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Survey on storage method, insect pest and loss assessment of stored grains in Anseba region, Eritrea

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ABSTRACT

Method of storage and loss assessment of stored grains of farmers of Anseba region, Eritrea was carried out in 2015-16. 96% farmers stored their grains 6-12 months, 77.7% for food, 15.2% sale after increase of price and 7.2 % farmers for seed purpose. In Anseba region the method of storage are traditional and their type, size and shape are quite similar. The storage types are basically plastic bags, barrel, sacks, pots, hides and skins, gufet, and shirfa. The participants also reported that seeds are stored in pot, sack, godo, skin and Plastic bag (meshemae). In the present study the major storage pests of cereal were *Sitophilus granaries* L., *Sitophilus zeamais* Mostch, *Sitophilus oryzae* L. and *Sitotroga cerealella* followed by *Tribolium* spp. lesser grain borer and saw-toothed grain beetle whereas, in stored pulses *Callosobruchus chinensis* L. and *Callosobruchus maculates* F. are the major ones followed by *Acanthoscelides obtectus* Say and *Zabrotes subfasciatus.* These storage pests affected the quality and quantity of the grains and reduce their germination capacity. The germination loss for the damaged maize, sorghum barley were (58.5%), (2.17%) and (2.3%), respectively, whereas, in all undamaged cereals the germination was more than (85.0%). The germination of the damaged pulses grain varies from (12.3%) to (35.0%), the highest was observed in cowpea followed by faba bean and he lowest germination was recorded in stored lentil. The weight loss in cereals varies from (2.6%) in barley to a maximum in (15.8%) in sorghum. Likewise, the weight loss for pulses varied from (9.6%) to (42.6%). In general the weight loss of cereals and pulses in the region is very high with a mean of (8.4%) and (24.1%), respectively, which is very high to affect the food security of the region. Farmers use different type of traditional storage structure for grains and seed such as *Koffo* in the high land and *Gufet* in the lowlands with the main being plastic bags and sacks.

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INTRODUCTION

More than 70 per cent of the sub-Saharan African population is directly involved in agriculture as the primary source of income and food security (Abass *et al.*, 2014). Agriculture production and productivity are critical for eradicating extreme poverty and hunger in the continent and sub-Saharan African agriculture productivity and the per capita value of agriculture output is the lowest in the world (Abass *et al.*, 2014 and FARA, 2006). The primary role of an effective post-harvest system is to ensure that the harvested food reaches the consumer, while fulfilling customer satisfaction in terms of quality, volume and safety (Abass *et al.*, 2014). Good storage grants adequate protection from pest damage however, the major constraint of post harvest in under developing countries that farmers have their own indigenous grain storage methods since ancient times and most of them are not ready to adopt modern system. Therefore, most of the stores in Africa are traditional with poor pest control methods and ventilation (Appert, 1987 and Boxall, 1986). Post-harvest losses in the developed countries are lower than in the developing countries because of more efficient farming systems, better transport infrastructure, better farm management, and effective storage and processing facilities with safety (Abass *et al.*, 2014).

