

## Research Article

# Assessing Storage Insect Pest infestations and Faecal dropping of Rodent in Stored Grains from two districts of Southwestern Ethiopia

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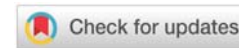
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## Abstract

This study was designed to assess the occurrence of major insects and rodent pest infestations in stored grain from two districts of Southwestern Ethiopia. Omo Nada and Bako Tibe districts were purposively selected because they are potential maize and sorghum growing regions with high postharvest losses. A total of 160 farmers' stores from both the districts were randomly selected. The grain samples used in the present study were stored for five different time periods, ranging from 1 to 5 months and from the same farmers' stores, to identify storage insect pest, determine grain weight loss and insect damage. The results showed that the dominant insect species in maize and sorghum grains were weevils (*Sitophilus* spp.) followed by the Angoumois gelechiid (*Sitotroga cerealella* Olivier) and flour beetles (*Tribolium* spp.). High number of insects were recorded from both plastered and un-plastered gombisa and polypropylene bags. Additionally, the amount of every insect pest in each storage container recorded per 100 g grain increased because the duration of grain storage increased. There have been 0.33-1.29g and 0.44-1g of rodent droppings per 100g sample of maize and sorghum grains, respectively. This showed that faecal dropping per 100 g grain increased along with increase in storage period. Grain damage showed significant ( $P < 0.05$ ) differences over the storage periods across the studied districts. A similar trend was observed for weight loss in each of the grains all districts. These results indicated that farmers are incurring a substantial grain loss to insects and rodent pests. Hence, there is an urgent need to devise appropriate tactics for protecting the losses in farm-stored maize and sorghum in Ethiopia.

## Introduction

Grains are the most important source of nutrition for one-third of the world's poorest population in Sub-Saharan Africa and South-East Asia. Among the grain crops, rice, wheat and maize represent about 85% of total global production [1]. In Ethiopia, Cereals constituted 87.3% of the grain production of the country, with 26.8% contribution from maize, 16.1% from sorghum, 15.7% from wheat and 28.7% from other types of grains [2]. However, production of cereals and grains are constrained by various biotic and abiotic factors. Post-harvest losses are one among the most constraints affecting food and nutrition security of smallholding farmers within the country [3,4]. Poor storage systems make grains susceptible to attacks from insect and rodent pests, which cause a substantial amount of losses in quantity and quality of grains.

Losses resulting from poor post-harvest management of grains are among the key constraints for improving food and nutritional security in Africa that results in grain weight losses of 20–30 % [3]. Consistent with Kumar and Kalita [5], approximately 50–60% loss of cereal grains occur during storage due to technical inefficiency. In Ethiopia, the typical grain losses owing to storage insect pests estimated to be 10 – 30% [6,7]. Among many storage insect pests, the rice weevils, *Sitophilus* spp. (*Coleoptera: Curculionidae*), and the Angoumois gelechiid, *Sitotroga cerealella* (Olivier) (*Lepidoptera: Gelechiidae*), are major pests of cereal crops in Ethiopia [8–10]. According to Sori and Ayana [11], *S. zeamais* can cause heavy infestations on maize and sorghum grain stored under traditional storage facilities and resulted in weight loss up to 41– 80%.

Like those in other African countries farmer in Ethiopia,

use traditional storage facilities such are gotera, gumbi, and polypropylene and jute bags. Gotera is an outside storage structure made up of mud or trash plastered basket work covered with thatched roofing and raised off the bottom with stones or wooden platform; Gumbi is an inside grain storage bin made from mud plaster mixed with teff straw [12]. Such storage structures often fail to guard the stored grains from insect pests and rodents. Traditional storage structures provide ideal conditions for the multiplication of storage insect pests and rodents. Although most smallholding farmers keep grain for a comparatively shorter period, substantial losses occur to stored grains.

Rodents are also considered as a serious postharvest pest, causing a big amount of losses and contamination of stored grains during storage which indirectly affects food security and income of the small-holder farmers [13,14]. To style effective postharvest pest management methods, knowledge of major pests and their relative abundances in reference to storage facilities is important. However, little information is there on storage insect pest infestations in reference to storage facilities. Therefore, the aim of this study was to assess storage insects of stored maize and sorghum and their associated losses of quantity in Southwestern Ethiopia.

