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Research Article

Assessment of Storage Structure, Cause of Gran Loss, and Methods Used to Control Storage Losses

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Abstract

Post-harvest losses, leading to substantial grain loss, stem from various factors such as insect infestation, mold growth, rodent damage, adverse weather conditions, and inadequate storage practices. This study investigates the storage structures employed by farmers in Zenzelma Kebele and identifies the primary causes of grain loss. Despite the persistence of traditional storage structures like "Gotera" and "Gota," there is a noticeable lack of adoption of improved storage methods. The research highlights insects and rodents as major contributors to grain loss, both in the field and during storage. Farmers mainly use chemical measures to combat these pests, including fumigation and pesticides like Malathion. Additionally, sun drying remains a widely used traditional method. The study's findings underscore the urgent need for integrated pest management (IPM) strategies and the development of cost-effective, environmentally sustainable solutions to reduce post-harvest losses. Understanding local farming practices is crucial for designing effective interventions that enhance food security and promote economic sustainability in maize production. By focusing on the specific conditions and practices in Zenzelma Kebele, this study provides valuable insights into the challenges and opportunities for improving grain storage and reducing losses. Tailored interventions, informed by local needs and practices, are essential to address these issues effectively. The adoption of improved storage techniques and IPM strategies can significantly reduce grain losses, thereby boosting food security and supporting the livelihoods of farmers. This research advocates for a holistic approach to pest management and storage practices, encouraging collaboration between researchers, policymakers, and farmers. By promoting sustainable agricultural practices and innovative storage solutions, we can work towards a more secure and prosperous future for maize producers in Zenzelma Kebele and beyond.

Keywords

Assessment, Storage Structure, Grain Loss, Control Methods, Mirab Gojam Zone

1. Introduction

Grain storage is a critical aspect of agricultural operations, ensuring the preservation of harvested crops for extended periods while maintaining their quality and nutritive value. However, despite advancements in storage technologies, substantial losses still occur due to various factors such as improper storage structures, environmental conditions, and pest infestation [1, 15]. Understanding the dynamics of grain storage, identifying the causes of loss, and implementing

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effective control measures are paramount for enhancing food security and economic viability in the agricultural sector [2].

This assessment delves into the multifaceted aspects of grain storage, focusing on three key components: storage structure evaluation, identification of causes contributing to grain loss, and the implementation of strategies to mitigate such losses [3]. By evaluating storage structures, including silos, warehouses, and on-farm storage facilities, researchers can assess their efficacy in maintaining grain quality and minimizing losses [4]. Furthermore, identifying the primary causes of grain loss, ranging from physical damage during handling to biological degradation by pests and pathogens, provides valuable insights for devising targeted control measures [3].

To control storage losses effectively, a combination of preventive and remedial methods is often employed, encompassing techniques such as fumigation, temperature and moisture management, hermetic sealing, and the use of protective coatings and insecticides [5]. This assessment aims to consolidate existing knowledge, draw upon empirical research, and offer practical recommendations to researchers and stakeholders involved in agricultural production and food security initiatives.

2. Material and Method

2.1. Survey Area and Interview Methods

The survey areas were strategically chosen based on their maize production potential, with farmers selected randomly within the study area, specifically the Zenzelma kebele, encompassing the Sifatra 'Got' or village. Thirteen respondents, including male and female farmers and students aged 20-75, were interviewed over a period of three days from June 4th to June 6th, coinciding with the 2022 cropping season. Various tools such as notebooks, pens, questionnaires, PCs, and other materials were utilized for data compilation.

Structured questionnaires were administered through personal interviews to gather primary and ancillary data from farmers, focusing on storage practices and types of storage structures used for maize grain. The research design incorporated observation and assessment. The extent of damage caused by post-harvest pests was evaluated through surveys with the 13 participating farmers. Severity was assessed on a scale of 0 to 2, where '0' indicated minimal loss, '1' signified moderate loss, and '2' represented the highest level of loss. Percentage losses were calculated and presented in both tabular and graphical formats.

