Original Research Article

Status of Postharvest Operations in Upper East Region of Ghana: The Case of Maize Producers

ABSTRACT

A baseline survey was conducted in the Upper East Region of Ghana to assess current postharvest practices and factors influencing long and bulk storage of maize. The research tools employed were field survey, farm visits and key informant interviews. Twenty farmers were randomly selected from each community making a total of 120 farmers. Household structure on average is made up 7±5 individuals, mean age of household heads was 47 years compared to their wives age of 38 years. Maize is mostly stored in polypropylene sacs and jute sacs on raised platform in household stores. Majority of respondents indicated that post-harvest losses during storage are critical challenges to production and household food security. The main causes of loss were insect pest, rodents and grain moulds. Majority of farmers store maize for 5-8months. Though some local and synthetic grain protectants were used, post-harvest losses in 1 year of storage were still beyond acceptable limits. However, there was high willingness to adopt new efficient methods of crop protection like biological control. The idea of community storage methods was still not a technology farmers may adopt; due to a myriad of socio-cultural reasons. The results of the baseline study will guide the implementation of the project as well as serve as reference point for future impact assessment. Overall, integrated strategies involving clean farm operations, use of appropriate storage technologies and provision of improved storage structures are required to reduce current losses.

Key words: Maize farmers, postharvest losses, storage and biological control

INTRODUCTION

Maize (*Zea mays* L.) has become an important staple food crop in all parts of Ghana. Currently, maize based cropping systems have become dominant in drier northern savanna areas of Ghana where sorghum and millet were the traditional food security crops. According to SRID (2011), maize is the most cultivated in Ghana, occupying up to 1,023,000ha on arable land compared to rice (197,000ha), millet (179,000ha), sorghum (243,000ha), cassava (889,013ha), yam (204,000ha) and plantain (336,000) (SRID, 2012). Currently, Ghana is net-importer of maize even though it has great potential to be self-sufficient and net-exporter. Per capita consumption of maize is estimated at 44 kg/person/year (FAOSTAT, Feb 2013). Declining yields of maize are now observed due to decreasing soil fertility and high cost of fertilizer. Over the last 2 decades, a myriad of maize varieties, cultivars and hybrids have been released. These genotypes possess traits such as early maturing, drought resistance, diseases and pest resistance, striga resistance, as well as additional nutritional values such as quality protein, yellow and sweet corn. Grains of these genotypes possess diverse textural, physical and compositional characteristics which relate differently to light, moisture and temperature as well as susceptibility to pests and disease pathogens; particularly during prolong storage. This requires commensurate postharvest techniques and strategies to contain harvested surpluses. Also, due to intensification and productivity increase, the need for bulk and prolong storage has become critical. This increase can be attributed to government and donor assisted projects such as providing subsidies on agricultural inputs. Nonetheless, current storage methods are suited for small-holder farmers requiring storage of less than 1 ton. Interventions to introduce large storage units such as community warehousing, community grain banks or metal silos which can contain several tons of grain is still constrained by national agricultural policies as well as low adoption from farmers.

One of the challenges faced by African countries in achieving food security is high postharvest losses. It has been estimated that the value of postharvest losses in sub-Saharan Africa is about US$48 billion a year. In Ghana, for example, postharvest losses for maize, cassava and yam are estimated to be 35%, 35% and 24%, respectively (CTA 2014). According to the World Bank (2011) important volumes of cereals are lost after harvest in developing countries which worsens the hunger situation. In addition to the lost in volumes, quality of grain is also compromised resulting in lower market opportunities and nutritional value. In fact, in 1975, the United Nations brought postharvest storage losses into international focus when it declared that “further reduction of postharvest food losses in developing countries should be undertaken as a matter of priority” (FAO 1981).

Generally, stored maize can be damaged by insect pests if they are not properly conditioned and protected (Obeng-Ofori, 2008). It has been found with maize in Ghana that for every 1 percent damage above 5 percent (damage referring to grains with insect holes), the value decreases by 1 percent. So if undamaged grain is worth US$1.00/kg, then grain with 10 percent damage is worth only US$0.95/kg, and with 20 percent damage it is worth only US$0.85/kg. These potential losses in value can make a substantial difference to a family’s livelihood (DFID Crop Postharvest Program) *FAO.*This challenge may be exacerbated due to cropping intensification and introduction of hybrid cultivars. Maize is harvested towards the cessation of the rainy season and stored during the drier months of the year. Maize is often stored on cobs in traditional grain silos or shelled into jute and polypropylene sacs with or without protection for storage. However, pest infestation is a perennial constraint; the conditions favorable for grain storage are as well suitable for insect pest reproduction.

