

Baseline Survey on Postharvest Handling Practices by Maize (*Zea Mays* L) Grain Growers and Traders in Lower Eastern Kenya

Reuben Muasya

rmuasya@seku.ac.ke

South Eastern Kenya University

Grace Kamotho

Karatina University

Miano Kabethi

Karatina University

Rebecca Karaya

Karatina University

Lydia Asiko

Karatina University

Michael Gachahi

Karatina University

Esther Kimani

Kenya Agricultural and livestock research Organization

Shelmith Munyiri

Chuka University

James Karanja

Kenya Agricultural and Livestock Research Organization

Research Article

Keywords: Maize drying, storage, pests, Aflatoxin, post-harvest

Posted Date: March 25th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-8730225/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: The authors declare potential competing interests as follows: The interest the authors were interested in was show the risk of aflatoxins in maize on humans and our interest was to provide the knowledge necessary to ensure safety of human beings when using maize as a food crop.

Abstract

Maize (*Zea mays* L.) is Kenya's principal crop and staple food which is used by many communities in different forms such as "ugali", "githeri", "mukimo" and "muthokoi". However, postharvest loss along its handling value chain is a major challenge to its production and especially in Lower Eastern Kenya. This study sought to establish how the target farmers carry out postharvest practices such as processing of grains, storage, control of pests and aflatoxins to reduce post-harvest losses. A mixture of techniques including administering questionnaires to household heads, focused group discussions and key informant interviews were used. Data was collected from 319 farmers in Kitui, Makueni, Machakos and Tharaka – Nithi Counties in lower Eastern Kenya. The study revealed that majority of farmers (85.9%) dried maize before storage with a high number of farmers (67.7%) drying maize in the sun. It was noted that a large number of farmers (81.8%) shelled maize before preparing it for storage. However, it was observed that most farmers in this region did not store a lot of maize because the maize yield was low, where 32.3% of the farmers indicated that they harvested less than 10 bags of maize, 2.8% harvested 11–30 bags while 1.9% harvested above 30 bags. Majority of farmers 66.9% reported being aware of occasional food poisoning incidences in their counties of residence while 33.1% of the respondents were not aware. The study also revealed that methods used by farmers for storing maize resulted in loss of maize as confirmed by 47.0% of the farmers. The major challenges facing maize storage included pests as identified by 57.4% of the farmers. It is important that all maize growers and traders be continuously sensitized and educated on proper postharvest handling of maize grains to reduce losses.

INTRODUCTION

Maize (*Zea mays* L.) is a vital food crop cultivated in most parts of the world, especially in low and middle-income countries. Globally, it is the third most grown cereal crop that serves as the primary source of food to more than one billion people (IITA, 2009). It is a staple food in many Sub-Saharan Africa (SSA) countries, with the annual per capita consumption varying from country to country (Hassan et al., 2001; Pingali, 2001). In Kenya, maize and its products are the staple food to the majority of the population (Ransom, 1996), with an annual per capita consumption of approximately 77 kg (FAO, 2011). Most of the maize harvested is stored to ensure continuous supply between seasons. Traditional storage methods are mainly used by farmers (Nukenine, 2010) but have the disadvantage of being susceptible to insects and other pests attacks (Lathiya et al., 2008), among other unfavourable conditions that might lead to contamination and spoilage. Even though the area under maize cultivation in Africa has increased, the production and supply have declined (Groote et al., 2011). This has been attributed partly to climate changes and heavy postharvest losses (Auffhammer, 2011). These losses have been estimated at 20–30% of the total staple maize harvested (Yusuf and He, 2011), valued at approximately US\$4 billion annually (FAO, 2011). The high postharvest losses are associated with poor maize postharvest practices, informal marketing systems, and unfavourable physical and environmental factors. Other factors include pests and fungal attacks (Hell and Mutegi, 2011; Tefera, 2011).