Storage is an interim and repeated phase during transit of agricultural produce from producers to processors and its products from processors to consumers (Thamaga-Chitja *et al.*, 2004). There is a continuous need to protect the stored products against deterioration, especially loss in quality and weight during store and safe delivers to consumers. Storage insect pests have become cosmopolitan since humans began harvesting, drying, threshing, winnowing, processing, bagging, storage, transportation and distribution of agricultural products before reaching the final consumer. Stored product pests are responsible for the loss of millions of dollars every year by contaminating the products, as well as destruction of important documents and heritage artifacts in homes, offices and museums. In Eastern and Southern Africa alone, post-harvest losses are valued at US $1.6 billion per year, or about 13.5 per cent of the US $11 billion total value of grain production (World Bank FAO, 2011). Indeed, this calls for more reliable and verifiable data on post-harvest losses (Obeng-Ofori, 2011). Post harvest storage losses in sub-Saharan African countries due to climate change induced higher temperature, humidity, and rainfall variability exacerbate postharvest challenges (Stathers *et al.*, 2013) and insect pest infestation accounts for 20-50 per cent of losses of grain in store (Anankware, 2013) and overall damage caused by these insect pests, worldwide is estimated to be 10-40 per cent annually (Upadhyay and Ahmad, 2011). The insect pest destroy and damage the food and stored grains in farmers stores, public and government warehouses due to unstable environmental condition and storing technology. Occurrences of small moths, beetles and weevils crawling over walls and ceilings, presence of flour like residues below and surrounding stored items, webbed grains can all symptoms for possible storage pest infestation. Infestations in stored grains or beans can also be detected when these are soaked in water, and hollowed out seeds rise to the surface, along with the adult storage pests, and other debris. Other telltale signs are clumping or webbing of particles. Direct feeding damage by insects reduces grain weight, nutritional value, and germination of stored grains. Infestations also cause contamination, odor, mold development, and heat-damage problems that reduce the quality of the grain and may make it unfit for processing into food for humans or animals. In addition commercial buyers may refuse to buy insect contaminated grains, or may pay lower prices. The climatic conditions of an area have an important influence on the rate of deterioration of the in stores; they affect the re-absorption of moisture from the atmosphere, as well as the biological activities of the pest (Hayma, 2003). The deterioration of grains in store could be in the form of weight loss, chemical change in protein, carbohydrate, and oil content, and of contamination by chemical toxin, rodent urine and insect frass (Wheatly, 1973). On-farm storage studies made in Eritrea under the Dry lands Coordination Group showed that staple grains of cereals and pulses produced by small farmers in Eritrea are attacked by different storage pest species of insects, rodents and birds (Haile, 2006). Annual grain losses of upto 50 per cent in cereals and 100 per cent in pulses have been reported, although average losses stand at roughly 20 per cent (Nukenine, 2010). Traditional on-farm grain storage methods usually fail to alter the ambient temperature and environment and are therefore highly susceptible to molds and attacks from storage pests (Anonymous, 2016). The purpose of present study was to find out main factors that

influencing the post-harvest losses and food security of poor farmers of Eritrea.

MATERIAL AND METHODS

Survey on storage method and type of pest was conducted in zoba Anseba during 2015. The study was conducted using semi structured questionnaires and framers grouped discussions (FGD). During the survey 5-8 village administrations were randomly selected from each sub-zoba and from each village 15-20 households (HH) were selected to filling of the semi structured questionnaires with the help of the Ministry of Agriculture (MoA) staff and village administration. The criteria used for selection of the village administration and households were agricultural productivity and uniform coverage of the sub-zobas and HH. During the survey the data collected were storage type, altitude of the area and pest control practices used by farmers. The data collected for each day was checked for proper filling of the questionnaires. All the data collected were subject for analysis using SPSS statistical package. From each HH 0.5-1kg of grain samples of cereals, pulses and oilseed crops were collected for studying of grain damage, weight loss, germination levels and types of storage pests. The grain samples were checked for storage pests in the laboratory and the species were identified and recorded. In addition, from each grain crop, samples of 500 seeds were counted to determine damaged and undamaged seeds, weighted and calculated to determine per cent loss, using gravimetric method (FAO, 1985 and Boxall, 1986).

$$\text{Per cent loss in weight} = \frac{\text{Und - DNu}}{\text{U (Nd + Nu)}} \text{x100}$$

where U= Weight of undamaged grain

D= Weight of damaged grain

Nd= Number of damaged grain

Nu= Number of undamaged grain

Germination loss assessment was done in the laboratory using pertidish with 100 seeds each from the damaged and undamaged grains. Germination loss was calculated as follow:

