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BAGS TO BULK STORAGE APPROACH FOR REDUCING MAIZE POSTHARVEST LOSSES IN MALAWI, MOZAMBIQUE AND ZAMBIA.

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ABSTRACT

The main challenge for agriculture is the feeding of the estimated 9 billion people by 2050. Besides increasing food production, attention should be directed towards reducing food loss and waste. It is estimated that 1.3 billion tons of food produced globally is lost or wasted. Sub Saharan Africa, Eastern and Southern Africa lose food valued at about US$ 4 billion and US$ 1.6 billion per annum respectively. This food can meet the annual food requirements of at least 48 million of the 220 million undernourished people in Africa. Malawi, Mozambique and Zambia experience annual maize post-harvest losses of 20% - 30%. Despite the availability of technologies for reducing postharvest food losses worldwide, their adoption remains low in Africa. Therefore, identification and elimination of constraints to the adoption of existing technologies for reducing postharvest losses should be considered. To improve the flow of information on the available technologies a capacity building programme which targeted 300 smallholder farmers and grain traders was developed in Southern Africa. The results of the post training showed an insignificant adoption of the 30 ton metal silos due to inappropriateness of the technology, cost and weak support infrastructure.

Keywords: postharvest losses, bulk storage, food waste, technology.

1.0 INTRODUCTION

The problem of global food loss and waste is real (FAO, 2011; Lipinski *et al.*, 2013; and HLPE, 2016). Nearly one third of the food produced globally every year eventually goes uneaten (FAO, 2011; The Consumer Goods Forum, 2015, Bahadur, 2016; IPFRI 2016). Nearly 800 million people globally suffer from hunger on a daily basis and 160 million of these are children and

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about quarter of the undernourished people live in sub-Saharan Africa.

Although there are many agricultural commodities in sub - Saharan Africa (SSA) which experience postharvest losses, this study focused on maize because it is the most important cereal and staple food for about 1.2 billion people in the region (IITA, 2009, FEWSNET, 2016). Most countries in Southern Africa, particularly Malawi, Mozambique, Zambia are concerned about the food security situation and the future outlook because of low agricultural productivity and the impact of climate change. Another factor contributing to food insecurity are postharvest losses which occur along the value chain and are estimated to range from 20% - 30%. With regard to cereals, it's estimated that at least 14 billion tons of food valued at US$ 4 billion is lost in sub Saharan Africa annually (World Bank, 2011). These estimates are exclusive of postharvest losses (PHL) in the form of reduced revenues arising from quality and market opportunity losses. Much as there is a lot of knowledge about PHL, there is lack of accurate figures on the actual level of losses in sub - Saharan Africa (Parfitt *et al.*, 2010 and Sheahana *et al*., 2016).

There are competing definitions of food loss and waste. Although food waste is mainly defined at retailing and consumption stages where agricultural products are predominately meant for human consumption, waste takes place at different stages of the food supply chain (Lipinski *et al.*, 2013)). According to FAO (2013) food losses are "a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption". In reinforcing the debate of food losses, Lipinski *et al.*, (2013) asserted that food loss is the absence or decrease in food quality caused by spillage and spoilage because of poor food handling and transportation. Food losses take place at production, postharvest and processing stages in the supply chain (Parfitt *et al.*, 2010).

Post-harvest losses are caused by several factors which include inappropriate handling or bio-deterioration by micro-organisms, insects, rodents or birds (Kumar and Kalita, 2017;Grolleaud 1997; Boxall, 2002). In the developed world, large quantities of food produced is wasted for reasons such as it has passed expiry date and includes that which remains on the plate after meals (Hodges *et al.*, 2010, WRAP, 2007). Food losses and waste in developing countries are caused by financial, managerial, and technical constraints in harvesting methods, handling, storage, cold chain infrastructure, packaging and marketing systems (ibid).

In a bid to reduce food insecurity in the sub Saharan Africa region, intervention in post-harvest food loss reduction is seen as an important intervention (World Bank 2011; FAO, 2010). Other reasons for reducing food loss and waste include social, economic gains and environmental sustainability (Kader 2003; Gustavsson *et al.*, 2011, Parfitt, 2010)). One of the constraints to reducing food loss and waste is that some of the institutions that have the capacity to address the

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problem, such as governments and private sector are not very clear about where to start from due to inadequate empirical data to guide them during policy formulation (Sheahana *et al.*, 2016).

