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THE STATUS OF MAIZE STORAGE PESTS AND THEIR MANAGEMENT PRACTICES IN GINDEBERET DISTRICT, WEST SHOA

BY

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This is to certify that the thesis prepared by Tolesa Bekele entitled the status of maize storage pests and their management practices in Gindeberet District, West Shoa, presented in partial fulfillment of M.Sc in Biology

Signed by the examiner

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Declaration

I declare that this thesis is my original work and that all sources of data and material used for this thesis has been duly acknowledged. I solely declare that this thesis is not submitted to any other situation to anywhere for award of any academic degree or diploma certificates.

Name Tolese Bekele

Date of submitted------------

Signature -------------------

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Table of Contents

List of Tables

List of Figures

List of Plates

ABBREVIATION/ ACRONYMS

IMWI	International Maize and Wheat Improvement
FGD	Focus Group Discussion
GGB	Greater grain Borer
NRI	Natural Resource Institute
M/D	Muka Dima
K/S	Kiltu Sanbata
G/A/S	Goro Aba Sabat
L/M	Laga Mecha
L/R/M	Land Resource Management

ABSTRACT

Maize (*Zea may* L.) is one of the most important cereal crop cultivated in the World and it constituted one of the major diets of millions of people. Males constitute the majority of smallholder farmers in providing and managing a larger part of farming activities. Use of hybrid maize varieties has potential to improve household food security and income. Maize varieties traditionally grown by farmers in a particular area have evolved some degree of resistance to local pest populations. Some factors such as prolonged harvesting time, grain maturity, husk cover, distance of the old storage and maize variety highly expose stored maize grain to storage insect pests. Farmers were trained on prompt harvesting, separating of damaged grain from undamaged during storage and cleaning of stores before storing the new produce. The objective of this study to know the status of stored maize grain insect pests and their management. The sources of data were both primary and secondary sources. Data were analyzed using a computer software, excel 2011. Majority of the respondent farmers were males (87.63%), while females were only 12.3%7. Most farmers attended primary school (48.45%) and secondary school (8.25%). About 36.08% of the respondents' haven`t gone to formal education. The findings of this research indicated, majority of the farmers participating in farming were males with less formal education, practice traditional pest control measures when storing maize particularly when the grow hybrid varieties greater than traditional types. Further studies on storage maize insect pests and their managements need to be continued.

Key Words: Pest management, storage structure, damage grain, storage insect pest, Maize variety

1. INTRODUCTION

1.1. Background and Justification

Maize is the third important cereal crop globally after wheat and rice (FAO, 2011). In Africa, maize mainly grown by small-scale farmers for utilization as both human food and animal feed. Merchants brought it to West Africa and then to Southern part of Africa. Eventually it reached Ethiopia from the south through East Africa (Benti*et al.*, 1992). Maize is well known and an important cereal crop in the world agriculture which some call it "Queen of cereals" as it is adaptable to different agro-ecologies, gives lucrative yield and cosmopolitan in distribution (Waktola, 2014). Maize is a staple food in Africa, which is an important source of energy and protein. Maize is the largest among cereals, in total production and area coverage. It accounted for 28% of the total cereal production in 2010/11 compared to 20% for teff and 22% for sorghum, which are the second and third most cultivated crops (Beza, 2014). Maize grain is rich in carbohydrate, protein, oil and crude fiber. In Ethiopia, maize crop grown for its food, feed, fire wood, also for construction values. Maize is being stored traditionally by farmers for sustainable supply of food for the family and also to look for good price. Presence of insects in stored maize grain affects farmers in two ways. First, the presence of insects in the grain beyond economic threshold level leads to price penalties or rejection of grain by the buyers. Secondly, insect feeds both on the embryo and endosperm of maize grain which in turn reduce the germination capacity of the grain in addition to weight loss. Insect feeding also leads to losses of biomass which has an impact on the marketability of the grain. Farmers use different control options to reduce the infestation of stored maize grain insect pests. Before storage, farmers use different traditional methods which prevent the forth coming infestation including sanitation. After infestation occur farmers use different pest management options which may include insecticide as a last alternative.

1.2. Objectives

1.2.1. General objectives

To recognize the status of stored maize grain insect pests and their management.

1.2.2. Specific objective

1. To identify species composition of stored maize grain insect pests in the study area.

2. To determine the existing traditional and modern practices for the management of stored maize grain insect pest in the study area.

3. To enhance farmers perception concerning stored maize grain insect pests.

4. To recognize factors that enhance stored maize grain insect pest infestation.

2. LITRATURE REVIEW

2.1. Economic importance

Maize is one of the most widely grown crops worldwide as different varieties adapted to various environmental conditions including temperate, tropical and sub-tropical zones. In the world, about 70% of maize production area is found in the developing countries. Globally, maize ranked third after wheat and rice in terms of volume produced and importance (Wende, 2013). Nutritionally maize contains approximately 72% starch, 10% protein and 4% fat, supplying an energy density of 365 Kcal/100 g (Ranum et al., 2014). In addition it has high protein and fat contents as compared to other cereals. It also contains vitamin B complex such as B_1 (thiamine), B_2 (niacin), B_3 (riboflavin), B_5 (pantothenic acid) and B_6 that makes it advised for hair, digestion, skin, heart and brain. Furthermore, it contains vitamin A, C and K together with large amount of beta carotene and fair amount of selenium that helps to improve thyroid gland and play important role in proper functioning of immune system (Kumar et al., 2013). In Eastern Africa, the area under maize production was 15,130,956 hectares with an average yield of 1.729 t/ ha^{-1}. In sub-Saharan Africa small scale-farms are resource limited and grow maize with diverse cropping system were the crop faces many biotic and abiotic stresses (Wende, 2013). Postharvest maize insect pests are a major constraint to food security and income generation in Sub-Saharan Africa showing significant yield losses and grain quality degradation (Fikremariam et al., 2009). From harvest to consumer market, maize grain postharvest losses in Africa has been estimated to range from 14% to 36% (Dubale et al., 2015). In Ghana, about 15 % of maize grains harvested are lost annually due to attack of *S. zeamais*(Baido, 2010).

Insect pests in the store cause over 16% losses on maize around Bako (Ahmed et al., 2014). These problems have been aggravated as high yielding and improved varieties have replaced traditional varieties which are generally susceptible to storage insect pests than local varieties. Most of the studies conducted on maize grain lost due to insect pests based on farmer’s perception collected during field surveys (Golob, 1982; Hodges et al., 1983). The main objective of grain storage is to maintain quality of the grains for a long period and the basic requirements of every grain storage structure or systems are to protect the grains from stored grain insect pests (Dubale et al., 2014). Information on storage pests of maize management methods in West Shoa Zone, Gindeberet District of Oromia regionalstate is not available**.** This thesis was carried out to assess the major insect pests associated with stored maize and the management methods farmers' use in the woreda. The main economically important maize stored grain insect pests are included under two orders: Coleoptera and Lepidoptera.

2.2. Order Coleoptera

Sitophiluszeamais

Sitophiluszeamais is found in a family Curculionidae. Its common name is maize weevil. It is the most common pest of stored maize in most African countries including Ethiopia (Ahmed, 2015). Maize weevil prefers maize, also reported as a pest of cassava, rice, sorghum, and wheat. Minor hosts include taro, soybean, common beans and cowpea. Maize weevil causes substantial losses in maize or sorghum. Attack may start in the mature crop when the moisture content of the grain has fallen. Subsequent infestations in storage results from: the transfer of infested grain into storage or from the pest flying into storage facilities probably attracted by the odors of the stored grain. Re-use of sacks borrowed from neighbors or traders is a source of maize weevil. In stored maize heavy infestation may cause weight losses ranging from 30% to 40%. In Africa it occurs in all sub-regions. In Ethiopia, due to maize weevil about 20% storage losses and 25% price reduction for the damaged grains were reported for maize resulting in large income losses with value ratio not exceeding one(Ahmed *et al*., 2014).

***Prostephanus truncates** (Horn)*

Prostephanus truncates is found in the familyBostrichidae. Its common name is larger grain borer (LGB). LGB is present in West, East and Southern Africa. LGB is a serious pest of stored maize and attack maize in the field just before harvest in some areas. The primary host is maize in particular maize on the cob both before and after harvest. LGB also bores into non-food substances such as wood, bamboo, and even plastic, which poses challenge to controlling the pest. Infestation in maize may start on the mature crop in the field, i.e. when moisture content is at or below 18%. Weight losses of up to 34%- 40% recorded from maize cobs stored for 3- 6 months with an average loss of 8.7% (Hodges *et al.*, 1983). Larger grain borer is a much more damaging pest than other storage insects. Including Maize weevil and Angoumois grain moth under similar conditions by boring adults a loss of 70% has been recorded after only 4 months of on farm storage (Hodges *et al*., 1983).