With a lack of proper effective and affordable storage methods, farmers resort to crude storage methods. Maize stored using such methods experience substantial pest damage, and rodent attack (Kadjo et al., 2016). Maize is also susceptible to fungal infestation, especially of the *Aspergillus* and *Fusarium* species. This is common from the period of its growth to harvest, transport, and storage, which exposes it to mycotoxin contamination associated with these fungal species, especially aflatoxins and fumonisins (Shephard, 2008). Mycotoxin contamination in maize has been enhanced by climatic conditions, and postharvest handling practices, which provide a conducive environment for fungal growth and subsequent production of mycotoxins, as well as insect infestation (Kumar, 2008). Mycotoxin contamination is associated with huge losses to the farmers and to human health (Wagacha & Muthomi, 2008; Darwish, 2014).

METHODOLOGY

The baseline survey was conducted to establish how the target farmers carry out postharvest practices such as processing of grains after harvesting, storage and control of pests and aflatoxins to reduce post-harvest losses. A mixture of techniques including administering questionnaires to household heads, focused group discussions and key informant interviews were used. A disproportionate stratified random sampling was used as illustrated by Chung *et al.*, 2016. This is a sampling method in which the size of the sample drawn from a particular stratum is not proportional to the relative size of that stratum (Chung *et al.*, 2016). The strata were counties and sub-counties. Thus, data from Makueni County was taken from Kibwezi which has so far registered most aflatoxin incidences in Kenya (Kyatha, 2014). From Kitui County, Mutomo sub-county was sampled while in Tharaka-Nithi County, Tharaka North sub-County was considered. In Machakos County, data was taken from Yatta sub-County. Data collected was analysed using SPSS computer software and presented using descriptive statistics.

SECTION ONE: FARMERS BACKGROUND INFORMATION

Number of respondents was 319 drawn from five counties in South Eastern region of Kenya as shown in Table 1.1.

Table 1.1
Number of respondents from different counties

County	No of respondents	Percentage
Kitui	49	15.4
Kibwezi	89	27.9
Tharaka nithi	84	26.3
Machakos	97	30.4
Total	319	100

Across all the four counties, majority of the respondents were women (79%) while men were only 21%. Majority of the respondents were middle aged at 51%, followed by the old aged at 28%, and the youth were the least at 21%.

Education level

Education level was contextualized as the highest level of formal education attained by a respondent and was classified. The highest number of respondents (45.7%) had attained upper primary education, followed by secondary education level at 23.4%, no formal education was at 13.6%, lower primary was 10.8% and tertiary education at 4.7% respectively.

Number of members in the households

Majority of the households (52.3%) were of average size with between 6–10 members. This was followed by small size families with less than five members at 45%. Only 2.2% of the respondents had large families with more than 11 members, Table 1.2.

Table 1.2
Number of members per household

Family size	Number of respondents	Percent
< 5	145	45.5
6–10	162	52.3
> 10	12	2.2
Total	319	100

Size of land

Land size per member was recorded where majority of the respondents (70.5%) were small scale farmers with less than five acres of land. This was followed by farmers with 6 to 15 acres at 23.5%. Only 6.0% of the respondents had more than 15 acres of land, Table 1.3.

Table 1.3
Size of land

Size of land in acres	Number of respondents	Percentage
< 5	225	70.5
6–15	75	23.5
> 15	19	6.0
Total	319	100

SECTION 2: MAIZE PRODUCTION BY GROWERS

The baseline survey revealed that the farm yields are relatively low as only 5% (320) of farmers in all the four counties produced more than 50 bags of maize per acreage while the majority over 85% produced less than 10 bags. About 70% reported maize yields ranging between 0–5 bags per acre.

Maize productions per acre

Farmers reported that unpredictable weather patterns such as insufficient rainfall or too much flooding that washed off crops were some of the climatic challenges they faced that were beyond their intervention. Majority (84%) of all the 320 farmers in the 4 counties recounted that drought posed an enormous challenge to production of maize. Pest infestation especially Fall Army Worm, Maize stock borer and Weevils were reported as a draw back to their agricultural production. Poor quality of chemicals and fertilizers, expensive farm inputs, lack of market for the produce, compounded by unfavourable prices by the buyers/brokers further aggravated their farming efforts. Farmers lacked appropriate and adequate storage for the farm produce which they would use to wait for the produce to appreciate for better prices. Approximately 22% and 19% of the farmers explained that expensive farm inputs and lack of capital was a setback respectively.