On-farm infestation of notorious storage pests such as larger grain borer (*Prostephanustruncatus*), lesser grain borer (R*hyzoperthadominica*)*,* maize weevil *(Sitophiluszeamais),* granary weevil *(S. granarius)* as well as mycotoxins accumulation, are a threat in grain storage. Indiscriminate use of common grain protectants such as Actellic (Pirimiphos methyl), bioresmethrin (pyrethroid) phostoxin and Gastox (Aluminium phosphate) is widespread among small-holder farmers (Sugri, et al 2010). Most farmers acquire agro-chemicals from non-accredited input dealers without any training on appropriate use. There is the need to integrate production and postharvest practices to achieve quality food for consumers. Integration of good agronomic operations, pest management and appropriate storage techniques to minimize pest damage is therefore very essential. This project seeks to improve agricultural productivity and farm family livelihoods by deploying improved storage and handling practices to reduce postharvest losses of smallholder farmers in the Upper East Region of Ghana (Osei-Agyeman *et al* 2014).

As part of activities of the project titled ‘containing productivity increases of maize in Northern Ghana through large-scale storage methods’, a baseline study was initiated to generate relevant information to describe the prevailing socioeconomic conditions in the project communities. The results of the baseline study are expected to guide the implementation of the project and to serve as a data base (reference point/measuring scale) against which progress can be measured. The study will also measure the levels of key project indicators to inform the setting of targets. This will also help in the design of the indicator performance tracking table (IPTT). Moreover, it will provide the basis for future impact studies. More specifically the baseline study will; Assess crop (maize) production system in the project communities, identify maize postharvest challenges and the causal factors, provide inventory the existing storage methods. The study will as well assess the level of awareness of using biological control methods in maize storage, assess the willingness to adopt biological control, and estimate the rates of adoption of existing storage methods and determine the factors affecting adoption of improved storage methods.

MATERIALS AND METHODS

Study Area

The Upper East Region (UER) of Ghana lies between longitude 1015'W to 005'E and stretch from latitude 10030'N to 1108'N. The region lies in the Sudan savanna agro-ecology, which forms the semi-arid part of Ghana. The area is part of what is sometimes referred to as interior savanna and is characterized by level to gently undulating topography. Important crops include millet, sorghum, maize, rice, sweet potato, groundnut, cowpea, soybean, cotton onion and tomato. The sheanut tree grows wild and it is an important cash crop. It has alternating wet and dry seasons with the wet season occurring between May and October during which about 95% of rainfall occurs. Maximum rainfall occurs in August-September, and severe dry conditions exist between November and April each year. Annual rainfall ranges from 800-1200 mm. There is wide fluctuation in relative humidity with low values as much as 30% in dry season and above 75% in the wet season (www.ghanadistricts.com).

Approach

The study used different data collection methods. These included both quantitative methods (questionnaires) and qualitative (participatory rural appraisal tools, focus group discussions, key informants interviews) methods. Besides that, secondary data were obtained through desktop research of literature on existing studies already done on similar subjects. Semi-structured questionnaire was developed and administered to multi-phase purposive and randomly selected farmers within the project district to enable us obtain data for the project to assist in project implementation.

Focus group discussions (Chambers, Robert 1993) were carried out with randomly selected farmers within the project districts. This was aimed at collecting qualitative data to support the data gathered by the farmer questionnaire and also serve as a means of triangulation to ensure that the data is realistic and reliable. This was guided by a pre-printed checklist tailored to meet some of the information needs of the study.

Sampling Technique

The population of interest for the study included all farmers in Bawku East, Binduri and Pusiga District of the Upper East Region of Ghana. The unit of study is the farmer who we define for purposes of this study as an individual who lives and farm within the selected communities. A purposeful, random and multi-phase sampling approach targeting maize producing communities and households was adopted. This procedure allowed us to take a representative sample with characteristics that can be generalized for the entire population which it represents.

The sample size was determined using the following formula:

$N = (Z^2PQ \div D^2)$.

Essentially three factors determine the size of the sample for a survey within a population:

Estimated prevalence of the variable studied – in this case, farmers in the community. The confidence level aimed at the acceptable margin of error.