Sitophilusoryzae

The Lesser grain weevil which is also called the Rice weevil is not only an important pest of stored maize also can damage sorghum, wheat, rice, and cassava. It also infests pearl millet, barley, lentil, millets, peas, rye, broad bean, and cowpea. From the stored pests the lesser grain weevil regarded as one of the most destructive primary pests of stored cereals, because of its voracious feeding on whole grains resulting in weight loss, fungal growth and quality loss through an increase in free fatty acids. Its invasion may cause an increase in temperature to grain and may facilitate the establishment of fungal colonies secondary insect pests and mites. In maize or sorghum attack by the lesser grain borer may start in the mature crop when the moisture content of the grain has fallen to 18-20%. Subsequent infestations in storage result from the transfer of infested grain into the stores or from the pest flying into storage facilities. In stored maize heavy infestation by the lesser grain borer may cause weight loses up to 30%-40%. The lesser grain weevil like the maize weevil is found in all warm and tropical parts of the world and may also be found in temperate climates. *S. zeamais*and *S. oryzae*are serious pests of stored cereals in the tropics (Dick, 1988).

2.3. Order Lepidoptera

***Sitotrogacereallela* (Olivier)**

The Angoumois grain moth mainly infests maize in addition to crops like oats, barley, rice, pearl millet, rye, sorghum, and wheat. Angoumois grain moth found in all sub-regions of Africa and it is common in Ethiopia (Ahmed *et al*., 2014).However,Angoumois grain moth often found alongside with other pests with which it may act difficulty. The complex with other storage pests resulted in grain losses of up to 90% in varieties of soft grains by combination with maize weevil. However, angoumois grain moth and maize weevil with losses of 70% was in untreated maize mainly caused losses in storage.

2.4. Nature of damage

Although, prevalence of insect pests increases in a countrywide there is light information on farmers' knowledge about pests, their economic importance, management methods and the possibility of resistance and significance of resistant cultivars. A record of such information develops awareness and eventually improves insect pest control. Researches on the genetics of weevil resistance in maize indicate that resistance governed by both additive and non-additive gene action (Kasozi, 2013). Generally, storage time and population of insectsinvolved in infestation influence the percentage losses. However, empirical information on the relationship between *P. truncatus*and *S. zeamais* population densities and the extent of damage, dust production and weight loss to maize over a storage period is scanty. One in five kg of grain produced in sub-Saharan Africa would have been estimated to be lost by pest infestations and associated grain decays which maize grain loss remained the highest (FAO, 2011). About 10 to 12% of maize grains stored in traditional storage containers similar to gombisa lostdue to insect pests. About 18% maize grains stored in polypropylene sacks for the storage periods of six months had lost (Dubale et al., 2015). The most important storage insect pests known to cause heavy losses to stored maize in Ethiopia are maize weevils (*S. zeamais*) , the Angoumois grain moth (*S. cereallela)*,the tropical warehousemoth(EphestiacautellaHubner),theIndianmealmoth(plodiainterpunctellaHubner),flour beetle(Tribolium spp.) and carpophilus spp.(Abraham Tadesse,2003). In the store,maize insect pests cause losses ranging from 20 to 30% in Ethiopia(Emana,1993)

2.5. Management strategies

2.5.1. Physical control

The lack of suitable grain storage structures and storage management technologies force maize growers to sell their produce immediately after harvest. Consequently, farmers receive low market price for any surplus grain they may produce. The majority of (93.3%) of Ethiopian farmers store grains traditionally both in and outdoors depending on the quantity produced per household. This exposes their stored grains to be attacked by storage insect pests and other factors that contribute to deteriorations reported annually in Ethiopia in the range of 2-30% (Dubale et al., 2015). Population of storage insect pests can be regulated by physical factors. These are temperature, relative humidity, moisture, different kinds of radiation, light intensity, heat& level of oxygen (Emana, 1993). Among various methods tested at Bako Agricultural Research Centure (BARC), slight roasting or warming maize on heated clay pan and exposure to the sun gave comparable results to the standard insecticide, pirimiphos-methyl at 10ppm in protecting maize grain from maize weevil (DemissewKitaw et al, 2002). Another method is the recirculation of air within a building and heating with mobile electrical heaters (Hofmeir,2000). Abraham Tadesse (2003) reported that solar heating of maize grain placed on a black polyethylene sheet and covered with a translucent plastic sheet for at least five sunny days caused significant mortality of maize weevil.

2.5.2. Biological control

Conventional biological control techniques for possible application in stored-grain pest control includes control by the use of predators, parasitoids, insect diseases and sterile males, the use of pheromones for pest monitoring, mating disruption or enhanced mass trapping and the use of resistant crop varieties can be mentioned (Dubale, 2014) .Insect pests well affected by natural enemies that biological control is one of the promising area that needs further exploration for affecting maize weevil (Kasozi, 2013). Insect parasitoids have been shown to be effective in suppressing a limited number of pest species in bulk grain storage and warehouses. One of the more effective parasitoids is *Theocolaxelegans* (Westwood), a small pteromalid wasp (1–2 mm long) that attacks primary grain pests whose immature stagesdevelop inside grain kernels including the weevils (*Sitophilus*spp.), the lesser grain borer (*R. dominica*F.), the drugstore beetle (*Stegobiumpaniceum* L.), cowpea weevils (*Callosobruchus*spp.) and the Angoumois grain moth (S. *cerealella*) (Shankar, 2015).

2.5.3. Botanical control

Traditionally, a wide range of plant substances, minerals and ashes has been used by farmers to protect stored maize against insect pests. Generally, these materials do not have an acute insecticidal activity, but serve as a physical barrier or repellent preventing insects from moving through the grain bulk. To achieve a significant reduction in the levels of infestation a higher concentration of the protectant is usually required than is necessary when using conventional insecticides (Golob*et al.*, 1980). Botanical extracts either used directly or in form of powders or liquid extracts (Kasozi, 2013). The most effective method proved for storage of maize in granaries with intermittent layers of *Hyptisspicigera*, which resulted in full protection of the commodity against any insect damage. It is therefore thought that the mode of action of both *Hyptis*species is due to the release of bioactive molecules contained in the essential oil. The uses of botanicals help to improve the storability of maize with less damage from maize weevil (Waktole, 2014; Gueye, 2013). Coffee husk and wood ash were found to be effective in controlling *S. zeamais* and *S. cerealella* (MeseleGemu *et al*., 2013)

2.5.4. Chemical control

Chemical control of insects directly either through stomach poisoning, by interfering with their nervous system, or indirectly as protectants restricting grain infestation. The commercial chemicals used were organophosphate-pyrethroid combinations such as pirimiphos-methyl and permethrin. Malathion is among the common practices adopted in eastern and southern

Africa. Nevertheless, the use of chemicals for control maize weevil has many challenges including their prohibitive prices, human and animal health hazards arising from their toxicological nature and through their abuse in addition to persistence in the environment. Furthermore, development of insecticide resistance by the maize weevil renders chemical control measures less effective and ultimately more expensive in addition to being unsafe (Kasozi, 2013). Although effective, their repeated use for decades has disrupted biological control by natural enemies and led to out breaks of other insect species and sometimes resulted in the development of resistance (Park *et al*., 2003). Fumigants are low molecular weight chemicals, highly toxic and volatile and are therefore self-dispersing and non-persistent.

3. Materials and Methods

3.1 Description of the Study Area

Gindebert ‘woreda’ is situated in Oromiya region of west Shewa Zone. Kachise is the capital town of Gindebert ‘woreda’. Kachise was located $9^0$30’N and $38^0$34’E (Figure 1). It was located at an altitude of 2600m and at distance of 193 kms from Addis Ababa and 138 Km away from Ambo.

Gindebert *woreda* bordered by Amara regional state Yejube ‘woreda’ in north, Jeldu, Elfeta, and Ambo in south, AbunaaGindebert ‘woreda’ in East and Midakegne and East Wollega zone AbaboGuduru ‘woreda’ in the west. According to the elders of the ‘woreda’ the name of Gindebert is derived from two words i.e. Ginde means Tree and beret means fence so Gindebert means the land surrounded by tree. Administratively, the ‘woreda’ is divided in to 32‘kebeles’ administrations ‘Kebeles’ 31 rural and 1 Urban, out of which17 ‘Kebeles’found in kola, 14 ‘Kebeles’ in the WoinaDega” and 5 ‘Kebeles’ in kola and were considered as potentially surplus production areas.