To identify major post-harvest activities contributing to losses, respondents estimated the amount of maize grain lost in kilograms for each specific activity. Total losses were determined by summing up the estimations provided by the respondents and dividing by the corresponding number of respondents, assuming a production of 10 quintals of maize. This methodology provided insight into the average loss within every 10 quintals produced.

2.2. Data Analysis

The collected data underwent input into Excel, enabling the creation of a frequency table. Subsequently, these frequencies were transformed into percentage frequencies to offer a more lucid representation of the data. Descriptive statistics were then utilized to perform a multiple-response analysis on the gathered data types, facilitating a thorough comparison and interpretation of the results.

3. Result and Discussion

3.1. Assessment of Different Storage Structures of Farmers to Store Maize Product

The survey results underscore the importance of traditional storage structures like Gotera and Gota in Zenzelma Kebele and Sifatra Got, particularly concerning maize grain storage. Among respondents, 76% utilize traditional Gotera, while Gota emerges as the predominant choice, with 100% adoption (refer to Table 1). Interestingly, none of the respondents reported using improved Gotera structures, consistent with prior research [6]. Alternative storage structures such as Lakota, Aibet, Walla, Sherfa/Kefo, Dibignits, Grain Pro Cocoon, Plastic Drum, Warehouses, Pics Bags (Triple Bag), Grain Pro Super Bag, Gunny Bag, Underground Pit, and Balcony are rarely utilized for maize grain storage by farmers. Instead, maize grain is predominantly stored using Crib (Maize Cobs), Plastic Bag, Jute Bag, and Fertilizer Bag, accounting for 61.54%, 61.54%, 92.31%, and 69.23%, respectively (see Table 1). This reliance on traditional and less efficient storage structures may contribute to potential post-harvest losses. Notably, the study area exhibits minimal adoption of improved storage structures, in contrast to previous reports [7].

Table 1. *Frequency of respondents for different storage structures used.*

Storage Structure	Frequency		Frequency percentage	
	yes	no	Yes (%)	No (%)
Gota	13	0	100.00	0.00

Storage Structure	Frequency		Frequency percentage	
	yes	no	Yes (%)	No (%)
Trad. Gotera	10	3	76.92	23.08
Impro. Gotera	0	13	0.00	100
Lakota	3	10	23.08	76.92
Aibet	1	12	7.69	92.31
Walla	1	12	7.69	92.31
Sherfa/Kefo	3	10	23.08	76.92
Dibignits	0	13	0.00	100.00
Underground pit	0	13	0.00	100.00
Balcony	0	13	0.00	100.00
Crib (Maize Cobs)	8	5	61.54	38.46
Gunny bag	3	10	23.08	76.92
Plastic bag	8	5	61.54	38.46
polypropylen bag	3	10	23.08	76.92
Jute bag	12	1	92.31	7.69
Pics/Triple bags	4	9	30.77	69.23
Grain Pro Super bag	1	12	7.69	92.31
Grain pro cocoon	0	13	0.00	100.00
Plastic drum	0	13	0.00	100.00
Fertilizer bags	9	4	69.23	30.77
Ware houses	0	13	0.00	100.00

3.2. Assessment of Different Causes of Maize Grain Loss

The survey results from the study area provide insights into the multifaceted factors contributing to post-harvest grain losses in maize. According to surveyed farmers, primary causes include insect infestation and rodent damage in storage, accounting for the entirety of maize grain losses. Field and storage losses are also attributed to pests like insects, rodents, termites, and birds, each contributing substantially, ranging from 92.31% for each category (see Table 2). Furthermore, mold growth in the field, theft, adverse weather conditions, interference by other animals, and improper harvesting practices are significant contributors to post-harvest losses, with reported losses ranging from 60% to 77%. Although considered relatively minor, factors such as shattering during harvesting and transportation of harvested maize from the farm to storage still result in notable losses, reported at 30.77% and 38.46%, respectively, by surveyed farmers.