Farmer use various coping strategies which include: taking their produce to the market place to bypass brokers, sourcing for buyers outside the counties mainly from the big cities, formation of farmers' group who assist in collecting, storing and selling of the farm produce and boosting their income in support of acquisition of farm inputs. Some farmers use chemicals to control pests and diseases while others resolved to use bulls in place of heavy machinery for farming.

Approximately 76% (237) of the farmers sampled reported that they planted maize as an intercrop (Fig. 2.2) and cited the benefits of intercropping as maximization on the land use, ensuring a soil cover and as a cushion crop during extreme weather. However, intercropping had some demerits such as difficulties in controlling pests and weeds, reduced yield due to competition, inconsistent harvesting periods due to differing maturity levels of the crops. Maize was mainly intercropped with beans, green

grams, cow peas and dolichos. Green gram was intercropped either with pigeon peas or sorghum or millet.

Maize production systems

Slightly more than half of the farmers 50.5% (161) sourced their seed maize from seed companies. More than half, 57% (181) of the other respondents reported that they saved their own seeds for planting. Majority of the farmers 85% (272) sourced hired labour for their maize production while approximately a third (28%) used family members as their source of labour.

Farmers reported that they would identify maize ready for harvesting when the stalks and leaves dried out or when leaves color turned from green to brown. They would use hands to 'kupepeta' that is, to feel the 'dry' sound of the maize grain. This would be followed by biting the maize seed to confirm if hard and powdery. Some farmers also explained that the extension officers trained them to determine whether maize is dry enough by placing dry salt and maize kernels in a tightly sealed jar. The maize kernels would be considered dry if the salt does not adhere to the sides of the jar after shaking and rolling it gently for 2–3 minutes. Or Farmers had also been trained to place maize kernels in dry water glass and shake where the sound of maize kernels while being shaken will differ according to amount of moisture content in the grains.

MAIZE POST-HARVEST

Farmers' data collection instrument had various items which sought information on farmers' post-harvest practices in Makueni, Machakos, Kitui and Tharaka-Nithi Counties in Lower Eastern Kenya. Analysis of farmers' responses showed that those harvesting the new season's maize when they had the previous harvest in the stores were 25.1%. However, 32.9% of the farmers indicated that they did not have maize in store at the time of harvesting the new crop. This information was confirmed by the observation that 39.5% indicated that they sold their maize while in the farm before harvesting and 32.3% of the farmers confirmed that they did not have maize in the stores when prices were at the peak.

Farmers used various methods of preparing maize before storage. Majority of the farmers (85.9%) indicated that they dried maize before storage with a high number of the farmers (67.7%) drying the maize in the sun. Regarding the period of drying maize for storage, 80.8% of the farmers dried maize for over 6 days. Only 19.1% dried it for less than 6 days. This shows that the drying of maize in the sun is the most popular form of drying. It was noted that a large number of farmers (81.8%) shelled maize before preparing it for storage. Various forms of tests were conducted by farmers to ascertain whether maize was fully dry. The most commonly used tests included biting (22.3%), use of hands (29.2%) and ease of shelling (16.6%). Other preparation activities carried out by farmers before storage included selection (35.1%), sorting (36.7%) and dusting (34.5%). However, it was noted that most farmers in this region did not store a large quantity of maize because the maize yield was low. In addition, majority of farmers sold

the maize in the farm or after a short period after harvesting. Notably, 32.3% of the farmers indicated that they harvested less than 10 bags of maize, 2.8% harvested 11–30 bags while 1.9% harvested above 30 bags.

Once farmers ascertained that maize was dry and ready for storage, farmers used various ways of storing maize with 21.9% using ordinary gunny bags, 31.7% used improved gunny bags and 53.3% used floor bans when storing maize. After placing maize in bags, the maize was then placed in the kitchen or bedroom as most farmers did not have granaries. The few who had granaries had structures that were substandard; some with no roof, others without rodent proof and some without proper ventilation. These methods of storing maize resulted in reduction of maize as confirmed by 47.0% of the farmers. The major challenges facing maize storage included pests as identified by 57.4% of the farmers.