In the aftermath of the food crises of 2006/2008 and the anticipated food shortages in future, investment in reducing postharvest losses are considered to be potentially more cost effective and environmentally sustainable possibility to boost food security of particularly more vulnerable populations (IFPRI, 2011). Owing to the fact that food loss and waste reduces net food supply available for human consumption, it's envisaged that the reduction of food losses and waste would contribute to increasing net food supply, which subsequently could lower food prices locally and globally (FAO, 2011; Lipinski *et al.*, 2013, Lundqvist, de Fraiture and Molden, 2008).

The dearth of infrastructure and poor production and harvesting techniques in many third world countries are bound to remain key factors in the creation of food waste. Although the reduction of postharvest losses is acknowledged as a cardinal element of improved food and nutrition security (Nellemann et al 2009), less than 5 percent of the funding for agricultural research is apportioned to postharvest systems (Kader, 2003).

While there may be other technologies for preventing PHLs in existence or under research, most discussion in literature is skewed towards the hermetic storage structures. The experimentation on use of acoustics to detect pest outbreaks in storage indicates that further innovations for PHL reduction is on the way (Sheahana *et al.*, 2016). They further say that arising from the compounding effect of crop deterioration accrued from the field, consideration should be given to interventions which reduce PHLs prior to harvesting of the crop.
There are opportunities for reducing postharvest losses through application of availability technology, arising from renewed world interest in addressing postharvest losses in response to the food crisis experienced during 2006-2008. For example, a variety of technologies are available for reducing PHLs, including crop protectants and storage containers such as hermetically sealed bags (PICS) and metal silos.

Despite the availability of knowledge and technologies for reducing PHL, there is poor flow of information to the ultimate users; the smallholder farmers and other value chain actors (Nellemann et al. 2009 and Shiferaw *et al.*, 2012). In addition, the factors which determine the adoption of technologies for reducing postharvest losses by value chain actors are not clearly known (Mwangi *et al.*, 2015).

Therefore, the use of technology to mitigate postharvest maize losses is one of the promising strategies that could be used to address food insecurity in Malawi, Mozambique, Zambia and

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other sub-Saharan African countries (FAO 2010; Nellemann *et al.*, 2009; Parfitt, 2010**)**. It's against this background that a series of training workshops in grain handling and storage management was developed in Southern Africa.

2.0 MATERIALS AND METHODS

Between 2014 and 2015, the Southern Africa Trade Hub under the Feed the Future Programme supported 12 training workshops attended by 300 participants from Malawi, Mozambique and Zambia. The objective of the training workshops was to strengthen the capacity of smallholder farmers and grain traders to reduce post-harvest losses of maize during handling and marketing and to transition from bags to bulk storage. The training was targeted at smallholder farmers and traders dealing with cereal grains of at least 300 - 1,000 tons annually.

3.0 PLANNING OF THE TRAINING WORKSHOPS

The SierkYbema Grain Services of South Africa collaborated with Zambian Centre for Lifelong Learning Limited (ZL3 Ltd), ACE Ltd in Malawi and Unilurio University in Mozambique in running the training workshops. Planning for the workshops involved a series of meetings with trainers, suppliers of post-harvest equipment and commercial grain trading companies that buy grain from small scale grain aggregators. Some of the significant outcomes of the planning meetings included agreement on the workshop content, delivery methods, criteria for selection of participants and post training activities.

The expected outcomes of the training were:

- Shared understanding of the concepts and practices of grain handling;
- Increased knowledge and skills in grain handling;
- Increased skills in the use of grain handling equipment such as, moisture testers, sample dividers, sieving equipment;
- Exposure to pesticides used in preventing PHL caused by insects and rodents; and
- Increased adoption of 30 ton metal silos.

4.0 IMPLEMENTATION OF THE TRAINING WORKSHOPS

The training employed participatory learning and action methods. This approach used learner centered training styles aimed at developing skills and abilities of adult learners to diagnose and solve their own problems. The training delivery further employed a process of competence building and self-discovery for learners, whose needs, experiences and goals were the focus of

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the workshops. The practical sessions gave the participants an opportunity to exchange views on the opportunities, challenges and problem solving approaches in grain handling and trading.

The training workshops in the three countries included theory practicals and demonstration of various postharvest storage technologies. With regard to hermetic storage environments, the participants were shown the operations of 30 ton metal silos. These metal silos were robust units made from galvanized iron and capable of storing a wide range of grain crops. Since metal silos are hermetic and water resistant, they provide long term storage of grain which contributes to a reduction in postharvest grain losses and enhancing food and income security of the farmers. The metal silos used during the trainings were under promotion by the manufacturers that had even established a credit facility for traders interested in acquisition of this technology for storage of grains.