Table 2. *Response frequency of farmers to different causes of maize grain loss in field and Storage.*

Cause of grain loss	Frequency		Percentage frequency	
	yes	no	Yes (%)	No (%)
Insect in the field	12	1	92.31	7.69

Cause of grain loss	Frequency		Percentage frequency	
	yes	no	Yes (%)	No (%)
Insect in the storage	13	0	100.00	0.00
Molds in the field	10	3	76.92	23.08
Molds in the storage	6	7	46.15	53.85
Rodents in the field	12	1	92.31	7.69
Rodents in the storage	13	0	100.00	0.00
Other Animals	8	5	61.54	38.46
Termites	12	1	92.31	7.69
Birds	12	1	92.31	7.69
Theft	9	4	69.23	30.77
weather	9	5	69.23	38.46
Spillage/Damaged storage	4	9	30.77	69.23
Broken kernuls	7	6	53.85	46.15
Shattering	4	9	30.77	69.23
harvesting Method used	8	5	61.54	38.46
Threshing/cleaning method	11	2	84.62	15.38
Transportation farm to storage	5	8	38.46	61.54

Thirteen farmers participated in assessing post-harvest grain losses caused by various pests in this study. Severity was categorized into three grades: 0 for minimal loss, 1 for moderate loss, and 2 for the highest loss. The percentage of losses was then calculated and presented in tabular and graphical formats. Results indicated that the most significant causes of grain loss, graded as severity grade 2, were attributed to insects in the field by 61.54% of farmers and insects in storage by 69.23% of farmers. Conversely, factors such as transportation from farm to storage, shattering during harvesting, mold growth in storage, harvesting method, and adverse weather conditions were associated with minimal damage (severity scale 1) to both stored and on-farm maize grain.

Rodent infestation in the field and broken kernels were classified as medium damage factors (severity level 1), each reported by 61.54% of surveyed farmers (see Table 3).

***Table 3**. Response of farmers to cause of maize grain loss level of damage in field and storage.*

Cause of grain loss	Frequency of Level of Damage			Frequency Percentage		
	Sev.0	Sav.1	Sav.2	Sev.0 (%)	Sav.1 (%)	Sav.2 (%)
Insect in the field	1	7.69	3	7.69	23.08	61.54
Insect in the storage	2	15.38	2	15.38	15.38	69.23
Molds in the field	4	30.77	5	30.77	38.46	7.69
Molds in the storage	1	7.69	5	7.69	38.46	0.00
Rodents in the field	2	15.38	8	15.38	61.54	23.08
Rodents in the storage	3	23.08	5	23.08	38.46	38.46
Other Animals	3	23.08	2	23.08	15.38	23.08
Termites	1	7.69	4	7.69	30.77	53.85

Cause of grain loss	Frequency of Level of Damage			Frequency Percentage		
	Sev.0	Sav.1	Sav.2	Sev.0 (%)	Sav.1 (%)	Sav.2 (%)
Birds	5	38.46	4	38.46	30.77	23.08
Theft	2	15.38	4	15.38	30.77	23.08
weather	3	23.08	5	23.08	38.46	0.00
Spillage/Damaged storage container	0	0.00	3	0.00	23.08	7.69
Broken kernels	1	7.69	8	7.69	61.54	7.69
Shattering	3	23.08	1	23.08	7.69	0.00
harvesting Method used	7	53.85	3	53.85	23.08	0.00
Threshing/cleaning method	5	38.46	4	38.46	30.77	15.38
Transportation farm to storage	2	15.38	3	15.38	23.08	0.00

Severity levels were categorized as follows: 0 indicating lower damage, 1 for medium damage, and 2 representing the highest damage. The survey findings highlight farmers' significant concerns about insect and rodent pests, both in field and storage environments. Therefore, it is imperative for researchers and governmental entities to prioritize efforts to control these post-harvest pests. Implementing integrated pest management (IPM) practices is crucial due to the multifaceted nature of the issue. This conclusion resonates with the findings of previous research conducted by Fufa et al. [8].

