPro hermetic bags with a capacity of 25-50 kg.
  - c. Polypropylene bags with a capacity of up to 50 kg.
  - d. GrainSafe bags (one in each village) with a capacity of 1 ton.

6. The storage equipment was monitored monthly for 5 months. LURAS project staff, DTEAP staff, PAFOs, DAFOs and farmers (including young volunteers) were involved in the monitoring of maize storage. The following aspects were monitored:
  - a. Condition of storage equipment
  - b. Presence of insects
  - c. Presence of/or damage by rodents
  - d. Evidence of fungus
7. After 4 months (February 2020), the storage containers were opened and samples of maize were collected. Farmers decided to continue the trial and maize was stored until May 2020.
8. The samples collected in February 2020 were shown to traders so they could provide their assessment on the quality of the stored maize.

The characteristics of the drying and storage technologies are as follows:

➤ **Small scale mobile dryer**

The small-scale portable dryer is a cylinder made of two layers of bamboo slats supported by metal rings. This dryer has capacity to dry up to 400 kg of maize in a 6-8 hour period, depending on the moisture content of the grain and the environmental conditions. A separate portable fan uses a cook stove to produce heat. Interestingly, maize cobs can be used as fuel.

Figure 3. Small-scale dryer



➤ **Small scale fixed dryer**

The small scale fixed dryer is a rectangle box made of metal with a heating chamber under it. The dryer measured 2 meters by 3 meters in width and depth, respectively, with a height of 0.4 meters. The dryer has the capacity to dry up to 800 kg of maize in a 4-6 hour period, depending on the moisture content of the grain and the weather. A separate portable fan uses a cook stove to produce heat. Interestingly, cobs can be used as fuel.

Figure 4. Metallic dryer



Both dryers were built and installed by Mr Sengchanh Pethkhounleuang (former Head of Division of Extension Production Techniques and Agro-Mechanisation at DTEAP), with support from the project.

Furthermore, farmers were trained in the use of the driers by Mr Sengchanh. CIMMYT technicians also provided training to farmers on how to sun dry maize grains and use traditional non-costly ways to assess humidity level before storage.

After drying, the maize grains were cleaned using a locally built metal screen. The moisture content of the grains was measured with an electronic moisture meter.

Figure 4. Cleaning dry maize



➤ **Hermetic metallic silo**

The metallic silo is a metal cylinder with a coned top made of galvanised metal sheeting (gauge 25) with a top inlet and a lateral small outlet. The inlet and the outlet are covered with a lid and sealed with a rubber band. The metallic silos had a capacity of 600 kg of maize and were made by two local blacksmiths with support from three CIMMYT technicians and an experienced blacksmith.

Figure 5. Building a hermetic metallic silo



The silos were filled with dry and clean maize to different capacities. The oxygen of the silo was depleted using a candle.

Figure 6. Filling a hermetic metallic silo with dry and clean maize



The silos were placed in a wooden pallet in the storage are (inside a granary or a house) for protection and to avoid high temperature fluctuations inside the silo which could lead to moisture condensation.

➤ **GrainPro hermetic bags**

The hermetic bag is a multi-layer polyethylene bag with barrier layer with a capacity of up to 69 kg with a plastic zipper. The bag allows to generate an airtight environment to create a low oxygen atmosphere using insect respiration which results in 100% insect mortality of all life stages. The bag was filled with up to 50 kg of dry maize and then placed inside a polypropylene bag creating a hermetically sealed environment in which the maize was stored. The bag was then placed next to the silo.

Figure 7. Hermetic bag inside a polypropylene bag



➤ **Non-hermetic polypropylene bag**

Polypropylene bags are commonly used to transport and store grains. A 50 kg bag was filled with dry maize and then placed next to the silo.

Figure 8. Module with hermetic silo, hermetic bag and polypropylene bag



➤ **GrainSafe bag**

The GrainSafe bag is a flexible PVC bag that is sufficiently hermetic to preserve the quality and the quantity of dry agricultural commodities without using chemicals or pesticides. Grains are stored in an airtight environment to create a low oxygen atmosphere using insect respiration which results in 100% insect mortality of all life stages. The bag was filled with polypropylene bags containing dry grains of maize.

Figure 9. Polypropylene bags with maize placed inside a GrainSafe bag



Air was extracted from the bag with a converter air blower. The bag was placed in a protected space.