## Materials and methods

### Study areas and sample collection methods

Study areas included the select zones, Woredas and Kebele's depending on their potential towards maize and sorghum production and selection of farmers was made together with Woreda agricultural experts. It cover two major maize and sorghum producing zones of South-western Oromia, Ethiopia; namely, Jimma and West shawa. A total of 600 g grain sample of each storage structure was collected. The grain samples were taken from the top, middle and bottom of a storage structure and then bulked together to make a composite sample. Samples were collected at monthly intervals for up to five months from the same stores for storage insect pest studies, faecal dropping of rodent studies and grain damage and weight loss assessment. Sample collection was carried out after the grain was stored for one month and samples were enclosed in plastic bags and brought to the Postharvest Management Laboratory of Jimma University, College of Agriculture and Veterinary Medicine (JUCAVM) for laboratory analysis.

### Data collection

**Identification of major insect pests:** About 100g of sample was taken from each of the storage for the laboratory insect identification. The grain was sieved through 2 mm mesh sieve (to remove dead and alive insects from the sample taken and to leave the grain on sieve) as method used by Abraham [15]. Both live and dead insects removed from each sample were counted, placed individually in a veil containing 70% ethanol and identified using the procedure described by Borror, *et al.* [16]. The collected insects were identified through their morphological characteristics using a dissecting microscope (at a magnification of 25–60x) for species identification.

**Faecal dropping of rodent:** Sample of 100g was taken from each of the storage for the identification of rodent faecal droppings. The sample was spread out on a plastic sheet to separate rodent faecal droppings. Faecal dropping removed from each sample were weighed and the weight of faecal dropping of rodent present in grain was computed [13].

$$\text{Faecal dropping} = \frac{\text{Weight of faecal dropped}}{100\text{g}}$$

**Grain damage and weight loss assessment:** Assessment of damaged grain: Insect damage was recorded by the count and weighing method. Each 100g grains were taken from initial to last storage periods and from each of the storage types and the number of insect damaged and un-damaged grains were determined using a hand lens by searching for the presence of hole on seeds. The percentage insect damaged grains was calculated according to the methods used by Wambugu, *et al.* [17] as follows,

$$\text{Insect damaged grain (\%)} = \frac{\text{Number of insect damaged grain} \times 100}{\text{Total number of grain}}$$

**Grain weight loss:** For the assessment of grain weight loss, 100 grain samples were taken from initial to last storage periods and from each of the storage types and the number of insect damaged and un-damaged grains were identified and tallied using a hand lens to inspect for the presence of a hole or burrow. Grain in each portion were then counted and weighed using a digital balance. The percentage of weight loss was then calculated [18].

$$\text{Weight loss (\%)} = \frac{(W_{ux}N_d) - (W_{dx}N_u) \times 100}{W_u(W_d + N_u)}$$

In the above formula,  $W_u$  is the weight of undamaged seeds,  $N_u$  is the number of undamaged seeds,  $W_d$  is the weight of damaged seeds and  $N_d$  is the number of damaged seeds.

### Data analysis

A 2 x 3 factorial design was used for the analysis of damaged grain, weight loss of maize and sorghum grains stored in the farmers' traditional storage structures with two storage types (Gombisa/Gotera and polypropylene sack) and three storage duration levels (1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> months). The data on the insect count, per cent grain damage and weight loss were analysed using one-way analysis of variance (ANOVA) with a generalized linear model. Then the data were arcsine transformed to normalize the variances. Significance level was set at 0.05, and the means were separated by Tukey's Honestly Significant Difference test. All statistical analyses were conducted using MINITAB 16 statistical software.

## Results

### Identification of storage insect pests

Maize weevils (*Sitophilus* spp.), Angoumois grain moth

(*Sitotroga cerealella*), and flour beetle (*Tribolium spp.*) were the insect species identified from both samples (Table 1). In Omo Nada district, there were significant differences in the number of maize weevil recorded during storage periods of stored maize ( $P = 0.05$ ), but the storage type did not affect the number of insects. However, in Bako Tibe district, the number of maize weevils showed highly significant ( $P = 0.005$ ) differences, with interaction effects of storage duration and storage types. Likewise, in stored sorghum grain there were significant differences in the number of maize weevil recorded during storage periods both in Omo Nada ( $P = 0.014$ ) and Bako Tibe ( $P = 0.020$ ) districts. In both districts, the number of Angoumois grain moth and flour beetle recorded in stored maize and sorghum were significantly affected by storage durations with the exception of flour beetle recorded in stored maize in Bako Tibe district.