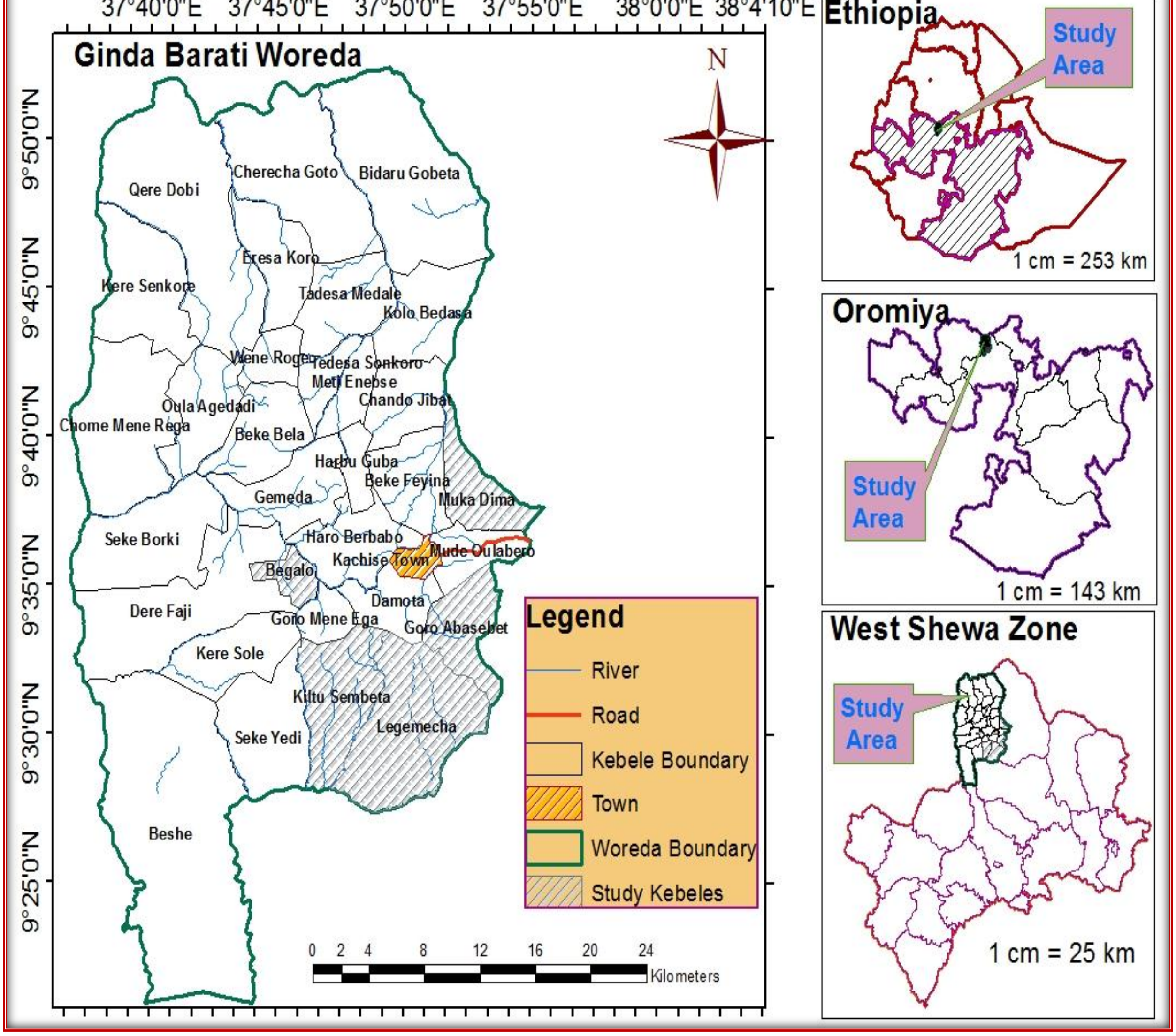

Figure.1 Map of study area

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In the West Shoa, Gindeberetworeda covers an area of 120km^2. The study targeted the villages which are well-known for maize production in the district with the total of 2500 households sampling 97 farmers, assigning 5 extension agents and 2 focus groups.

3.2. Data collection

Data were collected using both primary and secondary sources. The primary data were obtained from distributed questionnaires, interviews, focus group discussion, observations made to the storage structures by photocamera. The data collected from five kebeles namely MukaDima,Bagalo,KiltuSanbata,Goro Aba Sabat and LegaMecha consisting 5, 7, 9, 9, and 10 households respectively. Moreover, focus group discussion, five extension agents interviewed and 10 farmers filled questionnaire from each kebele. Secondary data sources were published and unpublished materials which include research works, books and internet. Data were collected by using purposive sampling based on the information provided by the Woreda Agricultural Development and Land Resource Management Sector and Agricultural Extension.

Survey on the prevalence of maize insect pests on maize grain would collected from the Office of Agriculture of Gindeberet district of West Shoa zone. The questionnaire were distributed for purposively sampled population.The questionnaire were prepared for 50 participants,observation,and an interview would made for 5 participants. Questionnaire was employed to collect quatitative and qualitative data from selected farmers.The questionnaire were prepared in English and translated to Afan Oromo for respondent farmers. Maize production in the study area occurs once in a year and the peak harvest was in December to February and hence,the data would collected before maize harvesting season. Through structured questionnaires by posing direct and information seeking open ended questions to the interviewer,qualitative and quantitative data were collected from the farmers.Information about their experience in maize production,distribution,severity prevalence and management practices options of the farmers in the past and present situation of the pests were collected from sampled maize harvesting farmers and an interview would made for the Head and dispute of Agriculture Office of the district

3.3Method of data analysis

Data were analyzed using a computersoftwares, excel 2011 to perform descriptive statistics, frequencies & percentages. The results were displayed by tables and graphs. Specimens were identified comparing with related sources from internet and books. Results from different data collection sources were discussed. Data from the interview were edited and arranged and coded before subjected analyses.

4. Results

4.1. Sex, age and education of the respondent farmers

Sex, age and education level of the respondent farmers are shown in Table 2. Out of 97 smallholders (excluding extension agents and focus groups), majority of them were males (87.63%), while females were low participant in farming (12.37%). There was general information in Gindeberet that males constitute the majority of smallholder farmers providing most of the labor and managing a large portion of the farming activities. The farmers' age was 44.5 years in average. More of the farmers attended primary school (48.45%) and (8.25%) secondary school with only 36.08% of the respondents haven't gone to formal education. This indicated that the sampled population had a relatively high literacy level. The highest frequent farming experience was 15 years. The elders highly participated in farming than the youth which its proportion was 26.1% & 1.7%, respectively. Age, educational level and experience were co-related. The elders whose ages were ≥ 60 who have no formal education estimated to 36.08% had greater experience than youths whose age were 20-29 from data gathered.

Table 1. Sex, age & education of the respondents

Demographic characteristics		Frequencies (N=97)	Percent
Sex	M	85	87.62
	F	12	12.37
Age	20-29	2	2.06
	30-39	20	20.61
	40-49	38	39.17
	50-59	9	9.27
	60 and above	28	28.86
Education	Non	35	36.08
	Primary	47	48.45
	Second.	8	8.25
	Prep.	2	2.06

	Higher educ.	5	5.15
Experience	5	2	2.06
	10	8	8.25
	15	32	32.98
	20	30	30.92
	≥25	25	25.77

4.2. Maize variety cultivated in Gindeberet

Different maize varieties cultivated in Gindeberet district are shown in Table 3. According to focus group discussion and extension agents on variety of maize cultivated in Gindeberet greater than 50% of the farmers cultivated hybrid varieties, while local variety were grown by less than 25% of the farmers. The local varieties grown were Fesho and Abuna, but four hybrid maize grown were Shashamane and Gudane hybrid varieties dominating. From the local variety Abuna was grown largely.

Table 2. Maize varieties cultivated at Gindeberet district based on survey data

Item	Variety	Mukadima	Begalo	KiltuSanbeta	Goro Aba Sabat	L/Mech	Total	%
Traditional	Fesho	2		2	1		5	10
	Abuna	1	2	1	3	1	8	16
Hybrid	BH660	2	3	2	1	1	9	18
	BH661	2	1	2		1	6	12
	Shashamane	2	3	3	2	2	12	24
	Gudane	1	2	2	3	2	10	20

Similarly data gathered through questionnaire resulted most farmers grow hybrid and traditional varieties side by side (47.2%). Farmers economically depend on hybrid maize was equal to 44.4%. Only 8.3% of the respondents cultivate traditional maize variety a lone in the whole sample (Table 4).