Figure 10. SafeGrain bag closed



# Analysis

## Dryers

The smaller portable dryer managed to dry the maize to the required moisture level (under 14%) but, despite the advantage of being portable and more economical, it had several drawbacks. Firstly, the dryer is difficult to fill (see Figure 11 below). Secondly, because the dryer is made of bamboo slats the hot air escapes easily making the drying process slower. An outside cover would probably accelerate the drying (see Figure 12). When opened, and the maize falls and makes it difficult to collect (see Figure 13 below). It would be beneficial to have a small outlet to retrieve the dried maize.

Figure 11. Small dryer being filled



Figure 12. Small drier in operation



Figure 13. Small portable dryer being emptied



The bigger dryer (on the right on the Figure above) is able to dry up to 800 kg of maize in about 4-6 hours. While the dryer has a larger capacity and is more efficient, it does require a lot of labour in loading the maize into the dryer and is some effort in emptying. Furthermore, while the maize is dried, any insects in the grain try to escape the heat. Finally, while the maize is cooling down, and while the dryer is being emptied, cold air can be pushed through the chamber which blows out small impurities.

## Cleaning

The cleaning process is labour intensive. It took a team of 4 to 6 people (mostly women) to clean 1 ton of maize about 4 to 6 hours. A mechanical device could be easily built locally to shake the metallic mesh and make this process less labour intensive. Additionally, a machine specifically made to do shred and clean the maize can be purchased by a group of farmers or by an agripreneur and provide this service, as will be suggested later.

Figure 15. Cleaning maize grains



Grain samples were taken from each container before closing them and analyses of insect presence and damage were conducted. The results of these analysis are available upon request.

## Measurement of temperature and moisture

Measurements of temperature and moisture were taken from maize stored in the different containers of six households (5 in Xai village and 1 in Haing Neing) at the time of closure (November 2019), in February and in May 2020 in addition the two large hermetic bags (GrainSafe). These are presented in the following Table. As the figures show, while weight remained stable for maize stored in all hermetic technologies, there was a noticeable increase in moisture levels, in particular in the hermetic silo. This could have been because silos were opened in February 2020 to take samples. It confirms the importance of proper closing of the silo and the extraction of oxygen through the use of a candle. Overall, the moisture content of maize remained at reasonable levels for all maize stored in hermetic containers. For maize stored in polypropylene bags the moisture content increased excessively, as expected. Interestingly, the wide variations in temperature in the maize stored in hermetic containers, as the outside temperature changed, did not seem to affect its weight or moisture content too much.

Table 1. Average moisture content and weight of maize type of storage

	Hermetic Silo									Hermetic Bag (HB)									Polypropylene Bag (PB)								
	Weight		Moisture			Temp			Weight		Moisture			Temp			Weight		Moisture			Temp					
	Nov 19	May 20	Nov 19	Feb 20	May 20	Nov 19	Feb 20	May 20	Nov 19	May 20	Nov 19	Feb 20	May 20	Nov 19	Feb 20	May 20	Nov 19	May 20	Nov 19	Feb 20	May 20	Nov 19	Feb 20	May 20			
Household 1	241	240	13.2	13.5	14.8	24.6	21.1	25.1	50	49.5	13.7	13.7	14.7	28.6	22.1	26.2	49	38	13.6	14.5	14.3	28.3	23.2	26.2			
Household 2	401	400	13.4	13.9	15.0	29.7	20.8	25.0	50	50.5	14.3	13.7	15.0	29.6	20.6	25.3	50	39	14.4	13.5	14.3	29.6	21.4	26.0			
Household 3	300	200	13.4	13.5	14.8	27.2	21.4	26.3	50	50	13.5	13.5	14.6	27.0	21.0	24.4	50	39	13.4	16.0	20.4	26.8	23.3	26.8			
Household 4	289	300	12.7	13.2	14.5	28.0	20.4	26.2	25	25	13.5	13.3	13.8	28.1	20.6	25.2	25	18	13.5	13.4	15.1	28.1	21.7	26.0			
Household 5	400	400	13.6	13.6	14.7	25.5	20.3	25.5	50	50.5	13.3	13.5	14.4	25.7	21.9	26.0	50	50	13.5	15.9	20.4	26.1	24.2	27.4			
Household 6	394	347	12.4	14.0	15.2	28.6	17.4	27.5	30	29.7	12.3	13.6	14.7	29.3	21.2	26.9	30	N/A	12.7	13.5	N/A	29.3	22.4	N/A			
GrainSafe1	978	866		13.9	14.6		19.63	23.9																			
GrainSafe2	892	893		15.4	15.3		19.07	28.8																			