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \text{x100}$$

RESULTS AND DISCUSSION

The present study showed that 96 per cent of the farmers in Anseba region keep their grains in store for months after threshing to use the grain during the rest of the year and also for seed to be used in the next cropping season. In the surveyed sub regions 77.7 per cent of the participants reported that they store their grain for food, 15.2 per cent reported for sale when the price of grain is increase and 7.2 per cent reported to be used as a seed for the next season. The majority of the respondents 37.1 per cent also reported that they store their grain up to six months, where 13.8 per cent of the respondents store their grains upto 9 months. About 5.3 per cent of the respondents store their grains for 12 months. In Tanzania on average, households harvested 1.2 tonnes maize and stored 75 per cent while 67 per cent of sunflower and groundnuts were stored and farmers used to store their grain 3-6 months (Abass *et al.*, 2014). The per cent of farmers who store their grains over one year is very low only 1.9 per cent. In all the sub regions of Anseba, the stores of farmers are traditionally used for temporary or long term for storage of grains. The type, size and shape of their stores are quite similar in the different sub-regions. The storage types are plastic bags, barrel, sacks, pots, birob (made from doum palm leaves), Koffo (build with cattle dung, wood ash and soil), hides and skins, gufet, and shirfa. And most of these stores are built inside the house in protected area. Similarly the farmers of West Africa store their crops in homes, on the field in the open area, in jute or polypropylene bags, conical structures, raised platforms, clay structures and baskets (Motte *et al.*, 1995, Addo *et al.*, 2002; Ofosu *et al.*, 1995 and Hell *et al.*, 2000), whereas in East and Southern Africa, farmers store their crops in small bags with cow dung ash, in wood and wire cribs, pits, metal bins, wooden open air or roofed cribs, and in raised platforms and roofed iron drums enclosed with mud (Wambugu *et al.*, 2009 and Kankolongo *et al.*, 2009).

During the study of pest of pulse crop from region, different species of Bruchid were recorded *Acanthoscelides obtectus* and *Zabrotes subfasciatus*. *Callosobruchus chinensis* and *Callosobruchus maculates* (Table 1 and 2). Field pea and Faba bean were affected by *Callosobruchus chinensis*, *Acanthoscelide obtectus* and *Zabrotes subfasciatus*. In Adi Tekelezan, faba bean stored in farmer's house was found 100 per cent damaged by *C. chinensi*. The present finding is supported by Abass *et al.* (2014) that the assessment of the farmers' storage areas after six

months the major pests identified in the storage areas of most farmers were larger grain borer (*Prostephanus truncatus*), grain weevil (*Sitophilus granarius*) and lesser grain borer (*Rhizopertha dominica*). According to African Postharvest Losses Information System (APHLIS) physical grain losses (prior to processing) can range from 10 to 20 per cent in Eastern and Southern Africa alone. Based on APHLIS estimates, the damage is valued at US$1.6 billion per year, or about 13.5 % of the total value of grain production US$11 billion (World Bank FAO, 2011 and Abate *et al*., 2000). In the present survey, different bruchids and harvester ants were also reported as storage pest in various villages of the region. In Hamelmalo and other sub regions, seed harvester ants are major pest of grains in store during the night where they steal/carry the grains from the store/storage structure to their nests. Farmers in the study region reported that cereals such as sorghum, maize, barley, wheat and pearl millet, pulses like cowpea (*Adagura*), faba bean and oilseed crop such as groundnut are damaged by different storage pests in the surveyed areas Table 3. According to the FGD and interviewed farmers, sorghum, pearl millet and maize from cereals and cowpea from pulse are more affected by the storage pests with 63, 56.4, 22.7 and 14.9 per cent, respectively (Table 2).