According to farmer's knowledge and fertility of the land is one factor to select which variety to be grown. The farmers those have the fertile fields by natural fertilizers as cow dungs use the traditional maize types Abuna and Fesho. On the other hand hybrid types need artificial fertilizers additional to the land fertility. The hybrid types those supplied by the government were Shashamane, Gudane, BH660 and BH661. The previous researches indicated another factor based on the need of high yield and taste when used for food (Charles et al., 2016). This could attribute to cross-border influence where farmers would prefer to plant hybrid maize which viewed as higher yielding and therefore likely to provide surplus grains for sale by ignoring taste. Use of hybrid maize varieties has potential to improve household food security and incomes. Traditional varieties are locally grown and are result of farmer selection over many generations (Charles et al., 2016). Traditional varieties have long growing season, but they are tasty and resistant to environmental conditions (Charles et al., 2016).

Table 3. Maize variety cultivated in Gindeberet

Item	Description	Frequency	Percent
Variety of maize cultivated in Gindeberet	Hybrid	28	44.4
	Traditional	5	7.93
	Both	30	47.62

4.3 Factors affecting pre-harvest or post-harvest infestation of stored maize grain insect pest.

According to farmers perception prolonged harvesting time, grain maturity, husk cover, distance of the old storage from the field and store, and maize variety cultivated are some of the factors that affect stored maize grain insect pest described shortly.

Prolonged harvesting time

When compared to other factors prolonged harvesting time expose maize grain to more infestation under field conditions as some of stored maize grain insect pests like *Sitophilus*spp., *S. cerealella* and others are field to storage pests. About 8.3% of the farmers mentioned that prolonged harvesting time is an important factor which determines stored maize grain insect pest infestation in the store (Figure 2). Prompt harvesting is recommended to minimize the risk as indicated by Dick (1988).

Maize grains maturity

As shown in Figure 2 about 5.6% of the respondents indicated grains that are not physiologically matured stored damaged by storage maize grain insect pest which is in line with Dick (1988).

Husk cover of ears

By their farming experience 2.8% farmers respond husk cover level condition could speed infestation. A good husk cover that was tight and extended above the ear would minimize field infestation, reduce insect damage and attack by secondary microorganisms (Mwololo et al., 2012). Most lines with flint grain texture had higher numbers of husk leaves and subsequently tighter husk cover than dent ones described by (Girma et al., 2008). Intact husk on a cob forms a partial barrier to insects seeking to infest maize grains in the field mentioned in Dick (1988). Bird damage to husks also increased the susceptibility of cobs in the field to attack by storage pests (Ajibola, 1971; Ashman et al., 1971).

Distance of storage

Similar response given to storage distance (2.8%) as it can lead to grain damage before storing. This suggested that infested stores were the main source of field populations that the dispersal behavior of pests from infested stores. The adjacent store increased the chance of infestation of maize cultivars when cobs dried in the field moderately before harvest. This reduces the long distances in their search for food. It is true that a number of pests of stored grain have slightly lost the power to fly long recorded by (Kasozi, 2013).

Variety of Maize Cultivated

It is generally true that the maize varieties traditionally grown have evolved some degree of resistance to environmental conditions. Unfortunately, none of the major maize breeding centers has incorporated resistance to post-harvest pests into their breeding programs leading many new high-yielding cultivars more susceptible to attack by storage pests than the poorer yielding varieties they intended to replace. Resistance in stored maize to insect attack has been attributed to physical factors such as grain hardness, pericarp surface texture, and nutritional factors such as amylose, lipid and protein content or non-nutritional factors, especially phenolic compounds (Fikremariam et al., 2009, Groot,2004).

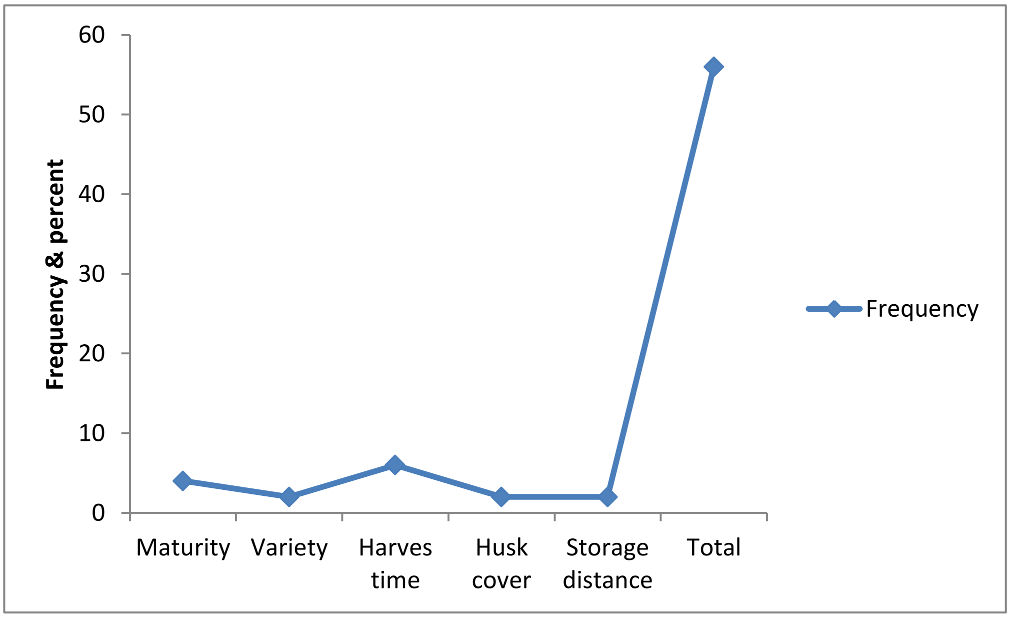

Figure 2.Factors affecting stored maize grain insect Pest infestation rate

This figure justified maize harvest time alone had greatest influence to increase infestation indicated by farmers. The second was grain maturity (4), while the rest three got the same value by two farmers each. Exposure to all of these factors brought intense grain deterioration as pointed by 50 farmers from the questionnaire. Generally, unless farmers would not actively solve such infestation factors (Figure 2), the product easily exposed to uncontrolled grain damage.

4.4. Control measures farmers practice before/after storing

Farmers tried their best to persist grains pest free. The control measures that farmers practice to minimize maize infestation were sorting damaged cobs, proper drying and sanitation around storage. Most of the farmers exercise all of the pest control measures together. When valued lonely ranked as sorting damaged grain, proper drying, and storage hygiene respectively.

Sorting damaged grain

Sorting is the practice of separating damaged and undamaged maize cobs from each other. During storage observation, most of the farmers performed this work immediately at the time of harvesting. Others separate after few days of drying (Figure 3) or keeping mixed until winnowing period. By any cases damaged and pure maize cobs separated seriously by human effort to reduce contamination and spread of post-harvest insect pests as described in (Shankar et al., 2015).

Proper drying before storage

Drying is an important procedure to ensure protection. It worsens conditions for the development of insect pests. Farmers perform this measure attain grain moisture content not more than 12-13%, depending on the relative humidity which was essential before seeds could be stored safely (Manandhar et al., 2001). Efficient drying minimizes introduction of insects and appeared to cause mortality of the insects. Where field drying is ineffective or impracticable, farmers generally hung maize cobs above a cooking fire to dry or spread out on racks or mats in direct sunlight. The idea of (Groot, 2004) loosely oppose as drying practice was not very effective against insect pests due to their high drought tolerance.

a. Clean cobs b. Damaged cobs

Plate 1. Sorting and drying practices

Sanitation

Ensuring crop and grain sanitation is a key step for effective weevil control strategies. Elimination of husk from maize ears in the fields and storage facilities breaks the insect pest development cycle. The first step towards good storage hygiene was choosing a suitable site for the storage structure. Both sanitation and sorting are almost correlated control measures. The previous findings justify this idea as stores and their immediate surroundings must be kept as clean as possible (Groot, 2004). Thus, it is always necessary to clean grain storage facilities between different crop harvests and storage to extend the period of infestatio(Kasozi, 2013), (Rajasri et al., 2015).