More importantly, when the hermetic containers were opened in February 2020, all the maize was in good condition with no signs of insect damage or fungus. As mentioned previously, farmers requested to continue storing the maize for two more months to continue observing the performance of the storage being tested. When the hermetic containers were opened again in May 2020, all the maize seemed to be in good condition with no signs of insect damage or fungus.

Grain stored in polypropylene bags was considerable affected by fungus and insects.

Figure 16. Maize stored in Polypropylene bag



## Laboratory analysis

Grain samples were obtained from each storage container for a laboratory analysis. Each sample was placed in a labelled plastic bag, sealed and then transported to the National Rice Research Centre for analysis. In the laboratory, grain samples were analysed for moisture level, percentage of grains damaged by insects and/or mould, percentage of germinated grains, percentage of grains with incomplete germinated and percentage of grains not germinated. A summary of the results is presented below.

Table 2. Average moisture content, % damaged grains and germination rates of stored maize

Storage	% Moisture	% Damage from insects and mould	% Germinated grain	% Incomplete germination	% No Germination
Silo	15.0	4.2	72.3	1.5	26.2
HB	15.0	2.4	83.4	1.3	15.3
PB	14.4	76.5	12.5	1.5	86.0
GrainSafe	15.1	3.2	79.5	1.5	19.0

HB = Hermetic bag; PB = Polypropylene bag

As the table shows, maize stored in the small hermetic bag show the lowest proportion of damage from insects and mould, while the silo and the large hermetic bag (GrainSafe), have a slightly higher proportion of grains damaged by insects and mould. Equally, maize stored in hermetic bags had the highest proportion of germinated grains, closely followed

by maize stored in GrainSafe bags and silos. Unsurprisingly, a large proportion of the grain stored in polypropylene bags was mouldy and did not germinate.

## Cost-benefit analysis

A cost benefit analysis was conducted to compare the profits obtained by farmers using the different storage technologies tested with the profits obtained by farmers when selling their maize at harvest. Given the high number of different technologies and practices tested, only summary of the analysis is presented in the following table.

Overall, in production two scenarios were considered. One scenario where farmers obtain a high yield, at about 8 tons per ha, and a second scenario where farmers obtain a low yield of 4 tons per ha. Regarding post-harvest costs, a number of scenarios were considered, including two dryers (small and large dryer) and three different storage technologies (metallic hermetic silo, GrainSafe bag and green hermetic bags) all described below.

The results show that gross profits per ton are highest at “low season”, this is for undried and uncleaned grain late in the year, around December or January, where prices of this type of grain increase to around 1,700 LAK per kilo. Gross profits are almost as high if maize is stored in a hermetic metallic silo, and sold around April/May on the following year when prices for clean and dry maize reach around 2,200 to 2,300 LAK per kilogram. It is important to consider that this estimated gross profits are considering the costs of producing the silo for this trial (\$100 USD), which arguably should go down if they are produced in a large-scale for sale. The gross profits per ton of maize grain stored in a GrainSafe bag decrease considerably, given the higher cost of the bag (\$400 USD), even considering that its estimated life (8 years) is higher than the estimated life of a silo (5 years). Gross profits for maize of grain stored in hermetic bags are slightly higher than those of grain stored in Grain Safe bags. However, the storing large quantities of grain in small hermetic bags would probably entail a considerable logistical problem.