According to the interviewed farmers and FGD discussions and from assessing the pest species of the collected sample grains, the major storage pests of barley and wheat are *Sitophilus granaries*, *Sitophilus zeamais*, *Sitophilus oryzae* and *Sitotroga cerealella* followed by *Tribolium* spp., lesser grain borer and saw-toothed grain beetle. All these pests were recorded in the highlands (over 1900m in altitude) of AdiTekelezan, Geleb, and Halhal. These storage pests affect the quality and quantity of these grains and reduced their germination capacity Table 3. Sorghum, maize, and pearl millet were also affected by *Sitophilus granaries, Sitophilus zeamais*, *Sitotroga cerealella.* These pests are primary storage pests of sorghum, maize and millet causing losses in grain weight and affect the quality of the grain. The

Table 1 : Storage pests of cereals and pulses in Anseba Region

Crop type	Storage pests		Family	Status
	Common name	*Scientific name*		
Barley and wheat	Weevil	*Sitophilus granaries* L.	Curculionidae	Major
	Rice weevil	*Sitophilus oryzae* L.	Curculionidae	Major
	Lesser grain borer	*Rhyzopetha dominica F*	Silvanidae	Minor
	Floor beetles	*Trbolium confusum J*	Tenebrionidae	Minor
		Tribolium casteneum H	Tenebrionidae	Minor
		Tribolium destructor U	Tenebrionidae	Minor
	Angoumois grain moth	*Sitotroga cerelella*	Gelechiidae	Major
	Flour mite	*Acarus* spp.	Acarida	Major
Maize, sorghum	Maize weevil,	*Sitophilus zeamais* L.	Curculionidae	Major
pearl millet	Rice weevil	*Sitophilus oryzae*	Curculionidae	Major
	Granary weevil	*Sitophilus granarius*	Curculionidae	Major
	Rust red grain beetle	*Cryptolestes ferruginus*	Cucujidae	Major
	Angoumois grain moth	*Sitotroga cerelella*	Gelechiidae	Major
		Ephestia cautella	Pyralidae	Major
	Confused flour beetle	*Tribolium confusum J*	Tenebrionidae	Major
		Tribolium castaneum H	Tenebrionidae	Major
	Saw-toothed grain beetle	*Oryzaephilus surinamensis*	Silvanidae	Major
	Lesser grain borer	*Rhizopertha domenica*	Bostrychidae	Major
	Flour mite	*Acarus* spp.	Acarida	Major
Faba bean, field pea,	Bruchid	*Callosobruchus chinensis* L.	Bruchidae	Major
Lentil, Chickpea,		*Callosobruchus maculatus* L.	Bruchidae	Major
cowpea		*Acanthoscelides obtectus* L.	Bruchidae	Major
		Zabrotes subfasciatus L.	Bruchidae	Major
	Flour beetle	*Triboliumc astaneum H*	Tenebrionidae	Major

major storage pest in Africa were identified as larger grain borer, *Prostephanus truncatus* (Horn), grain weevil, *Sitophilus granarius* (L.) and the lesser grain borer, *Rhyzopertha dominica* (F.) (Bourne, 1977; Dick, 1988; Holst *et al.*, 2000 and Hodges, 2012) and similar insect were also identified by Abbas *et al.* (2014). *Tribolium* spp. mainly *Tribolium castaneum, Tribolium confusum,* and *Tribolium destructor* and other pests *i.e.* saw-toothed grain beetle follow the damage of the primary species and cause further damage to these grains. According, Padin *et al.* (2002) rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), the red our beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) and the bean weevil, *Acanthoscelides obtectus* (Say) (Coleoptera : Bruchidae) cause both quantitative and qualitative damage to grain. During the survey most of the stores were found full of storage pests causing serious damage to stored grains. Survey done by Utono and Claire (2013) found that 52 per cent of respondents were able to identify *Tribolium castaneum* (Herbst) (Coleoptera: Tenobrionidae) and *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae) and 26 per cent identified as *Sitophilus zeamais* (Motsculski) (Coleoptera: Curculionidae), 16 per cent identified *Lasioderma serricorne* (Fabricius) (Coleoptera: Anobiidae) and 6 per cent indentified *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) in their grains in Nigeria, Kebbi state. The various types of pulses grown in the sub regions were affected by storage pests of different species. Cowpea, groundnut, faba bean, field pea and chickpea are also attacked by different species of