Awareness of aflatoxin poison in maize by farmers

Table 2.1 shows that majority (66.8%) of the respondents were aware of maize Aflatoxin poison while 33.2% were not aware of the poison. Further, 93.7% of respondents were not aware of any maize varieties resistant to Aflatoxin poison while 5.6% reported to have had some awareness. Probed further on where the resistant maize varieties were being grown the respondents could not confidently give the information. A high number of respondents (67%) had been sensitized and trained on Aflatoxin poisoning while 33% had no access to training and information on aflatoxin. Various agents disseminated the information on Aflatoxin poison to farmers.

Table 2.1
Awareness of Aflatoxin poison in maize by farmers

Practice	Number of respondents	Percentage
Awareness of aflatoxin poison in maize by farmers		
Yes	213	66.8
No	106	33.2
Awareness of maize varieties susceptible to Aflatoxin poison		
Yes	18	5.6
Don't know	301	94.4
Last time farmers sensitized on Aflatoxin poison in maize		
Never	105	33
1-2years	152	47.6
2.1-3	23	7.2
< 3 years ago	39	12.2
Agents that sensitized farmers on Aflatoxin poison		
Local Administration	137	42.9
Brochures and pamphlet	21	6.6
Radio	77	24.1
Churches and Schools	65	20.3
Extension	166	51.9
Others (internet, tv, friends)	33	10.3

SECTION 3: TRADERS BACKGROUND INFORMATION

Data was collected from 20 maize traders. Maize traders were drawn from the five sub-Counties where farmers were also sampled. There was equal number of respondents for each gender. Majority (75%) of traders interviewed were aged between 36 to 60 years, 15% were youth below 35 years, while 10% were over 61 years of age.

Source of grains

Most of the traders (55%) source maize grains from local sources within their counties especially from County headquarters. Some traders, 45% source the maize grains from outside their home counties

exclusively during seasons of maize grain scarcity. During those periods, maize grain prices are normally exorbitant in the home counties and traders source the grains from a far. However, there is always a tradeoff due to high transport charges and weather conditions especially if the maize is sourced from wetter regions of the country.

Maize Grain Handling Practices by Traders

Table 3.1 indicates that between the period of selling and re-stocking, maize traders hold less than five bags of maize at any given time. Majority of the traders (60%) hold maize stocks for 11 to 30 days, while 30% keep the stocks for less than 10 days. Only 10% of the traders store maize for more than 30 days. Half of the traders reported that the maize stocks lasted for longer than expected. Majority of the traders (70%) reported that they did not treat the maize before storage while only 30% treated the maize before storing. Majority of the traders (55%) indicated that they stored the grains on the floor, while 45% indicated that they used raised platforms. Half of the traders (50%) reported separating the new and old stocks of maize to ensure the old stocks were sold first while the other half (50%) observed that they sold the stocks as one lot.

Table 3.1
Maize Grain Handling Practices by Traders

Practice	Number of respondents	Percentage
Quantity of maize grains stocked		
1 bag	8	40.0
2 bags	4	20.0
3 bags	6	30.0
4 bags	2	10.0
Duration of stocking maize grains		
< 10 days	6.0	30
11–30 days	12.0	60
> 30 days	2	10
Maize grain stocks lasting longer than expected		
Yes	10	50.0
No	10	50.0
Drying of maize after storing for a period		
Do not dry maize	14	70
Dry maize	6	30
How traders stored maize grains		
On raised floors		45
Directly on the floor		55
Separated new and old stock		
Yes	160	50
No	159	50
Treats maize grains before storage		
Yes	7	30
No	14	70

Ability to identify aflatoxin contaminated maize

Majority of the respondents (74%) reported that they were able to identify aflatoxin contamination while 26% said they may not. On finding aflatoxin, 70% of the traders disposed maize by throwing it away, 13% gave aflatoxin infected maize to animals, another 12% sold it while 5 percent of the traders submitted samples of the maize to government officials for further identification and way forward. Majority of the traders (65%) reported that they had been sensitized on the adverse effects of consuming aflatoxin infected maize. Most of the traders (77%) reported that health officials were their main source of information on Aflatoxin while those informed by Agricultural Extension Officers were 8% and sensitization from other sources such as radio and television were 15%. Only 10% of the respondents reported that they had not heard about maize poisoning while a great majority of the traders (90%) had heard about it.