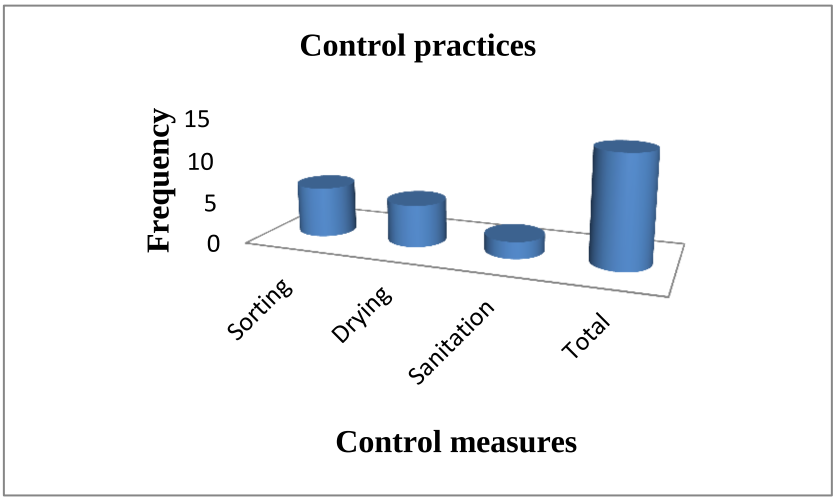

Figure 1.Control measures farmers practice to reduce infestation

The least control measure farmers support, but controversial to the truth was sanitation. Sorting and drying accepted by six and five farmers consequetevily. 50 farmers frequently practiced all activities that enable them to reduce extraordinary grain damage.

4.5. Form and place of maize grain storage

At complete maturation stage farmers have begun to harvest. The three forms of grain storage are shelled cobs, unshelled cobs and winnowed maize. No one of the small holders had seen storing either shelled or unshelled cobs (non-winnowed maize) form. Forty-two (100%) storages hold winnowed maize grain (Table 5).

Table 4. Form and place of storage

Item	Description	Observed storage	Percent
Form and place of maize grain storage	Form of storing		
	Shelled cobs	-	-
	Unshelled cobs (non-winnowed maize)	-	-
	Winnowed maize	42	100%
	Where maize stored		
	In door	39	92.86%
	Out door	3	7.14%

Table 5 item 2 the field observation showed that 92.86% of small holders store their product in door leading to damage due to high temperature. Only less number of farmers 7.14% store their crop in well-aerated area out door protecting more sun light and rain, forming hat above the storage (Plate 4 b). Storages in warm temperature have great chance in pest development that act up on maize. In Table 6 first item 65(91.55%) farmers agreed storing winnowed grain in advance. Cobs were easily susceptible and damaged by pests merely 4.22% agreed the clue of winnowed maize exposure to pests.

Table 5. Form of maize storage and variety exposed to storage pest (questionnaire)

Item	Description	Frequency	Percent
Form of maize grain stored	Unshelled	3	4.22
	Non- winnowed	3	4.22
	Winnowed	65	91.55
Variety of maize more exposed to storage pest	Hybrid	66	91.66
	Traditional	6	8.33

One way of decreasing infestation and damage to maize grain is form of storage. Because, it can render or offer chance of fast movement for insect pests from one to another seed.Winnowed maize is advantageous that described to minimize the movement of pests all through the storage for feeding as well as breeding (Gueye, 2013). Additionally, it made the atmospheric condition unfavorable to pests not to rise in number, but shelling maize does not itself offer complete protection from pest, though creates favorable conditions for the development of infestation sited in (Dick, 1988).

a. Stored maize cobs b. Winnowed maize

Plate 2. Form of maize storage; Cob (a) and winnowed form of maize (b).

4.6. Maize variety exposures to pest

Naturally plants have heritable barriers which protect/minimize detrimental effects from foreign organisms or stress conditions. These barriers may be physical and thus directly blocks plant attack by a pest or a disease pathogen by physical means; or they may be biochemical and thus their reactions are triggered by invasion of the plant or plant part.

On item (2) of (Table 6) farmers answer linked to the fact that traditional maize varieties are best resistant to insects with little defenselessness (8.33%). In other way hybrid varieties were susceptible to pest than traditional (91.66%). This evidenced earlier that traditional diversities in a particular area have evolved some degree of resistance to local pest populations (Dick,1988).

4.7. Storage types in Gindeberet

The basic requirement of storage was to provide the maximum possible protection from pests, to allow grains remain clean and stay long. Farmers mend or use different types of storages based on environmental resources. From the open ended question of focus group and extension agents based on their life span maize storage structures can be grouped to temporary or permanent storage structures in similar sense describeb by Bbosa (2014).The deccision to use either permanent or temporary storage was unique to each individual's situation while permanent storage was prefered to maintain grain quality even some temporary systems were becoming popular due to their flexiblity.

4.7.1.Permanent storage

Permanent storage includes any fixed structure not easily moveable such as metal silos,ground cements,mud/clay,gotera or bamboo and others having long life.

Advantages of permanent storages

It provides grain would be "safe",important for future resale,reuse for handling and facilities can be used for other purpases (multi purpose).

Disadvantages of permanent storages

The problems faced in the usage of long life storage includs; it needs to be cleaned before use,costly to setup, took time to build and maintenance is required.

4.7.2.Temporary storage

This includes a system that has a limited life span including grain wood and sacks.Some of the advantages of temporary storage structures were readly available in the time of excess production, usually have minimal investiment and portable. Short life span storages specified by drawbacks of incapable aeration (moisture and heat) managements, grain and material waste easily formed in the system, limited resale value, grains easily comtaminated and damaged with its short life storing grain.

Majority of smallholders store their grains in sacks as modern (73.6%), others (26.3%) store in traditional granaries. Preference of using storage structures imposed by different factors like age or ability to mend the storage, economic influence, and culturally sex related.

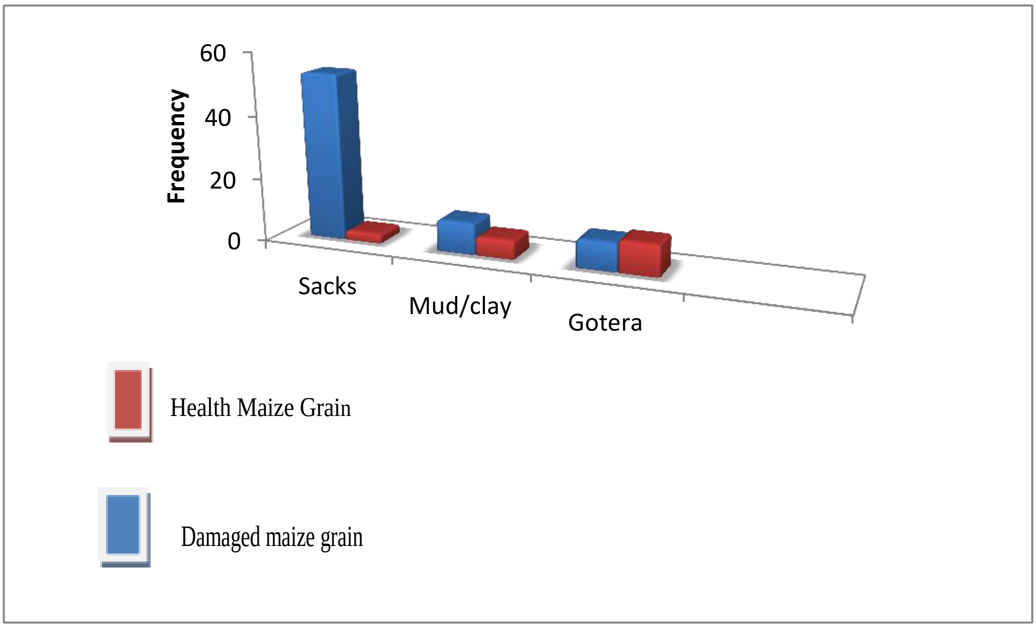

Figure 2. Storage types

The observed information also developed these factors, which restrict the type of storages used in the district to highly three forms; 89% sacks, 6% clay/mud and 4% bamboo/gotera. Modern granaries perceived to be expensive for majority of smallholders in the district, therefore not commonly used unreasonably similarly referenced in (Charles et al., 2016).

4.8. Modern storage

Sacks

Although, this structure assumed as traditional, farmers admit as a modern one. They are good short term storage options. Grain sacks were at higher risk of having puncture holes from wild life, mechanical damage or trees. To solve such problems sacks should be monitored regularly from damage and repaired to reduce grain spoilage. Option to reduce the breakdown were using a thicker poly sacks, locating in a well-drained area away from trees or other potential sources of damage and smooth surface with no stones or sharp objects advised. Handling system shortens the life span, even the lowest one year, more over three years. Currently the government is supplying the sacks that have ability to store maize free pest for more than one year. In contrast modern, permanent and qualified storages still not used in Gindeberet.

4.9. Traditional storage methods

Conventionally, tropics and sub-tropic farms mainly follow indigenous storage methods. Structures used traditionally were often inexpensive and environmentally motivated. Such containers allow for frequent consumption of the product on a daily or weekly basis. Larger granaries, expected for storing large quantities for longer periods built from long-lasting structures as in case of wooden granaries. Generally, this finding correlated to the earlier researches stating common storage structures used by most of Ethiopian farmers was traditional with poor construction that exposes the stored grains to different deterioration agents to which appropriate management and monitoring of all the influencing factors had not considered (Dubale, 2014).