Means within a column followed by different letters are significantly different at  $P < 0.05$  (Tukey test). Note: Unplastered gombisa/gotera in Omo Nada and plastered gombisa/gotera in Bako Tibe district

### Faecal droppings of rodent

The result of faecal droppings in maize and sorghum grain stored in Gombisa during five consecutive months of storage period show in Figure 1. In Omo Nada faecal dropping collected from maize ranged from 0.33-1.29 g droppings/100 g of sample, while in Bako Tibe it was ranged from 0.58-1.13g droppings/100 g of maize. In Omo Nada it was ranged from 0.44-0.92g droppings/100 g of sorghum, while in Bako Tibe it was ranged from 0.58-1g droppings/100 g of sorghum.

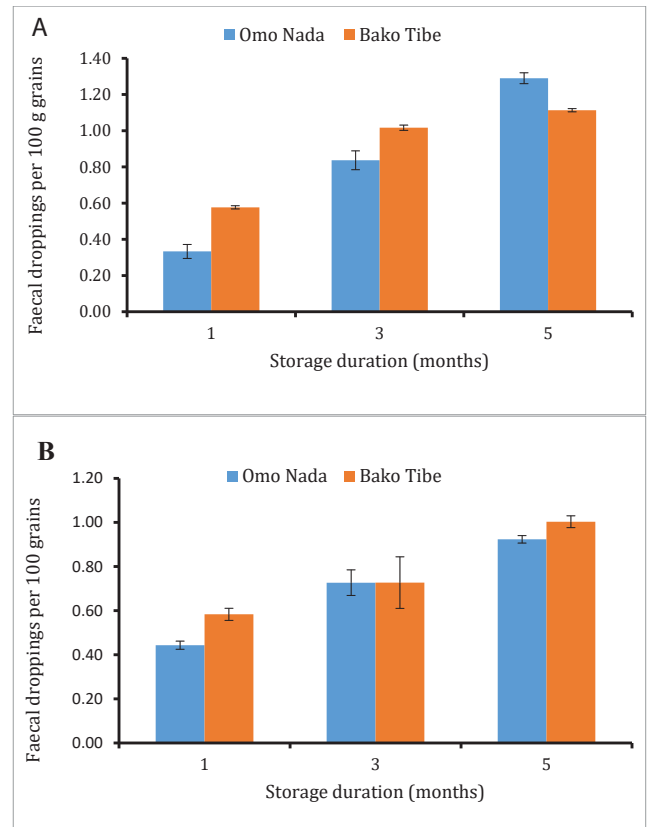
### Grain damage and weight loss

The per cent damage of stored maize grain was significantly affected by storage type ( $F_{1,12} = 8.92$ ;  $P < 0.01$ ) and storage duration ( $F_{2,12} = 417.16$ ;  $P < 0.001$ ) with the highest per cent damage (60.5±0.6) was observed in grain stored in Gombisa/Gotera at fifth month of storage (Table 2). The per cent damage of stored sorghum showed significant differences with storage duration ( $F_{2,12} = 335.73$ ;  $P < 0.001$ ) (Table 2). In all grain types, damage increased with increase in storage duration (Table 2).

The per cent weight loss (WL) of stored maize grain was significantly affected by storage duration ( $F_{2,12} = 310.82$ ;  $P < 0.001$ ). Similarly, the WL of stored sorghum varied significantly among storage durations ( $F_{2,12} = 198.54$ ;  $P < 0.001$ ). In all grain type, WL increased with increase in storage duration (Table 3).

### Discussion

In the present study, *Sitophilus spp.*, *S.cerealella*, and *Tribolium spp.* were recorded in maize and sorghum grains stored in gombisa and polypropylene bags storage containers.



**Figure 1:** Rodent droppings per 100-g sample (mean ± SE) from maize (A) and sorghum (B) grains sampled over five months in Omo Nada and Bako Tibe district, Southwestern Ethiopia.

**Table 1:** Number of insect pests sampled from maize and sorghum grains (100 g<sup>-1</sup> grain) in the Omo Nada and Bako Tibe districts, Southwestern Ethiopia.