DISCUSSION

Post-harvest handling practices are a series of interconnected activities from the time of harvest to the delivery of food commodity to the consumers (Abass et al., 2014). After harvesting, maize grains have to undergo several procedures such as harvesting, drying, threshing, sorting, dusting with insecticides, packaging or bagging, storage, transportation, and distribution before reaching the final consumer. Farmers in the study area, to some extent carried out some of the practices although not to the recommended levels. According to World Bank et al., (2011), the major physiological, physical and environmental causes of post-harvest losses in maize are mechanical damage of grains, excessive exposure to high relative humidity and rain; contamination by spoilage fungal pathogens; rodents and insects attacks. The methods of storing grain probably contributed highly to the loss registered by farmers. Grain was placed in jute or sisal gunny bags and stored in houses (bedrooms, living rooms and kitchens) and in poorly constructed granaries. These types of storage were also observed by Hell et al., (2000) in West Africa. In the study area, farmers justified the storage method by citing lack of resources to construct modern granaries and theft of grains. This problem can be mitigated through efforts such as sensitizing the maize growers and traders on effects of poor storage.

Other researchers have observed that post-harvest losses are aggravated by climatic variability (Hodges, 2012, Stathers et al., 2013). In Swaziland, it was observed that harvesting and drying-losses of 16.3% occurred when maize was harvested under damp conditions compared with 6–10% when maize was harvested during more favorable dry conditions in other locations (Hodges, 2012). This observation corroborated with information given by farmers that higher postharvest losses were realized during seasons of heavy rainfall.

Identifying best practices and innovative arrangements for increasing agricultural productivity to improve income and nutrition of farm households is a priority of most African countries. For this reason, improving post-harvest management systems is a priority for farmers and policy-makers (Rugumamu et al., 1997). New technologies and improved post-harvest management knowledge are required by the farmers. This study has identified good practices used by farmers in Lower Eastern Kenya that need to be documented and replicated in other areas. The extent and causes of post-harvest losses of

smallholder farmers need to be established. Additionally, appropriate interventions must be identified for each farming system. Therefore, the specific post-harvest characterization of each farming system would be required (Abass et al., 2014). This study identified causes of postharvest losses and has established good practices used by farmers in Lower Eastern Kenya that need to be documented and replicated in other areas. Some of the interventions that were identified include harvesting at appropriate stage, proper drying of grains, cleaning and dusting the granaries, treating the grains prior to storage and use of improved gunny bags.

CONCLUSION

Postharvest handling practices among the maize growers and traders in Kitui, Makueni, Machakos and Tharaka-Nithi counties may impact negatively on quality of maize grains especially in terms of safety. Although many farmers are aware of Aflatoxin poison in maize, some are not keen on proper postharvest handling practices so as to avoid the poison. It is important that all maize growers and traders be continuously sensitized and educated on the health effects of proper postharvest handling of maize grains to prevent continued consumer exposure to the toxins. Transporters of the grains to the market should also be included in the sensitization activities. In addition, the study area County Governments should channel resources towards buying driers and moisture meters for each ward to ensure proper drying of maize after harvesting and prior to storage. Farmers and traders need also to be facilitated to acquire improved bags which do not allow in insects and suffocates any insect in the grains.

Declarations

Consent by Participants

All participating farmers were informed about the purpose and procedures of the study, as well as their right to decline or withdraw at any time without penalty. Participation was entirely voluntary, and verbal informed consent was obtained prior to data collection. Participants were assured of confidentiality and anonymity, and all data were used solely for research purposes.

ACKNOWLEDGEMENT

The research team comprising of members from Karatina University, Chuka University, South Eastern Kenya University and Kenya Agricultural and Livestock Research Organization (KALRO), acknowledge the financial support from the National Research Fund (NRF). We also thank the County authorities and Agricultural Extension Officers in Kitui, Makueni, Machakos and Tharaka-Nithi, and all those who assisted in data collection.