N: required size of the sample

Z: confidence level of 95% (standard deviation of 1.96).

P: estimated prevalence of farmers in the project area (80%), i.e. the proportion of the target population with a given characteristic.

Q: 1-P.

D: margin of error of 5 % (standard deviation of 0.05).

$N = 3.8416 \times 0.8\ (0.1/0.0025) = 122$

A total of 122 farmers were randomly sampled from a purposive sample of two communities in the three districts of the Upper East region. The communities were selected because of their attitude to farming and response to project requirement.

Data was collected from farmers using structured questionnaires via face-to-face interview. Questions covered household demographics including age, household size, education and gender of household members. Household assets were inventoried to include both agriculture and non-agriculture assets and, crops and livestock inventories. An agricultural system module surveyed crop production and agricultural land use, storage methods, post-harvest trainings, etc. The data was analyzed using SPSS software.

RESULTS AND DISCUSSION

Demographic Information

Table 1-4 provide a summary of the demographic structure of the households sampled. In all, 42% of respondents were female farmers and 58% male farmers (Table 1). Household structure on average was made up of 7±3 individuals (Table 2). The mean age of household heads was 47 years compared to their wives whose mean age was 38 years. The results also showed that migration of household members was not common during the rainy season but up to 10% migrate down south when agricultural activities decline. The observations indicate that most of the household heads (99%) were involved in crop production. The annual agricultural related household income for about 26% of farmers raged from 100.00- 2,000.00 GHS as the lowest category whereas the biggest category of 8100 -10,000.00 GHS constituted about 18.5% of farmers surveyed. Farmers within the income brackets of 4,000.00 – 8,000.00 constituted about 43% of farmers surveyed (Table 3).

Table 1: Gender of respondents

Gender	Frequency	Percentage
Female	50	42
Male	70	58
Total	120	100

Table 2: Household composition and age of respondents

Description	Variable	Mean	Standard Deviation	Minimum	Maximum
Head	HH size	7	3	2	22
	Age (HHH)	47	14	26	78
(N = 120)	Age (WHH)	38	10	18	70

Table 3: Income status of households

Income (GHS 00)	Frequency	Percentage
1-20	31	26.1
21-40	14	11.8
41-60	26	21.8
61-80	26	21.8
81-100	22	18.5
Total	**119**	**100**

Majority of respondents (63%) had no formal education, only 26% had basic education and 10% had post-basic education (Table 4). Livestock rearing is considered as an occupation by very few households (1%). Majority (84%) of the respondents were crop farmers, 3% were students, a few were engaged in various forms of trade, and only 3% unemployed (Table 5).

Table 4: Educational status of respondents

Education level	Frequency	Percentage
None	75	63
Primary	15	13
JHS/Middle shool certificate	16	13

SHS/Technical school	12	10
Non-formal	2	1
Total	120	100

Table 5: Primary occupation of respondents

	Frequency	Percentage
Student	3	3%
Farmer	101	84%
Unemployed	4	3%
Employed	9	8%
Petty Trader	3	3%
	120	100%

Cropping Systems

Majority (89%) of respondents were engaged in crop production whiles a little minority were involved in animal (7%) and tree (4%) production as the main livelihood strategies (Table 6). Major livelihood crops include maize, sorghum, millet, soybean, cowpea, rice, sweet potato and vegetables (Table 7). Maize is cultivated on up to 4 acres and a maximum land size of 15 acres. The range for cowpea is 2-12 acres, whiles Bambara beans, groundnut and sweet potato recorded the least production area of 1, 2 and 2 acres, respectively.

Table 6: Main farming systems in the study area

Farming type	Frequency	Percentage
Crop production	107	89
Tree crop Production	5	4
Livestock marketing	8	7
Total	120	100

Table 7: Main crops and acreage of production

Crops	Acreage Mean	(Ha) Min.	Max.
Maize	4	0	15
Sorghum	1	0	4
Soyabeans	2	0	5
Cowpea	2	0	12
Vegetable	2	0	3
Pearl Millet	2	0	9
Groundnut	1	1	2
Bambarabeans	1	1	1
Sweet Potato	1	1	2

Total land size of HH	8	1	45

Maize Post-Harvest Operations and Losses

In Table 8, 95.8% perceived high levels of post-harvest losses in recent times while 4.2 % of the respondents were adamant. The main causes of maize grain damage were insect pests (69.2%), rodents (16.2%) grain moulds (6.7%), weight loss (5.7%) and loss of flavor/nutrition (1.7%). Only 1.7% of the respondents recorded no incidence of post-harvest losses and pest infestation at storage (Table 9)**.** Dzisi et al. (2007) identified field and post-harvest losses as the most important constraint limiting maize production in Ghana. They reported losses in the field and post-harvest sectors as 5-10% and 15-20% respectively. Edusah (2006) reported losses of up to 15 to 30%, which is close to the range reported (15-25%) by respondents of this study.