Table 2: Number of farmers (%) reported storage pests in their sub regions

Subzoba	Sorghum	Cow pea	Pearl millet	Barley	Maize	Wheat	Faba bean	Ground nut	Potato	Chick pea
Aditeklezan	21	40	0	26	35	16	54	0	12	5
Elaberid	80	45	10	0	0	0	0	0	0	0
Geleb	50	70	23	8	45	0	0	0	0	0
Hagaz	73	75	32	0	0	0	0	15	0	0
Halhal	63	55	25	13	54	0	0	0	0	0
Hamelmalo	63	50	39	0	0	0	0	13	0	0
Keren	75	60	17	0	0	0	0	0	0	0
Habero	73	0	27	0	0	0	0	0	0	0
Kerkebet	69	0	31	0	0	0	0	0	0	0
Mean	63	56.4	22.7	5.2	14.9	1.8	6	3.8	1.3	0.6

Table 3 : Average weight loss and percent germination of damaged and undamaged grains

Crop	Mean weight of seeds (g)		% germination			% Loss
	Damaged	Undamaged	No. of sample	Damaged	Undamaged	
Cereals						
Barley	1.1	2.1	54	2.3	90.3	2.6
Wheat	0.8	1.9	42	6.5	93.5	3.1
Maize	1.0	4.5	85	58.5	99.7	13.9
Sorghum	0.8	2.5	135	21.7	86.6	15.8
Pearl millet	0.5	1.5	129	8.2	94.3	6.7
Mean				19.4	92.9	8.4
Pulses						
Cowpea	2.5	6.5	22	35	94.5	30.3
Field pea	1.5	7.5	15	25	92.6	16.5
Faba bean	2.3	8.9	20	31	90.2	42.6
Chickpea	1.4	5.1	18	15	89.7	21.3
Lentil	0.8	1.5	4	12.3	93.7	9.6
Mean				23.7	92.2	24.1

bruchids.

Damage of stored grains:

The damaged and undamaged seed were compared in terms of weight and the damaged seeds had lower weight as compared to the undamaged seeds (Table 3). Among the cereals, maize and sorghum had highest weight loss as compared to barley and wheat. The damage of the pulses was very high as compared to cereals. Among the pulses cowpea and faba bean showed higher damaged than other groups of pulses. Faba bean had the highest weight lost than other pulses. Due to insect feeding quantitative grain loss is observed by Steffan (1963) and Golebiowska (1969). Loss of nutritional and aesthetic value, increased levels of rejects in the grain mass, and insects are also important pests of stored seed and may damage the seed embryos, causing a decrease in germination (Gallo *et al.*, 1978; Vieira, 1983; Baier and Webster, 1992 and Moino *et al.*, 1998).

Germination per cent:

Both cereals and pulses had a wide difference in germination per cent between the damaged and undamaged grains. Barely, wheat and pearl millet showed lower germination per cent than maize and sorghum (Table 4). The germination loss for the damaged maize was 58.5 per cent, for sorghum it was 21.7 per cent, while the germination loss for barley was 2.3 per cent (Table 3). In all cereals the germination per cent for the undamaged grains were over 85 per cent with the highest was for maize 99.7 per cent and the lowest was recorded from sorghum 86.6 per cent. The germination per cent of the damaged pulse grain varies from 12.3 to 35, the highest per cent was recorded from cowpea followed by faba bean with a mean of 23.7 per cent. The lowest germination per cent was recoded from lentil (12.3%) (Table 3). The highest germination per cent in pulses could be due to the damage of the pest might be more on the embryo than on the cotyledons. During the survey farmers reported that they use the damaged grains for seeds (34%) and animal feed (58%).