References

1. Abass A, Ndunguru G, Mamiro P, Alenkhe B, Mlingi N, Bekunda M (2014) Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania, *Journal of Stored Products Research*, Volume 57, April 2014, Pages 49–57
2. Auffhammer M (2011) Weather dilemma for African maize. *Nat Clim Change* 1(1):27–28
3. Darwish W, Ikenaka Y, Nakayama M, and Ishizuka M (2014) An overview on mycotoxin contamination of foods in Africa. *J Vet Med Sci* 76(6):789–797
4. De Groote H, Hall M, Spielman D (2011) Options for pro-poor maize seed market segmentation in Kenya. *Afr J Biotechnol* 10:23
5. FAO (2010) Reducing Post-harvest Losses in Grain Supply Chains in Africa: Lessons Learned and Practical Guidelines. FAO/World Bank, Rome, Italy
6. FAO (2011) *FAO Statistical Databases (FAOSTAT)*, Food and agriculture organization (FAO), Rome, Italy
7. Hassan R, Mekuria M, Mwangi W W (2001) Maize breeding research in Eastern and Southern Africa: current status and impact of past investments made by the public and private Sectors 1966–97. Tech. Rep., CIMMYT
8. Hell K, Cardwell K, Setamou M, Peohling H (2000) The influence of storage practices on aflatoxin contamination in maize in four agro-ecological zones of Benin, West Africa
9. *Stored Prod J* (2000) Res 36:365–382
10. Hell K, Mutegi C C (2011) Aflatoxin control and prevention strategies in key crops of Sub-Saharan Africa. *Afr J Microbiol Res* 5(5):459–466
11. Hodges RJ (2013) Post-harvest Weight Losses of Cereal Grains in Sub-Saharan Africa (2012) Available from: <http://www.erails.net/FARA/aphlis/aphlis/weight-losses-review/>
12. IITA *International Institute of Tropical Agriculture (IITA)* (2009) - Maize (*Zea mays*) Crop, IITA, Ibadan, Nigeria
13. Kadjo D, Ricker-Gilbert J, Alexander C (2016) Estimating price discounts for low-quality maize in sub-Saharan Africa: evidence from Benin. *World Dev* 77:115–128
14. Kumar V, Basu M, Rajendran T (2008) Mycotoxin research and mycoflora in some commercially important agricultural commodities. *Crop Prot* 27(6):891–905
15. Lathiya S, Ahmed S, Pervez A, and, Rizvi S (2008) Food habits of rodents in grain godowns of Karachi, Pakistan. *J Stored Prod Res* 44(1):41–46
16. Nukenine E (2010) Stored product protection in Africa: past, present and future, *Julius-Kühn-Archiv*, vol. 425, p. 26
17. Pingali P (2001) CIMMYT 1999/2000 world maize facts and trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. CIMMYT, Mexico City, Mexico
18. Ransom J, Palmer A, Zambezi B (1996) Maize productivity gains through research and technology dissemination, in *Proceedings of the Eastern and Southern Africa Regional Maize Conference*, vol. 5, Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Arusha, Tanzania, June 1996

19. Rugumamu CP, Sekwao C, Busyanya G (1997) Assessment of Gendered Household Crop Storage Technologies in Rural Tanzania GMC/SAREC. University of Dar es Salaam, Dar es Salaam, Tanzania
20. Stathers T, Lamboll R, Mvumi B (2013) Post-harvest agriculture in changing climates: its importance to African smallholder farmers Food Security, 5 (2013), pp. 361–392
21. Shephard GS (2008) Impact of mycotoxins on human health in developing countries. Food Addit Contaminants: Part A 25(2):146–151
22. Tefera T, Mugo S, Likhayo P (2011) Effects of insect population density and storage time on grain damage and weight loss in maize due to the maize weevil *Sitophilus zeamais* and the larger grain borer *Prostephanus truncatus*. Afr J Agric Res 6(10):2249–2254
23. Wagacha JM, Muthomi JW (2008) Mycotoxin problem in Africa: current status, implications to food safety and health and possible management strategies. Int J Food Microbiol 124(1):1–12
24. World Bank, FAO, NRI (2011) Missing Food: the Case of Post-harvest Grain Losses in Sub-Saharan Africa Economic Sector Work Report No. 60371-AFR. World Bank, Washington, DC
25. Yusuf B, He Y (2011) Design, development and techniques for controlling grains post-harvest losses with metal silo for small and medium scale farmers. Afr J Biotechnol 10(65):14552–14561