Table 3. Gross margins on maize production, post-harvest and storage

	High yield	Low yield
<b>Costs</b>		
Farming costs (LAK/ton)	452,500	905,000
Post-harvest costs (LAK/ton)	17,303	34,605
Storage costs (LAK/ton)	553,000	553,000
Other costs (brokers fees, transportation)		
<b>Total cost</b>	<b>1,022,802</b>	<b>1,492,605</b>
<b>Gross profit p/ton of grain at high season</b>	<b>830,198</b>	<b>360,395</b>
Gross profit p/ha of grain at high season	5,212,640	2,606,320
<b>Gross profit p/ton of grain at low season</b>	<b>1,230,198</b>	<b>760,395</b>
Gross profit p/ha of grain at low season	8,412,640	447,900
<b>Gross profit p/ton of grain after storage in silo</b>	<b>1,177,198</b>	<b>707,395</b>
<b>Gross profit p/ton of grain after storage in GS</b>	<b>1,027,198</b>	<b>557,395</b>
<b>Gross profit p/ton of grain after storage in HBs</b>	<b>1,064,00</b>	<b>594,000</b>

This cost-benefit analysis suggests that:

- Gross profits for maize are high at peak yield levels, even with the existing low post-harvest investment, but they decrease rapidly.

- Gross profits are highest for undried and uncleaned maize sold later in the season (November to January).
- The gross profits for stored maize are highest using the hermetic metallic silos, compared to other technologies tested, such as the GrainSafe and hermetic bags.
- The economic cost/impact of the high turnover of land should be costed to understand the real (environmental) impact of using land for only 3 years.

## Observations/Lessons learned

During this action research where multiple activities and technologies were tested, an important number of lessons were learned, as follows:

1. Storage of maize on cob. Farmers store their maize on the cob and with husks and leaves under their house and with no protection, until they decide to thresh it for selling. This can be for months and the damage to the maize from rats, fungi and insects can be substantial.

Other ways to store maize before threshing can be on metal cribs protected from rodents, in polypropylene bags without leaves, or on the cob with leaves but using some chemical to repel insects and rodents.

Additionally, the maize leaves are currently discarded and burned in the village. The leaves could be an important form of compost if left on the fields to rot.

2. Threshing. To ensure that the maize has a lower level of humidity before drying and storing, the maize has to be harvested for a few days or weeks before it is threshed and dried for storage, or humidity levels will not go down sufficiently during the drying process.
3. Cleaning. Maize has to be cleaned from impurities before being stored. During this trial, cleaning was done manually, using a small cleaner made with a metal sheet. This process was time consuming and required a lot of effort. Furthermore, this is a task that will likely be done by women, adding to their heavy workload.

An alternative would be to use a specialised machine to both thresh and clean the maize. During this research, a number of economical small-scale machines sold in Thailand were identified. Threshing and cleaning with such a machine can then be done as a service in a number of villages, by a young agripreneur. In discussions with traders and buyers, it was identified that they would pay a higher price for clean grains of maize even if it is not dried.

4. Drying is essential to keep the quality of the maize grains over a long period. At present, large scale traders dry and store maize before selling it to large multi-national buyers which process the grains into animal feed. However, there is an opportunity for small-scale agripreneurs to provide the service of drying grains of maize before being stored or before being processed for feed at the farm level.
5. While the construction of silos is a "simple" process, finding the right materials in Laos to build them is not easy. In the future, more work will have to be done to ensure that local suppliers have all the right materials and tools to build silos. Local manufacturers are unlikely to do this.

However, there is clear potential for producers to sell silos on a large scale, if there is some support to develop a supply chain. Furthermore, more testing can be done with silos of different dimensions to identify which ones suit farmers best.

## Recommendations – moving forward

Based on the findings of this research a number of recommendations can be made:

1. Test with farmers new techniques for harvesting maize, so that the maize is peeled at the field. This will ensure that the leaves stay in the field and work as compost and will reduce the pollution at the village when all the leaves are burnt. Furthermore, this may reduce the weight of the maize that is carried back to the village.
2. Test the use of cribs or other ways to store maize on the cob before it is threshed and dried. These storage technologies should also help in reducing the losses from rodents.
3. Test the use of a mechanical cleaner, to reduce the workload (of women) and make sure that farmers clean the maize grains properly before storing.
4. Conduct a new round of action research trying all the technologies tested in this action research in different environments and in different modalities with the provision of services for threshing, cleaning and drying by small-scale agripreneurs. Support can be provided to develop supply chains that can encourage young entrepreneurs to enter into business.
5. Support the small-scale production feed for livestock using the stored maize. After providing training to farmers participating in this research on the production of livestock feed, an opportunity was identified to use the stored maize to prepare feed (through a local micro-enterprise) for livestock. This could then be linked to other LURAS activities, such as livestock fattening and helping to identify alternative sources of income for farmers.