Table 8: Incidence and estimated maize postharvest losses under farmer storage

Incidence of produce infestation at storage			**Quantities of losses incurred (%)**		
	Frequency	Percentage	Range	Frequency	Percentage
Yes (incidence)	115	95.8	0 - 8	29	24.2
No (incidence)	5	4.2	10 – 25	67	55.8
			27 - 60	24	20
			TOTAL	120	100

Table 9: Description of major causes of maize postharvest losses

Main causes of losses	Frequency	Percentage
Insects infestation	83	69.2
Rodents	20	16.7
Grain moulds	8	6.7
Weight loss	5	4.2
Quality (taste/ aroma/colour)	2	1.7
No incidence	2	1.7
Total	**120**	**100.0**

Maize Storage Methods

Table 10 describes the various storage methods used in the study area. Majority of farmers, 40% and 27.3%, store maize in poly-sacs and jute sacs respectively. The use of poly-sacs has gradually replaced jute sacs due to low cost and ready availability. Though, the use of PICS sacs has recently been introduced, only few farmers opt for them apparently due to high initial cost. Up to 16.7% of farmers store their maize for 1-4months, 64.2% store maize for 5-8months, and 17.5 store up to 12months (Table 11). Only 1.7% store maize store maize beyond 12 months confirming that they produce in small quantities for subsistence. Only small quantities 1-3bags are stored by 37.5 % of respondents and up to 37.5% store 4-10bags, only about 8.3% stored more than 25bags of maize (Table 11).

Table 10: Maize storage methods

Maize storage methods	Frequency	Percentage	Ranked	Reasons for selection
Bare floor	15	12.6	3	Easy to store, affordability
Stored in jute sacs	33	27.3	2	Availability, durability,
Stored in poly-sacs	48	40.3	1	Availability, durability, low cost
Stored mud silos	10	8.4	5	Common traditional method, regulate grain use
Stored in maize ban	14	14	4	Regulates use of maize/ reduce wastage

Total	119	100

Poly-sacs was ranked the most preferred storage method. This finding is supported by a study by **USAID PHHS Final Report (2012)**. The reason for that rank is that it is not expensive, ready availability and durable. Jute sacs was ranked second most preferred and the reason was that it is available and durable. Bare floor, maize ban and mud silos were ranked 3rd, 4th, and 5th respectively. A survey concluded in Northern Ghana by ADRA and OIC demonstrated that that mud silos offer the benefits of improved food security by reducing storage losses with low cost. However the use of this technology is very low in the upper east region of Ghana.

Table 11: Duration of maize at storage

Duration of storage			Volume of produce stored		
Storage period	Frequency	Percentage	Bags	Frequency	Percentage
1-4 months	20	16.7	1-3bags	45	37.5
5-8 months	77	64.2	4-10bags	45	37.5
9-12 months	21	17.5	11-25bags	20	16.7
1-2 years	2	1.7	Above 25 bags	10	8.3
Total	120	100	Total	120	100

Polypropylene

Jute sacs

acs

Pest Management Strategies Adopted by Farmers

Results from focus group discussions indicated that farmers' prior knowledge on the type, severity and time of pest infestation in different commodities guided their choice of pest management. Table 12 provides a summary of approximate time of pest infestation and management options for different crops. Close to 44.2% of the respondents noticed pest infestation within 1-4 months, 33.3% within 5-months, whiles 12.5% noticed no pest incidence. From the group discussions, over 50% of respondents alluded that, except in cowpea and Bambara nuts, pest infestation occurred late at 6 months after storage. Farmers therefore applied postharvest chemicals few months after storage or when some level of infestation was noticed. Where storage was anticipated above 4 months, over 50% of farmers used some kind of protection. The use of biological control was not a familiar term; probably this control measure has not been introduced into the area. Only 1.7% of farmers resorted to the use of botanicals such as *neem* products, pepper, *mahogany* bark, *Jethropha* and other local oils. Majority use insecticidal dust (43.3%) and phostoxin (13.3%) for pest management. It was realized that only 1 respondent use ash to actually prevent pest attack. The common grain protectants were *Actellic* (Pyriphos methyl), *bioresmethrin* (pyrethroid) p*hostoxin*, *Gastox* (Aluminium phosphate), *Wander77 powde*r.