Grain type	Storage duration (Months)	Gombisa			Polypropylene bag		
		<i>Sitophilus spp.</i>	<i>Tribolium spp.</i>	<i>Sitotroga cerealella</i>	<i>Sitophilus spp.</i>	<i>Tribolium spp.</i>	<i>Sitotroga Cerealella</i>
<i>Omo Nada district</i>							
Maize	1 <sup>st</sup>	6.0±1.53 <sup>a</sup>	2.0±1.53 <sup>a</sup>	2.3±1.20 <sup>ab</sup>	4.7±1.85 <sup>a</sup>	0.7±0.33 <sup>b</sup>	1.3±0.33 <sup>b</sup>
	3 <sup>rd</sup>	31.3±2.68 <sup>b</sup>	3.3±0.88 <sup>b</sup>	4.0±1.76 <sup>ab</sup>	8.0±1.73 <sup>a</sup>	2.0±0.00 <sup>ab</sup>	6.3±2.18 <sup>ab</sup>
	5 <sup>th</sup>	36.3±2.64 <sup>b</sup>	6.0±1.52 <sup>a</sup>	6.0±2.31 <sup>a</sup>	7.3.0±1.73 <sup>a</sup>	4.0±1.00 <sup>ab</sup>	10.0±1.53 <sup>a</sup>
Sorghum	1 <sup>st</sup>	8.7±2.18	0.3±0.33	0.7±0.67	2.0±1.15	0.0±0.00	2.3±0.88
	3 <sup>rd</sup>	9.3±1.20	1.0±0.88	3.7±1.86	8.3±2.53	1.3±0.67	1.7±0.88
	5 <sup>th</sup>	22.7±4.37	5.3±2.85	8.3±1.67	20.3±3.22	7.3±0.84	7.0±4.73
<i>Bako Tibe district</i>							
Maize	1 <sup>st</sup>	2.7±2.18 <sup>b</sup>	0.3±0.33 <sup>a</sup>	0.7±0.33 <sup>a</sup>	2.7±1.45 <sup>b</sup>	0.7±0.67 <sup>a</sup>	1.3±0.33 <sup>bc</sup>
	3 <sup>rd</sup>	17.7±2.17 <sup>b</sup>	1.0±0.58 <sup>ab</sup>	6.3±2.40 <sup>abc</sup>	12.0±1.53 <sup>b</sup>	1.3±1.33 <sup>a</sup>	4.0±2.65 <sup>abc</sup>
	5 <sup>th</sup>	44.3±3.81 <sup>a</sup>	1.3±0.67 <sup>ab</sup>	11.3±2.60 <sup>a</sup>	15.0±3.00 <sup>b</sup>	4.3±1.45 <sup>b</sup>	9.3±0.33 <sup>ab</sup>
Sorghum	1 <sup>st</sup>	5.3±0.67 <sup>bc</sup>	0.3±0.33	0.3±0.11 <sup>c</sup>	1.7±0.88 <sup>c</sup>	0.0±0.00	1.7±0.67 <sup>c</sup>
	3 <sup>rd</sup>	19.3±3.22 <sup>ab</sup>	1.0±0.58	3.0±1.53 <sup>bc</sup>	9.7±0.88 <sup>abc</sup>	1.3±0.88	2.0±1.15 <sup>c</sup>
	5 <sup>th</sup>	25.0±4.00 <sup>a</sup>	2.7±1.33	7.3±0.88 <sup>ab</sup>	21.3±2.41 <sup>ab</sup>	3.7±1.20	7.7±0.88 <sup>a</sup>



**Table 2:** Insect damage (% number) of maize and sorghum grains during storage in different storage structures from Southwestern Ethiopia.

Grain type	Storage type	Storage duration (months)		
		1 <sup>st</sup>	3 <sup>rd</sup>	5 <sup>th</sup>
Maize	Gombisa/Gotera	10.3±0.6 <sup>d</sup>	37.5±2.6 <sup>c</sup>	60.5 ±0.6 <sup>a</sup>
	PP sack	9.3±0.8 <sup>d</sup>	34.8±2.3 <sup>c</sup>	52.3±1.6 <sup>b</sup>
Sorghum	Gombisa/Gotera	5.3±0.4 <sup>c</sup>	23.3±1.9 <sup>b</sup>	37.8±0.4 <sup>a</sup>
	PP sack	5.0±0.9 <sup>c</sup>	21.3±2.0 <sup>b</sup>	36.0±0.9 <sup>a</sup>

Means within a column followed by different letter(s) are significantly different at  $P < 0.05$  (Tukey test). Values are mean  $\pm$  SE.

**Table 3:** Mean percentage of weight loss of maize and sorghum grains during storage in different storage structures from Southwestern Ethiopia.