3.3. Assessment of Methods Used by Farmers to Control Maize Grain Loss in Storage

The survey outcomes offer insights into maize grain loss control practices within Zenzelma kebele, revealing a blend of traditional and modern approaches. Notably, none of the interviewed farmers employ cultural methods such as the use of traditional herbs or mixing with Teff, ashes, sawdust, clays, oils, triplex, or filter cake to mitigate grain loss. Sun drying emerges as the predominant practice, adopted by all surveyed farmers, followed by the use of fumigants/phosphine gases (92.31%) and Malathion dust (76.92%) (refer to Table 4). This contrasts with Abraham's findings in 1997 [9], which indicated fewer farmers utilizing Malathion dust. The prevalent reliance on chemical methods in Zenzelma kebele underscores the necessity to explore alternative integrated management techniques that are both cost-effective and safe for human health and the environment. Smoking is employed by only a minority of farmers, while others have yet to explore alternative options for reducing post-harvest loss. This observation aligns with Abraham's findings in 1997 [9] and underscores the imperative of exploring diverse strategies for maize grain loss management.

Table 4. Frequency of 13 farmers' responses for their maize grain loss controlling practices in the storage.

Methods to control storage losses	Frequency		Frequency (%)	
	yes	no	Yes %	No %
Use of traditional hurbs	0	13	0.00	100.00
Mix with Teff	0	13	0.00	100.00
Mix with Ashes	0	13	0.00	100.00
Mix with Sawdust	0	13	0.00	100.00
Clays oils	0	13	0.00	100.00
Triplex	0	13	0.00	100.00
Filter cake	0	13	0.00	100.00
Actellic dust	5	8	38.46	61.54

Methods to control storage losses	Frequency		Frequency (%)	
	yes	no	Yes %	No %
Malathion dust	10	3	76.92	23.08
Fumigant (phosphine gases)	12	1	92.31	7.69
Use of fungicides	7	6	53.85	46.15
Smoking	4	9	30.77	69.23
Drying	13	0	100.00	0.00

3.4. Assessment and Identification of Farmers' Experiences in Which Post-Harvest Activity Significant Maize Grain Loss Occurred

Table 5 illustrates these findings. Farmers identified storage losses primarily due to insect pest infestations and rodent damage, consistent with previous research findings on post-harvest losses in similar contexts [14, 10]. Some respondents also noted the presence of post-harvest fungal diseases in storage facilities, which aligns with studies highlighting fungal contamination as a critical issue in grain storage [13] During harvesting, mechanical activities such as throwing resulted in seed scattering, missed collection of stalks/husks, and interference from weeds, all contributing to losses. These observations support findings by [12], who noted that mechanical harvesting methods often lead to significant grain losses. Transportation and shelling activities were reported to cause grain losses due to dropping from bags with holes and cobs being thrown to the ground during shelling. Remarkably, no significant losses were reported during transportation from storage to the market, marketing processes, or milling.

Farmers noted minimal losses during drying and cleaning activities, suggesting that these processes are relatively efficient compared to other stages of post-harvest handling. This observation is corroborated by research indicating that proper drying and cleaning techniques can significantly reduce post-harvest losses [11].

Table 5. *Farmers' experiences in which post-harvest activities contributed to significant loss of maize grain.*

Cause of grain loss	Frequency of Level of Damage			Frequency Percentage		
	Sev.0	Sav.1	Sav.2	Sev.0 (%)	Sav.1 (%)	Sav.2 (%)
Insect in the field	1	7.69	3	7.69	23.08	61.54
Insect in the storage	2	15.38	2	15.38	15.38	69.23
Molds in the field	4	30.77	5	30.77	38.46	7.69
Molds in the storage	1	7.69	5	7.69	38.46	0.00
Rodents in the field	2	15.38	8	15.38	61.54	23.08
Rodents in the storage	3	23.08	5	23.08	38.46	38.46
Other Animals	3	23.08	2	23.08	15.38	23.08
Termites	1	7.69	4	7.69	30.77	53.85
Birds	5	38.46	4	38.46	30.77	23.08
Theft	2	15.38	4	15.38	30.77	23.08
weather	3	23.08	5	23.08	38.46	0.00
Spillage/Damaged storage container	0	0.00	3	0.00	23.08	7.69
Broken kernels	1	7.69	8	7.69	61.54	7.69