The other grain storage technologies demonstrated included Super Grain Gags, Zero Fly Bags and the GrainSafes. Although these bags can protect grain from moisture, insect pests and fungus, they are susceptible to damage by rodents.

5.0 TRAINING EVALUATION

In order to access the participant's level of knowledge on grain handling, they wrote a pretest at the start of the training workshops. The participants were continuously assessed through theoretical and practical tests administered at the end of each training session. The final evaluation of understanding of learning materials involved participants writing theory and practical tests. Of the 300 participants enrolled for the trainings, the 286 that passed the tests became certified to manage grain handling facilities in the Southern African Development Community (SADC) region.

The assessment indicated that participants were satisfied with the learning materials, practical exercises and the delivery of training. The participants further expressed the view that much as metal silos provided more versatile protection of grain than grain bags, the 30 ton capacity metal silos which were demonstrated during the training were not appropriate for their needs. The participants preferred that the credit facility for the purchase of the metal silos could have been made available for buying of grain as this would have increased their volume of business.

At the end of the training participants developed plans for the application of the knowledge and skills acquired from the training.

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6.0 POST TRAINING FOLLOW - UP

Six months after the training, a post training follow - up was conducted. The objectives of the follow-up study were to:

i. Determine the challenges faced by participants in applying the knowledge and skills acquired from the training;
ii. Evaluate the number of 30 ton metal silos bought by the trained grain traders; and
iii. Identify the technologies used by traders to reduce postharvest grain losses in their businesses.

7.0 DATA COLLECTION AND ANALYSIS

7.1 Data Collection Methods

The data collection tools included questionnaires for structured interviews directed at the respondents and a checklist used in focus group discussions (FGDs). The information from focus group discussions assisted to triangulate and qualify data collected from interviews and in making the recommendations on remedial measures to be undertaken. Other tools included observations. Key informants comprised maize processors and manufacturers of agro storage equipment. Data analysis was done using SPSS and content analysis.

7.2 Sampling

Purposive sampling was used because it helped to answer the study questions (Kumar 2011). Purposive sampling is virtually synonymous with qualitative research (Palys, 2008), also known as judgmental, selective or subjective sampling is a type of a non-probability sampling technique. The main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which best provide answers to research questions.

The grain traders interviewed were those that had attended the training workshops in the three countries. The 150 farmers (75 per district) will be randomly selected using RANDBETWEEN Excel function. The 60 sampled traders were at the standard error of the mean ≥ 0.05 (i.e. $n/N = 0.05$). Therefore this sample size was within the 95% confidence interval and 5% margin of error.

8.0 RESULTS AND DISCUSSION

The results from post training follow up showed a reduction in the grain rejected by the market on account of low quality. Grain losses incurred by the traders reduced due to improved handling

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methods. The study further established that the grain losses incurred by the traders reduced and this subsequently increased the volume of grain traded. Table 1 shows that methods such as cleaning, grading and application of pesticides to grain contributed to improved quality and reduction in postharvest losses. These results confirmed that capacity strengthening of actors along the food supply chain can contribute to the reduction of postharvest losses. In the absence of information about postharvest loss management, it is no wonder that there is a low uptake of innovations and technologies for preventing postharvest food losses among the actors in the food supply chain in Malawi, Mozambique and Zambia and other SADC member states.

With regard to adoption of metal silos, table 2 shows that 12 percent of the trained traders had bought the metal silos despite the availability of a credit facility to support the purchase of the technology. The few silos were bought by the large grain marketing companies on recommendation from employees that had attended the training. Reasons for the poor adoption were inappropriateness of the technology to the target group, high cost, lack of power for loading and offloading of grain and trucks for bulk transportation.

Table1 : Technology application

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pesticides to control pests	5	8.3	8.3	8.3
	combination of pesticides cleaning and grading	54	90.0	90.0	98.3
	No response	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Source: Field survey data: 2016

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Table 2: Purchases of metal silos

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	11.7	11.7	11.7
	No	51	85.0	85.0	96.7
	No response	2	3.3	3.3	100.0
	Total	60	100.0	100.0	

Source: Field survey data: 2016

The low adoption of the metal silos can be explained by the Technology Acceptance Model (TAM) which is widely used to predict and explain user acceptance of technologies (Davis, 1989, Venkatesh, 1996). TAM suggests that user acceptance and usage of a technology is determined by perceived usefulness (PU) and perceived ease of use (PEU).