Grain type	Storage type	Storage duration (Months)		
		1 <sup>st</sup>	3 <sup>rd</sup>	5 <sup>th</sup>
Maize	Gombisa/Gotera	2.4 $\pm$ 0.4 <sup>c</sup>	8.3 $\pm$ 0.7 <sup>b</sup>	14.3 $\pm$ 0.2 <sup>a</sup>
	PP sack	2.1 $\pm$ 0.6 <sup>c</sup>	7.9 $\pm$ 0.1 <sup>b</sup>	12.4 $\pm$ 0.2 <sup>a</sup>
Sorghum	Gombisa/Gotera	1.9 $\pm$ 0.1 <sup>c</sup>	4.9 $\pm$ 0.5 <sup>b</sup>	10.3 $\pm$ 0.6 <sup>a</sup>
	PP sack	1.8 $\pm$ 0.1 <sup>c</sup>	4.6 $\pm$ 0.5 <sup>b</sup>	10.2 $\pm$ 0.4 <sup>a</sup>

Means within a column followed by different letter(s) are significantly different at  $P < 0.05$  (Tukey test). Values are mean  $\pm$  SE.

These species were reported as the main storage insect pests of cereal grains in several parts of Ethiopia [9,10,19,20] and other African countries [3,21,22] in both studied districts and storage types, *Sitophilus spp.* were the foremost abundant species, which is corroborated by the findings of varied studies, like Mlambo, *et al.* [23]. Angoumois moth is a cosmopolitan insect and therefore it is the dominant species attacking different cereal crops in Africa [23]. Consistent with Golob [24], *S. cerealella* is especially related to unshelled maize and sorghum soon after harvest. As demonstrated during this study, the amount of each storage insect pest recorded increased because the duration of grain storage increased, leading to considerable losses.

Tefera, *et al.* [25] observed a rise in grain damage and weight loss due to was increased density of storage insects and the duration of the storage period. In earlier studies, Dubale, *et al.* [26] observed a rise in density of maize weevil and Angoumois gelechiid on maize stored in Gombisa and sacks over the storage periods.

The presence of faecal droppings in sample grain may be a sign of rodent infestation and it affects the standard attribute of stored grains [13].

The present study revealed that rodent faecal droppings per 100 g grain increased along with increase in storage period. This might flow from to a very fact that Gombisa a standard storage structures cannot protect rodent attack. Similar results were reported by Befikadu [27], that on-farm storage structures like Gombisa make grain vulnerable to rodent infestation within the Southwestern part of the country due to the recent and humid climate, and these structures aren't highly protective generally. Rodents are one among the main postharvest pests causing a substantial amount of losses. During this study, most farmers considered rodents a significant problem that causes estimated grain losses of 26–50%. A study conducted in Kenya showed that farmers perceived rodents causing up to 43% and 30% loss in maize stored on cobs and shelled grains, respectively [14].

The present study also showed that postharvest insect pests cause severe losses in stored grains for small-holding growers in Southwestern Ethiopia. Over 50% and 35% of damaged maize and sorghum grain, respectively, were observed by the fifth month of storage in Gombisa and polypropylene sack, which are the most common traditional storage structures in the study areas. Consistent with FAO [28], an estimated loss of 20 – 30% occurred in Africa due to poor postharvest management practices. For instance, in Ethiopia, the typical grain loss due to storage insect pests is estimated to be 10 – 30% [6,7].

In Ethiopia, Sori and Ayana [11] reported approximately 64.5% of grain damage in traditional farm stores within three to six months. Several factors like storage duration, storage type and management practice may have contributed to high grain damage by storage insect pests [3,29]. Grain weight loss from 10 – 15% in maize and sorghum were recorded during the fifth month of storage. Hell, *et al.* [30] observed 10 to 12% loss of grains stored in traditional storage structures due to insect pests in Tanzania. González-Torralba, *et al.* [31] noted that grain weight loss was found to be hooked in to storage duration, where a rise in storage time results in a big loss of grain weights. Furthermore, Tefera [3] also reported that storage losses depend on temperature and humidity, which favour the expansion of mould and bug infestation.

## Conclusion

In conclusion, no matter storage type, and therefore the traditional storage systems adopted by the farmers within the study areas couldn't effectively protect against storage losses caused by insect and rodent pests. As a result, grain damage consistently increased from the primary to the fifth months of storage. Similarly, grain weight loss increased because the duration of storage increased. This finding indicates the necessity for development of existing traditional storage facilities and therefore the adoption of improved storage facilities, like hermetic metal silos and PICS bags, which are proven to guard stored grains from insect pest infestation.

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## Availability of data

The data used to support the results of this study is available upon request from the corresponding author.

## Author contribution statement

Marid Tadesse carried out the experiment, collected, analyzed data, and led the write-up of the manuscript. Md. Jamshed Ali, helped with provides technical support for this study. Both authors read and approved the final manuscript.



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