Table 12: Period of pest infestation and common pest management strategies

Months after storage	Frequency	Percentage
1-4	53	44.2
5-8	40	33.3
After 8	12	10
No pest incidence	15	12.5
Total	120	100
Methods of maize grain protection	Frequency	Percentage
Only drying	48	40
Botanicals (neem, mahogany etc)	2	1.7
Photoxin tablet	16	13.3
Insecticidal dust	52	43.3
No measure taken	1	0.8
use of ash	1	0.8
Total	120	100

Farmers expressed their willingness to adopt both the poly-tank storage method and the biocontrol storage method. Those who indicated they will agree to adopt the poly-tank method were about 45% whiles those who strongly agreed also scored 45.5%. 55.5% of the farmers indicated they will agree to adopt the biological control method whiles 31.1% said they strongly agree to adopt the biological control method. From all indication the farmers are willing to adopt both the poly-tank and biological control method of maize storage in the Bawku municipality as shown in Table 13.

Table 13: Willingness to adopt new storage techniques

I will adopt a new poly-tank storage method		
	Frequency	Percent
Strongly Disagree	1	0.8
Disagree	1	0.8
Neither agree nor disagree	9	7.5
Agree	54	45
Strongly agree	55	45.8
Total	120	100
I will adopt biocontrol storage method		
Strogly disagree	1	0.8
Disagree	2	1.7
Neither agree nor Disagree	13	10.9
Agree	66	55.5
Strongly agree	37	31.1
Total	119	100

Conclusion and Recommendation

Overall, 42% of respondents were female farmers and 58% male farmers. Household structure on average is made up 7±5 individuals, mean age of household heads was 45-47 years compared to their wives 35 to 38 years. Majority of the household heads and their wives had no formal education and their primary occupation was crop-livestock production. Household wealth was largely concentrated on crop-livestock inventory and other off-farm livelihood such as agro-processing and petty trading. Maize was mostly stored in polypropylene sacs (48%) and jute sacs (33%) on raised platform in household stores. Close to 95.8% of respondents indicated that post-harvest losses during storage are critical challenges to production and household food security. The main causes of loss were insect pest (69.2%), rodents (16.2%) grain moulds (6.7%), weight loss (5.7%) and loss of flavour/nutrition (1.7%). Up to 16.7% of farmers stored their maize for 1-4months, 64.2% store maize for 5-8months, and 17.5% store up to 12months. Only 1.7% store maize beyond 12 months; confirming that they produce in small quantities for subsistence.

The major crops produced in the study area included: maize, millet, sorghum, peanuts, bambara nuts, soy beans, rice and sweet potato. The use of poly-sacs was ranked the most preferred storage method due to ready availability and low cost. Jute sacs was ranked second most preferred and the reason was that it is available and durable. The concept of community storage is still not a technology farmers may adopt; due to a myriad of socio-cultural reasons. Though some local and synthetic grain protectants were used, post-harvest loses in 1 year of storage were still beyond acceptable limits. However, there was a high willingness to adopt new efficient and effective methods like biological control, hermitic triple layer bags and poly-tank methods, which are being introduced to the communities.

The results of the baseline study was expected to guide the implementation of the project as well as serve as reference point for future impact evaluation. The overall objective of the project was to evaluate, deploy and disseminate medium to large scale storage methods and integrated pest management strategies for bulk and prolong storage of maize, which show minimal influence on food quality and safety. Overall, integrated strategies involving clean farm operations, use of appropriate storage technologies and provision of improved storage structures are required to reduce current losses. Quite recently, the Purdue Improved Crop Storage (PICS) triple-layer hermetic bags have been promoted as a potential insecticide-free, long-term storage of cowpea and maize. However, cost and access are still challenges requiring the attention of the Ministry of Food and Agriculture of Ghana. Although farmers were aware of these insects, they showed generally poor knowledge of their control. Majority used chemical protectants indiscriminately during storage. These were not only ineffective but pose health risks to the farmer and consumers. The need for training of farmers and/or agricultural extension officers on proper post-handling practices for grains is therefore require.

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