Cause of grain loss	Frequency of Level of Damage			Frequency Percentage		
	Sev.0	**Sav.1**	**Sav.2**	**Sev.0 (%)**	**Sav.1 (%)**	**Sav.2 (%)**
Shattering	3	23.08	1	23.08	7.69	0.00
harvesting Method used	7	53.85	3	53.85	23.08	0.00
Threshing/cleaning method	5	38.46	4	38.46	30.77	15.38
Transportation farm to storage	2	15.38	3	15.38	23.08	0.00

4. Conclusion

Understanding and addressing challenges in crop production is crucial, particularly with a growing population and limited yields. Maize, a staple crop for smallholder farmers worldwide, plays a vital role in ensuring food security. This assessment focuses on analyzing losses occurring throughout maize production, from cultivation to postharvest stages, and proposes strategies for mitigation. Postharvest losses in maize, mainly caused by insect infestation and mishandling during storage, packaging, and transportation, present significant concerns. Effective management requires the adoption of suitable packaging materials, upgraded storage facilities, and efficient transportation methods. Improving these aspects not only safeguards food security but also boosts export earnings and self-sufficiency in food production.

In traditional maize-growing regions, storage structures like Gotera or Gota, constructed from wood and grass, are prevalent. However, these structures are susceptible to pests, diseases, and rodent attacks, jeopardizing maize stocks. Transitioning to modern storage facilities becomes imperative to extend maize storage duration and curtail postharvest losses, particularly during storage and harvesting periods.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Garcia, D. A., et al. (2020). Grain Storage Losses: Causes and Management Strategies. Agronomy for Sustainable Development, 40 (6), 1-18. https://doi.org/10.1007/s13593-020-00653-4

[2] Ngugi, H. K., et al. (2018). Evaluation of On-Farm Grain Storage Structures and Their Impacts on Grain Quality in Sub-Saharan Africa. Journal of Stored Products Research, 77, 34-45. https://doi.org/10.1016/j.jspr.2018.03.005

[3] Navarro, S., et al. (2019). Understanding the Dynamics of Grain Storage Losses: A Review. Food Control, 101, 66-78. https://doi.org/10.1016/j.foodcont.2019.02.013

[4] Mbuge, D. O., et al. (2021). Integrated Pest Management Approaches for Grain Storage: A Review of Strategies and Implementation Challenges. Crop Protection, 142, 105464. https://doi.org/10.1016/j.cropro.2020.105464

[5] Pachauri, S., et al. (2017). Innovative Technologies for Grain Storage: A Review. Trends in Food Science & Technology, 70, 67-75. https://doi.org/10.1016/j.tifs.2017.10.008

[6] ISTA 2005 International Rules for Seed Testing: International Seed Testing Association, Bassersdorf, Switzerland. Link: https://bit.ly/32Bl6eP

[7] Alliance for a Green Revolution in Africa (AGRA). 2013. Establishing the status of post-harvest losses and storage for major staple crops in eleven African countries (Phase I). AGRA: Nairobi, Kenya.

[8] Fufa N, Zeleke T, Melese D, Daba T (2021) Assessing storage insect pests and post-harvest loss of maize in major producing areas of Ethiopia. J Agric Sc Food Technol 7(1): 193-198. https://dx.doi.org/10.17352/2455-815X.000106

[9] Abraham, T. (1997). The biology, significance, and control of the maize weevil, Sitophilus zeamais. In D. Pimentel (Ed.), Encyclopedia of Pest Management (pp. 105-112). CRC Press.

[10] Boxall, R. A. (2001). Post-harvest losses to insects - A world overview. International Biodeterioration & Biodegradation, 48(1-4), 137-152.

[11] FAO. (1994). Grain storage techniques: Evolution and trends in developing countries. Food and Agriculture Organization of the United Nations.

[12] Grolleaud, M. (2002). Post-harvest losses: Discovering the full story. Food and Agriculture Organization of the United Nations.

[13] Magan, N., & Aldred, D. (2007). Post-harvest control strategies: Minimizing mycotoxins in the food chain. International Journal of Food Microbiology, 119(1-2), 131-139.

[14] Tefera, T. (2012). Post-harvest losses in African maize in the face of increasing food shortage. Food Security, 4, 267-277.

[15] Hodges, R. J., & Farrell, G. (2004). Crop post-harvest: Science and technology, Volume 2: Durables. Blackwell Publishing.