Mud/clay or earthen structures

Three farmers observed using earthen structures repairing from clay/ soil straw paying their time surprisingly only mend by females. Sun drying harden it then used indoor providing a cool environment that keeps grains viable for germination at the next season. In the dryer regions where crops can be harvested with satisfactory low moisture contents more closed types of granaries have no alternative.

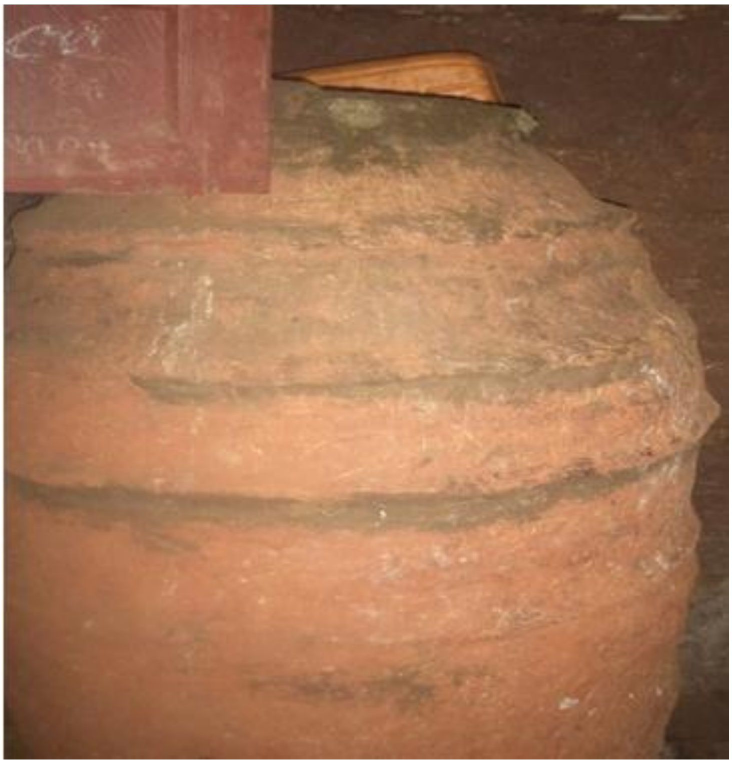

Plate 3. Mud storage

Wooden structures (Bamboo structure)

These containers differ in form and size based on the status of the farmers or quantity of grains stored. Local wood arranged regularly in rectangular to repair wooden structure or farmers use plant stem materials to repair the storage. This has a low life span (less than one year). The rest two forms were persistent about eight to ten years, in average (Plate 4 a & b).

a. Temporary bamboo b. Permanent bamboo

Plate 4. Type of bamboo storage (a & b)

Thirdly bamboo granaries can be four cornered, spherical, with a straw roof containing a protecting cover, or in the shape of a cone with the tip pointing downwards and resting on a foundation of stones. Grains inside these bamboo granaries well protected against rains and the invasion of insect pests. However, Bamboo granaries require good maintenance such as filling cracks, sealing holes or slits and detailed cleaning. Storage materials life depends on where it stays (indoor or outdoor), type and save guards (handling system) taken to it verified in (Shankar et al., 2015). Basically maize grains more exposed as well as damaged in sacks, clay and gotera respectively.

4.10. Maize storage insect pests in Gindeberet

Although, farmers were knowledgeable about pests of stored maize, some of their perceptions did not agree with scientific view .The presence of insects associated with both field and storage cause damage to maize. All the interviewed parties similar to FGD agreed on factors affecting the quality of the stored grain were rodents, termites and insect pests. According to (Table 8) species composition of storage maize insect pests exist in the environment dominated by *S. zeamais*, and *S. cerealella.P. truncates* appeared after six month of grain storage in view of lowest distribution in Gindeberet. During the third observation maize grain widely infested.

Table 6 . Maize insect pests in storages (observation)

Site	Number of storages with pests		
	1st observation December 20/2018- January 11/2019	2nd observation March 24- April 4/2019	3rd observation June 24-3, July 5/2019
M/ dima		5 [a]	6[a], 4[c]
Begalo	2[a]	2 [a]	4[a],1[b],5[c]
K/Sanbata	-	1 [a]	5[a],5[b]
G/A/Sabat	-	2 [a]	7[a],1[c],1[e]
L/Mecha	-	3[a]	1[a],4[c]

a=with maize weevil b=Angoumois grain maize d=larger grain borer e=all

c=maize weevil and Angoumois grain moth

After six months observation 23, 6 and 14, storages were full of maize weevil, Angoumois grain moth, both maize weevil and Angoumois grain moth respectively. The rest (1) storage damaged by maize weevil, angoumois grain moth and larger grain borer.

Insect pests have several negative effects on the grain of infested crops making meals made from infested grain nasty, causing unpleasant odors in the meals and reducing the nutritional content of the infested grain. Loss of seed viability and grain contamination with waste products resulted (Waktola, 2014). Nutrient loss caused as the pests feed on the dry matter of the grain (Magrath et al, 1996). Infestation may also lead to loss of marketability expecting intolerable loss (Benti, 1992). Taxonomic positions of insect pests associated with storage maize and their status in Gindeberet West Shoa shown below.

Table 7. Status of maize insect pest in Gindeberet

Order	Family	Common names	Scientific names	Status of the insect
Coleopteran	Curculionidae	Maize weevil	*SitophiluszeamaisMotschulsky*	Major
	Bostrichid	Larger Grain Borer	*Prostephanus truncates* (Horn)	Minor
Lepidoptera	Gelechiidae	Angoumois Grain moth	*Sitotrogacerealella (Olivier*)	Major

Maize weevil (*S. zeamais*)

It is a species of beetle in the family Curculionidae. The maize weevil has a length of 2.5 mm to 4 mm. This small, brown weevil has four reddish-brown spots on the wing covers (elytra). It has a long, thin snout, and elbowed antennae. *S. zeamais* appears similar to the rice weevil (*Sitophilusoryzae*).The difference between the two the former, has more clearly marked spots on the wing covers and is somewhat large in size with ability to fly (Wikipedia).

In Gindeberet, *S. zeamais* was the major storage pest. This species attacks both standing crops and stored cereal products in addition to maize. Grain infestation by the weevil usually begins in the field earlier to grain harvesting (Girma et al. 2008). Consequently, weevils increase in population within the grain causing intense damage. When *S. zeamais* larvae feed on the interior of individual grains, hulls detected on the maize kernels. Early detection of infestation is difficult. Appearance of flour-like grain dust, holes through which adults emerged, floating to the surface when placed in water and an increase in temperature of storage are sign of detection. Obvious sign is the emergence of adults.

Specimen Source Tadele T (CIMMTY), 2010

Plate 5. Adult maize weevils

Prostephanus truncates

The body is 3-4.5 mm long. The adult has the typical cylindrical bostrichid shape with dark brown color. There are many small tubercles over its surface. The antennae are 10-segmented and have a loose three-segmented club; the 'stem' of the antenna is slender and clothed with long hairs and the apical club segment is wider than, the preceding segments stated by (Hodges, 1998). This species found as a minor pest in the district which emerged in one store only after six months and accounts less damage to the grain. But, larger grain borer cause a serious damage contradicting with my finding (Hodges et al., 1983). This might be due to its character that LGB does not occur on all farms in the areas where it is first introduced, its distribution and damage caused can be irregular and unpredictable. Moreover, the presence of LGB in one year will not promise a repetitive infestation in the next year (Boxall, 2002).

Specimen Source Horn, 1878

Plate 6. Adult Larger Grain Borers

Sitotrogacerealella

The adult of *S. cerealella*is a small buff or Yellowish - brown moth which is 5-7 mm long with a wingspan of 10-18 mm. The wings are thin, long fringed and narrow (Emana, 1993).In some tropical areas, *S. cerealella* is regarded as the most serious pest of maize. Because of that, adults cannot penetrate densely packed grains; larvae are immobile. Shelled maize cobs are resistant to *S. cerealella*. Grain infested by moth larvae has unpleasant smell making maize less attractive for consumption (.Jacobson, 1990). *S. cerealella*appeared during the third maize storage observation opposing its pre-harvest infestation feature. Almost detection of Angoumois is similar to that of maize weevil. Adult moths fly to the fields of ripening grain as they are reaching maturity. Cultural measures that are helpful in reducing *S. cerealella*infestation are promptharvesting and threshing of the grains, elimination of other hosts of the pest from the vicinity of the main crop in the field or store, the use of materials (dolomite, wood ash, tobacco dust, sawdust and sand) that restrict movement of *S. cerealella*when mixed with grains and complete drying of grains prior to storage (Emana, 1993).