According to the Technology Acceptance Model (TAM) the two theories which determine an individual's behavioral intention to adopt a technology are perceived usefulness (PU) and perceived ease of use (PEU). Perceived usefulness is defined as "the degree to which an individual believes that using a particular system would enhance his or her productivity" while perceived ease of use is defined as "the degree an individual believes that using a particular system would free of effort" (Davis,1989). Of the two theories, perceived ease of use has a direct effect on both perceived on both perceived usefulness and technology usage (Adams et al,. 1992; Davis, 1989). Saga and Zmud (1994) found that an individual may adopt a technology if it is perceived suitable, beneficial and socially desirable even if they do not like using the technology.

Although several approaches and technologies for reducing postharvest losses in developing countries have been developed there are challenges in adopting these technologies in the rural areas (Rosegrant *et al.,* 2015). Shiferaw et al (2012) report that technologies face adoption challenges because of their inappropriateness for smallholder farmers, unavailability at the right time and right price. Although literature reports of several studies conducted on innovation and uptake of agricultural technology and its impact of smallholder farmer in developing countries, its adoption is slow and certain features of adoption are not yet properly understood although they are a critical creation of prosperity in developing countries (Bandiera and Rasul; 2011).

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9.0 LESSONS LEARNED

Some of the key lessons learned were that:

i. Metal silos have an important role to play in reducing postharvest losses because they offer long term storage of grains. The suitability of metal silos to the needs of grain traders is an important factor in the adoption of this storage technology. The stallholder farmers and traders preferred metal silos of 1-2 ton capacity because they were appropriate for storage of maize grain retained for consumption. Since the grain for the market does not get stored for more than 3 months it did not make any business sense to invest in a 30 ton metal silo for temporary storage.

ii. The 30 ton capacity metal silos which were on promotion during trainings were poorly adopted by the target market which preferred smaller capacity metal silos. Even the availability of credit to purchase the US$ 18, 000 metal silos was not attractive enough to make the grain traders invest into the metal silo technology.

iii. Although grain bags are not as versatile as metal bins in providing long term storage of grain, farmers and grain traders are likely to continue using this technology because of its suitability to the circumstances of the users.

iv. Poor adoption of the metal silo technology was due to inappropriateness of the technology to the circumstances of the target group.

v. The absence of adequate information about postharvest loss management, contributes to the low uptake of innovations and technologies for preventing postharvest food losses among the actors in the food supply chain in the target countries.

vi. Residential training was not suitable for traders as at times they had to leave the training venue in order to attend to their businesses. The use of open and distance learning (ODL) would have been a better option because it does not remove traders from their businesses.

vii. Small grain traders could not afford the cost of grain grading equipment such as moisture testers, sample dividers and sieves

viii. The concept of bags to bulk was not feasible due to lack of support infrastructure such as appropriate metal silos, trucks for transportation of bulk grain and electrical power for driving the equipment used in loading and off-loading of grain.

ix. After training there was an improvement in the quality of grain delivered by the trained traders to grain trading and milling companies.

x. Arising from the application of improved grain handling methods, there was a reported reduction in the quantity of grain lost along the supply chain.

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10. CONCLUSION

Most countries in Southern Africa, particularly Malawi, Mozambique, Zambia are concerned about the food security situation because of low agricultural productivity and the impact of climate change. Food insecurity is further exacerbated by postharvest losses which occur along the value chain.

Despite the availability of technologies for reducing postharvest food losses worldwide, their adoption remains low in Africa. Therefore, identification and elimination of constraints to the adoption of existing technologies for reducing post-harvested losses should be considered. Grain storage is a critical stage in the supply chain where losses should be minimized and appropriate technology to achieve this is required. The common storage systems used by small and medium producer includes granaries, plastic containers storehouses, plastic or jute bags.

The results of the post training evaluation showed an improvement in the quantity and quality of grain marketed by traders that had received training in grain handling. The adoption of the 30 ton metal silo, however, was insignificant because of the cost and inappropriateness of the technology to the operating environment of the target group.

The strategy to use bulk storage for preventing post-harvest grain losses through replacement of bags for packaging and transportation of maize is not yet feasible in Malawi, Mozambique and Zambia. This is due to lack of support infrastructure such as technology for on farm bulk storage, trucks for bulk transportation of grain and power for operating the equipment for bulk loading and off-loading of grain.

One of the limitations with this study was its focus on the 30 ton bulk storage bin. The study can be broadened and enhanced through the inclusion of other bulk storage technologies such as the 2 ton metal bin storage, GrainSafes and Purdue Improved Storage (PICS) bags. This technology is more suitable to the circumstances of smallholder farmers and grain traders because of its low cost and adaptability.

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