Grain weight loss in store:

The per cent of weight loss in cereals varies from 2.6 in barley to 15.8 in sorghum with a mean of 8.4 per cent (Table 3). Likewise the weight loss for pulses varies from 9.6 in lentil to 42.6 in faba bean with a mean of 24.1 per cent. The weight loss for barley and wheat is low this could be due to these crops are grown/cultivated and stored in higher altitude that are cool and ventilated store that are unsuitable for storage pest development and reproduction. The weight loss in grain is very high for pulses as compared to cereals. During the study farmers reported that the high loss of grain discouraged most farmers not to produce pulses and even if they grow, they allocate the marginal lands for these crop production. But pulses are important as cash crop, source of protein and useful in soil amelioration. The weight loss for sorghum, maize and all the pulses is very high due to these grains are affected by rimary pests under field conditions. The early infestations of these grains cause high loss under storage conditions. In general the weight loss of cereals and pulses in the region is very high with a mean of 8.4 -24.1 per cent, which is very high to affect the food security of the region (Table 3). This needs an attention and immediate action to save the loss through use of improved storage techniques, control methods and provide training to farmers on the subject.

Farmers storage management:

In zoba Anseba farmer practiced different types of storage management for the control of storage pests Table 4. Most of the storage management and care are done before the grain is put into the store. Over 34 per cent reported that they thoroughly dry the grain on '*Dande*' (*Dande* is a bed like structure about half a

Table 4 : Storage pest management practices adopted by subsistence farmers of zoba Anseba

Storage management practices	Sample size	% Respondents
Grain storage		
Cleaning store	154	34.2
Drying of grain	90	20.0
Pesticide	50	11.0
Fire	36	8.0
Dress wall	31	7.0
Mix with Ash	20	4.4
Sunning, and aeration	40	8.9
Plant material use	29	7.0
Seed storage		
Hang under the roof	89	36
Mixed grain	110	44
Mix with ash	50	20

meter high above ground with an area of 25 meter square or more depending on the size of the harvested material) before threshing of the grain. The freshly threshed grain is put in flat place inside the house for 20 to 30 days for drying and loosing of its moisture. In the house the impurities such as grain husk, broken straw and broken grains are removed from the grain. By doing this, farmers believe that the moisture content of the seed will be reduced and it will be very difficult for the pest to infest the grain. The FGD farmers also reported that grain is put into the store only after confirming that the grain is dried with no pest infestation.

Most of the farmers in AdiTekeleza, Elabered and Geleb reported that they clean their stores and dress the walls (7%) of the store by using dung and straw firing inside the koffo before the new grain is added or put in the store. Some farmers mix small seeded grains with large seeded grains to control pests. For example taff or finger millet is mixed with pulses and other big grains such as maize to control storage pests. This practice is widely used for storing seeds of different crops. The reason for this, according to farmers, is that the smaller seeds lower the temperature of the store, which makes it cooler for pest population buildup. Scientifically it is believed that in grain mixtures the space between grains are reduced and hence the pest dies due to lack of aeration. Others believe that grain mixture limits the movement of pest within store. About 7 per cent of the interviewed farmers reported that they use plant materials such as neem and tobacco leaf powders for the control of storage pests. Tobacco powders are mostly used for seed preservation and protection from pests and diseases. Over 14 per cent of the farmers also reported that they use wood ash for protection of grain storage pests. Some farmers use pesticides mainly diamethoate (Rogo 40% EC) for control of grain pulse pests in store. Most of the time pesticides are used after the infestation of the grain by storage pests. Sunning, winnowing and aeration are done to control pest population ones the grain is infested by the pest. Maize ears and sorghum panicles that are to be used as seeds for the next season are hanged up under the roof over the fire place to control the infestation of pests.

Conclusion:

The present finding indicated that 98 per cent of the farmers have store pest problems in their home and their grains was badly affected by storage pests. The major storage pests recorded during the survey were weevils of different species, grain moths on cereals and Bruchid on pulses. Other secondary storage pests recorded were *Tribolium* spp (flour beetle), lesser grain borer, saw-toothed grain beetle and mites. The samples of the grain collected from the farmers revealed that the grains were severely damaged by the storage pests. The damage caused weight loss, reduce seed germination and affect the grain and its baking quality. The percentage of weight loss for cereals and pulses were 8 and 24 per cent, respectively. Similarly the germination loss for pulses and cereals were 19.4 and 23.7 per cent, respectively. The weight and germination loss due to the pest is very high to affect the food situation in the region and the viability of seed for next season.

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