Source Internet Specimen

Plate 7 Adult Angoumois grain moths

4.11. Grain damage by insect pests

During the third observation, stored maize grains damaged in different levels in different sites of the district. In 13 storages (27.7%), grains infestation described as damaged, similar figure moderately damaged, and 44.7% (21storages) highly damaged by the storage insect pests discussed above. In other word thirteen storages containing traditional varieties (Table 3) stored in sucks described as damaged. Two storages treated by traditional pest management (mud),bamboo storages set out door (2) and one clay storage chemically treated plus eight sacks well-handled storages contain moderately damaged grains. Maize variety, storage type and place, management methods and other conditions were the indications for rate of grain damage.

4.12. Storage maize insect pest managements

All participants revealed either traditional or chemical insecticide managements used in grain stores, the former have been extensively used in grain storage facilities to control stored-product insect pests. Post-harvest pests have not received adequate attention yet they cause devastating yield and quality loss. Minimum number of Gindeberet farmers (19.4%) used traditional methods exceeded by chemical use (80.6%), Table 9.

Table 8.Pest management systems used (questionnaire)

Item	Description	Frequency	Percent
Maize storage insect Pest management methods	Tradition	16	19.4
	Chemical	58	80.6

4.12.1. Traditional Management Methods

Mixing maize grain and small cereals

Resource poor farmers in developing countries use different physical methods to protect stored grains against pest infestation by mixing grains with others. Small seed cereals are important to reduce stored maize infestation by lowering storage temperature as well as obstructing the locomotion of insect pests during search for grain. From diverse traditional methods of managing insect infestation in stored grains, one is mixing small cereals with large once (Tsedeke*et a*l., 2003). This could reduce or totally stop the developmental stages of insect pests, mainly larval stage. Both layering and mixing with teff was the easier system in practicing. Reducing the amount of teff during admixing lowers its effectiveness. In similar manner the thickness of layering practice results great influence to maize grain stored.

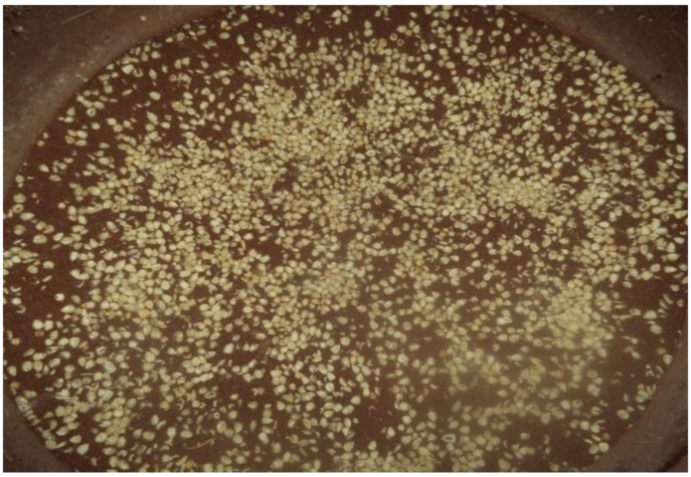

Plate 8 Traditional pest management teff mixed with maize grain

Mixing with ground chilies

Mixing ground chilies powder to the winnowed maize or rubbing to unshelled maize cobs repeal storage insect pests at least for six months as a fumigant making the atmosphere uncomfortable for survival of pests at different life cycles, especially larval stage. Today cost and less cultivation of chilies minimize application of this traditional management at alarming rate, but more effective than layering/mixing with teff detailed in (Ahmed, 2015). Tradition pest managements are important in developing high potential, environmentally friendly and sustainable management that may help to bridge the gap between current scientific and age-old practices published in (Shankar, 2015).

4.12.2 Modern (chemical method)

The use of conventional insecticides to reduce storage losses to food crops has become increasingly common in recent years. Chemicals with a relatively low mammalian toxicity recommended for direct application to food grains. Suitable 'contact' insecticides can be applied either as a liquid spray or dust for admixture with the grain (Mersal et al., 2011). To obtain even coverage of the commodity, contact insecticides should be applied before or during loading of the store. Treatment of the surface layer of cobs within a crib using an insecticidal spray can also be effective, but re-spraying at monthly intervals may be necessary at which insecticides break down, particularly on the surface of the crib. Some insecticides,

such as pirimiphos-methyl, applied as a spray to the surface layer of cobs, appear to vaporize and thus have an effect somewhat similar to fumigation (Arthur, 1995).

In general, once stores have been filled with maize, the only effective method of treating subsequent infestations is by fumigation. Fumigants have no residual activity and re-infestation of the stored maize can take place rapidly. According to open ended question provided, on the type of chemical insecticides farmers use, the common and successful were Malathion and celphos.

Malathion (Ethiolathion)

High percentage of farmers (Table 9) responded non alternative usage of malathion chemical. Farmers mix malathion dust with grain, except those use traditional management systems. This insecticide manufactured in the form of dust and liquid state (effective). Although, this method had a strong scientific basis, the users seldom know

(Erica.toft@expertradet.se., 2007). Malathion dust supplied in different quantities, as 50g, 100g or 200g; the common one 100g can fumigate 300kg maize lasting six months. The product to be dusted must well dry; otherwise, malathion breaks down very rapidly written in (Kasozi, 2013). Between treatment and consumption there should be a period of 12-13 weeks at which malathion breaks down completely without leaving harmful residues. Malathion is disadvantageous since not very effective against the lesser grain borer, caterpillars, moths and mites , unstable on concrete surfaces or whitewashed walls and has a nasty smell .Some of health problems related with malathion are intestinal disorders, kidney failure, lung damage and others documented (Center for Disease Control, Atlanta GA, 1979).

Celphos

It is tab insecticide used in a form of fumigant. Three tabs required for fumigating one sacks. Celphos socked to the upper, middle and lower position of sacks. Aluminum phosphide tablet formulation that releases phosphine fumigant is widely used for insect control in various stored products (Arthur, 1995, Rajashekar et al., 2006). Effectiveness of these insecticides ranked malathion (liquid), celphos (tab), and malathion (dust) one to three. Challenges of using chemicals against maize pests also described causing price penalties, human and animal health hazards, persistence in the environment and environmental pollution, food safety and the occurrence of resistance in the insect pests as justified by (Mwolo et al., 2012; Kasozi, 2013).

5. Discussion

Maize is one of the most important cereal crops cultivated in the World and it constituted one of the major diets of millions of people. It accounted for 28% of the total cereal production in 2010/11 compared to 20% for teff and 22% for sorghum,which are the second and third most cultivated crop (Beza, 2014) .In Ethiopia, maize crop grown for its food,firewood,also for construction values.To achieve the objectives of the study, 97 samples of household maize growers were selected for collecting of data on maize production. About 97 of the maize growers were selected from five kebeles of the total kebeles of the Worede.

Out of 97 smallholders (excluding extension agents and focus groups), majority of them were males (87.63%), while females were low participant in farming (12.37%).There was general information in Gindeberet that males constitute the majority of smallholder farmers providing most of the labor and managing a large portion of the farming activities. The farmers' age was 44.5 years in average. More of the farmers attended primary school (48.45%) and (8.25%) secondary school with only 36.08% of the respondents haven't gone to formal education. This indicated that the sampled population had a relatively high literacy level. The highest frequent farming experience was 15 years. The elders highly participated in farming than the youth which its proportion was 26.1% & 1.7%, respectively. Age, educational level and experience were co-related. The elders whose ages were ≥ 60 who have no formal education estimated to 36.08% had greater experience than youths whose age were 20-29 from data gathered.

. According to focus group discussion and extension agents on variety of maize cultivated in Gindeberet greater than 50% of the farmers cultivated hybrid varieties, while local variety were grown by less than 25% of the farmers. The local varieties grown were Fesho and Abuna, but four hybrid maize grown were Shashamane and Gudane hybrid varieties dominating. From the local variety Abuna was grown largely.

Field observation showed that 92.86% of small holders store their product in door leading to damage due to high temperature. Only less number of farmers 7.14% store their crop in well-aerated area out door protecting more sun light and rain, forming hat above the storage (Plate 4 b). Storages in warm temperature have great chance in pest development that act up on maize. In Table 6 first item 65(91.55%) farmers agreed storing winnowed grain in advance.

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After six months observation 23, 6 and 14, storages were full of maize weevil, Angoumois grain moth, both maize weevil and Angoumois grain moth respectively. The rest (1) storage damaged by maize weevil, angoumois grain moth and larger grain borer.

Insect pests have several negative effects on the grain of infested crops making meals made from infested grain nasty, causing unpleasant odors in the meals and reducing the nutritional content of the infested grain. Loss of seed viability and grain contamination with waste products resulted (Waktola, 2014). Nutrient loss caused as the pests feed on the dry matter of the grain (Magrath et al, 1996). Infestation may also lead to loss of marketability expecting intolerable loss (Benti, 1992).

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All participants revealed either traditional or chemical insecticide managements used in grain stores, the former have been extensively used in grain storage facilities to control stored-product insect pests. Post-harvest pests have not received adequate attention yet they cause devastating yield and quality loss. Minimum number of Gindeberet farmers (19.4%) used traditional methods exceeded by chemical use (80.6%), Table 9.

6. Conclusion and Recommendation

6.1. Conclusion

The findings of this research indicated, majority of the farmers participating in farming were males with less formal education, practice traditional pest control measures when storing maize cultivating hybrid varieties greater than traditional types. Prolonged harvest time, grain maturity, husk cover, distance of the old storage from the field and store, and maize variety cultivated affect stored maize grain insect pest invasion. The species composition of storage maize insect pests causing maize damage and loss were mainly maize weevil and Angoumois grain moth, hardly larger grain borer. Practicing all control measures simultaneously minimize maize infestation. Clay/mud, bamboo and sack containers well- known in Gindeberet. Lack of modified traditional and modern storage structures and poor handling systems caused maize grain damage and loss leading food in security. Chemical insecticides mostly used to manage storage insect pests. However, traditional pest management methods were important in developing high potential, environmentally friendly and sustainable management.

Generally poor control practices, quality of storage structures together with less management systems lead to early storage maize infestation and deterioration by maizeweevil,Angoumois grain moth and larger grain borer.

The result of the study showed that most farmers were harvested hybrid maize variety rather than traditional maize variety and store their maize in door and out door. The preference of using storage structures imposed by different factors like age or ability to mend the storage,economicinfluence,and culturally sex related.

6.2. Recommendations

- Need of training to develop farmers knowledge and perception on product storage and pest management.
- Working to develop, modify and increase supply of modern storages to farmers.
- Establish conservation measures of traditional maize varieties to retain genetic pest resistant genes.
- The Agricultural land resource management should work to supply hybrid insect pest resistant maize variety.
- It is necessary to see the introduction of storage maize insect pest predators.
- Increase public awareness and concern for environmental safety using physical pest managements.
- Further studies on storage maize insect pests and their managements recommended.
- The district Agricultural development Office should encourage women participation in maize production through provision of training and hybrid maize varieties.
- Emphasis should be given to continuos training and support for farmer maize cultivars on how to use hybrid maize production technology to enhance quantity and quality of maize.
- Increasing production and quality of maize by improving insect pest management practices.

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Focus Group Discussions with the government of agriculture office and crop storage staff to find answers to the following questions

1. Which are the most common maize varieties being grown in the wereda?

2. What community or bulk storage facilities are available (common storage methods)?

3. What are the most common storage problems/pests in the wereda?

4. What is the well- known management systems do farmers use?

Agricultural Development Interview response data

1. What maize varieties are farmers growing in the area?

2. What factors affect quality of stored maize?

3. What sources of information do stakeholders have on maize production, storage, and pest management?

3.1. Are there pest problems in maize production?

3.2. Which are the most important pests (storage pests) during pre- and post-harvest of maize (give rank)?

3.3. What control measures they use?

a) Aeration b) Sorting out infected grains c) drying d) inspections

4. Which management methods farmers use?

Traditional and Modern management

5. What aspects of maize storage (including pest management) would they like to investigate further?

Farmer's questionnaire

Dear farmers, this is conducting a study on status of maize storage insect pests and their managements. Thus you are kindly requested to respond to the questions based on what you are practicing (how you store maize and control maize storage insect pests).

N.B. Before you are answering the questions, please read it carefully and make sure that you have exactly understood what the question mean and give your answer with respect to the instruction.

Thank you in advance!

Part1. Back ground information

Direction 1: Please respond to the following questions by circling the appropriate items from the given alternatives.

Kebele ________________________________

Sex. a) Male b) Female

Age a) 20-29 b) 30-39 c) 40-49 d) 50-59 e) 60 and above

Level of education: a) Non b) Primary c) Secondary d) preparatory e) higher education

Farming experience (year): a) 5 b) 10 c) 15 d) 20 e) 25 and above

Part 2: Respond to the following questions accordingly.

1. What varieties of maize are cultivated in this village?

   a) Traditional 1) Gordod 2) Fesho

   b) Extension i) BH660 ii) BH661 iii) Shashamane iv) Gudane V)

2. What factors increase pre/post-harvest infestation?

   a) Maturity of grains b) Varieties of maize grain c) Prolonged harvest time d) Husk cover

e) Distance of last year storage f) all factors

3. What control practices farmers perform before storing (handling system)?

a) Drying b) damaged grains c) others

4. What are storage structures there in the village?

1) Sacks 2) Gotera (Bambo) 3) Mud/clay

5. What are the storage types mostly used by farmers?

a) Sacks b) Gotera c) Clay or mudy

6. Which storage type more exposed grain to pests?

7. What life span does the storage structure have (Year)?

a) 1-3 b) 4-6 c) 7-10

8. What damaged the quality of maize harvested and stored?

i) Insect pest ii) rodents

9. What are the common maize storage insect pests in the area?

1) Maize weevil 2) Larger grain borare 3) Angouimous grain moth 4) Maize weevil & Angoumois grain moth 5) All

1.0 Which pest is the most dangerous?

1. Maize weevil 2. Angouimous grain moth

11. Which variety of maize more infested?

a) Traditional varieties b) Hybrid varieties

12. What form of maize storage more susceptible to insect pests?

a\ Shelled cobs b) winnowed maize c) non-winnowed maize

13. What insect pest management systems farmers use?

A) Traditional b) Modern

14. Which management is common and successful?

A) Traditional b) Modern

Describe some types of traditional and modern pest managements.

1. What demographic characteristics observed?

2. Which type of storage structures farmers use?

3. What form of maize grain store practiced?

4. Where maize grain stored?

5. Which types of maize insect pests observed from harvest to the third observation?

6. What variety of maize observed from storage?

Surveying (observation) of storage structures

Farmer characteristics

Village _______________Farmer's name _______ _______________ Sex ____ Age ______

Level of education _______ Farming experience (year) _____ Type of storage _____

Storage No.______ Variety of maize cultivated_____________ Where maize stored __________

Form of maize storage a) shelled cobs b) unshelled cobs c) winnowed maize d) non-winnowed maize.

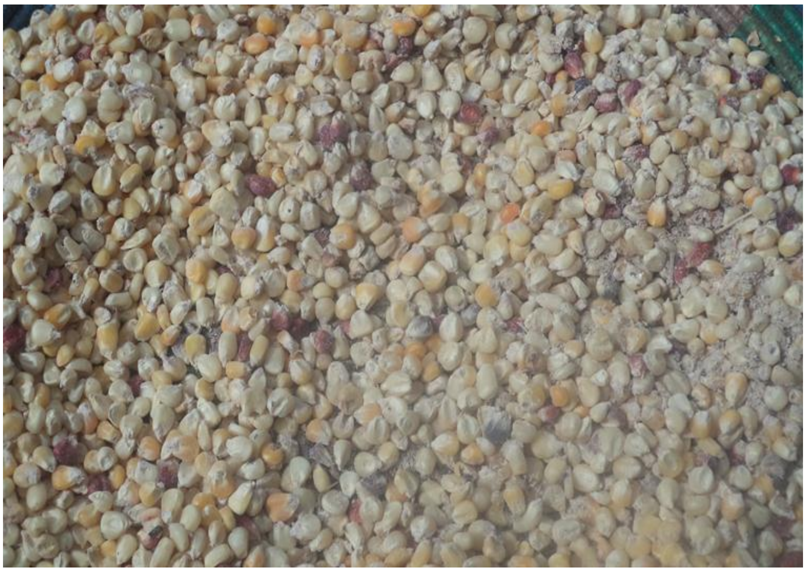
Annex 1

Source of data	Sample size			Total house hold
	Male	Female	Total	
Focus group discussion	2	-	2	2500
Interviewee	5	-	5	
Observation	36	4	40	
Questionnaire	42	8	50	
Total	85	12	97	

Annex 2

2.1 Cobs maize grain in the field

2.2 Temporary storage and drying practices



2.3. Storage maize grain