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Full Length Research Paper

Assessment of postharvest handling practices among smallholder maize farmers in Chemba and Kondoa Districts of Central Tanzania

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Post-harvest losses (PHLs) are recognized as an important challenge that exacerbates food insecurity in sub-Saharan Africa. The objective of this study was to assess postharvest handling practices among smallholder farmers of maize in Chemba and Kondoa districts, Dodoma Region, Tanzania. Data were collected using questionnaires and observation checklists through a cross-sectional field survey during the 20/21 cropping season. 120 smallholder farmers were randomly selected for the study. Results show majority (75%) of smallholder farmers use traditional post-harvest handling practices such as harvesting maize and placing on the ground, drying (on the ground) and storing in polyethylene bags. Moreover, very few farmers (25%) have the awareness that improper handling practices causes postharvest losses. The findings revealed that the use of traditional postharvest practices is not influenced by age at $\chi2 = 6.268$, $P = 0.989$ and level of education at $\chi2 = 1.599$, $P = 1.000$. It was concluded that inadequate knowledge of proper postharvest practices in the study area may affect the quality of maize grains. Improving postharvest management practices such as uses of technologies (moisture meters, portable dryers and hermetic storages devices) could help to reduce PHLs of maize and hence contribute to reducing poverty and food insecurity in the country.

Key words: Postharvest losses, maize, smallholder farmers, postharvest handling practices, Tanzania.

INTRODUCTION

Proper post-harvest handling practices are important in maintaining grain quality and safety while being brought to consumers and for trade. However, lack of knowledge among the smallholder farmers and other factors along the value chains remains a major challenge to reduce postharvest loss and maize grain contamination by aflatoxins in Sub-Saharan African (SSA) (Kachapulula et al., 2017). Weather conditions and poor postharvest management practices have been reported as the major factors of fungi infestation and subsequent production of aflatoxins in crops (Suleiman et al., 2017). Moreover, different measures like good agriculture practices (GAPs) such as timely planting and harvesting, the use of resistant crop varieties, good storage (at controlled

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humidity and temperatures) combined with good manufacturing practices (GMPs) (sorting and grading) were reported to be of help to combat the problem of PHLs and mycotoxins contamination in grains (Massomo, 2020). However, the implementations of these measures are not well understood by the majority of smallholder farmers in SSA.

Post-harvest losses (PHLs) remain a persistent challenge in Africa. According to the World Resources Institute, approximately twenty-three percent (23%) of the available food in SSA is lost or wasted (Global knowledge Initiative, 2014). It has been reported by the Food and Agricultural Organization of the United Nations (FAO) that, around 2 million African smallholder farmers would benefits in terms of income and increased food and nutritional security through the reduction of PHLs.

Maize (*Zea mays*) is a major food staple in Tanzania, and its production is dominated by small-scale farmers who constitute about 75% of the total production (URT, 2019). It is widely cultivated all over the country. Maize accounts for 31% of the total food production, constitutes more than 75% of cereal consumption and contributes about 34 to 36% of the total average daily calorie intake in Tanzania (Zorya et al., 2011). In the country, maize is used to prepare varieties of meals including '*Ugali', 'Makande'*, porridge and traditional alcohol. The importance of maize in Tanzania suggests that serious efforts must be made to reduce crop losses at all levels, especially in the post-harvest part (Suleiman and Rosentrater, 2015).

The problem of food shortage in developing countries could be overcome through the use of a variety of modern agricultural technologies (URT, 2012). Experience shows that the Tanzanian government's efforts to improve the agriculture sector have resulted in increased food crop production including maize. Despite increased maize production, periodic food shortages have been experienced, one of the reasons being PHLs of cereal such as maize (Twilumba et al., 2020). In Tanzania, PHL remains a serious and persistent challenge; the current level of PHL of maize is 20 to 40% in some rural areas which have a significant impact on food security and the economy of the smallholder farmers (Maziku, 2019).

Improving postharvest management practices could help mitigate losses along the maize value chain and contribute to poverty reduction and food insecurity in the country. Farmers must have to access and understanding of good postharvest practices in order to ensure food availability throughout the year. The good postharvest practices include proper harvesting/drying practices, good transport infrastructure and the use of improved storage technologies, such as hermetic storage bags and metal bin/silo. This could help to decrease the problem of PHLs in Africa (Twilumba *et al.,* 2020). The study's findings will help smallholder farmers reduce PHLs as a result increased food security. Furthermore, data would guide the selection of better intervention steps in order to ensure public safety.

MATERIALS AND METHODS

Study area

The study was conducted in Kondoa and Chemba districts in Dodoma region, Tanzania (Figure 1). The area is mostly semi-arid due to low and erratic rainfall. Kondoa District lies between latitude 4° 12` to 5° 38` South and longitude 35° 6` to 36° 2` East. Chemba District lies between 5° 14` to 36° 00` South and longitude 35° 53 to 24° 00 East. Its climate is wet savannah characterized by a long dry season (DEPRP, 2012). The districts were purposively selected due to multiple threats affecting the districts including drought, deforestation, soil degradation and hunger, imposing a pattern of risk evasion in traditional agriculture (URT, 2017).

Research design, sampling procedure and sample size

This study adopted cross-sectional research design and a multi-stage sampling technique as suggested by Etikan and Bala (2017). First, the district was purposively selected based on the reasons stated above. Secondly, simple random sampling was employed to select study villages. Thirdly, one hundred and twenty (120) respondents were randomly selected from smallholder maize farmers.

Data collection procedure and instrumentation

Data were collected in face-to-face interviews with respondents by using a semi-structured questionnaire, which were all pre-tested for improvement before actual data collection. The statement-wise analysis was carried out to determine the most post-harvest practice applied by respondents; nineteen statements were used to measure the respondents' understanding of post-harvesting practices as shown in INPhO-Post-harvest Compendium (Mejia, 2013). For each statement, the respondents were required to indicate their position concerning their level of understanding of the content contained in the statement by writing one (1) for poor practice, two (2) for moderate practice and three (3) for high practice. If one practice was marked poor for each of the 19 statements, it was scored 19 (i.e. 1 × 19); if one practice was selected moderate for each of the 19 statements, it was scored 38 (i.e. 2 ×19); and if one practice was selected high for each of 19 statements, it was scored 57 (that is, 3 ×19). Scores were combined to give a score range of 19 to 57.

A score above 19 was considered as highly experienced practice, a score of 19 represented moderately experienced practice and a score below 19 indicated poorly experienced practice. The mean score of each practice was obtained by adding the weights given to the standard by a respondent divided by the total number of respondents. The mean score was worked out for each practice and rank positions were assigned based on the mean score obtained after calculation.

Data analysis

The collected quantitative data were coded, entered in Statistical Package for Social Sciences (SPSS), edited and analyzed using the SPSS version 20 Computer software. Descriptive statistics for different measures were performed to compute relative variables. The mean, standard deviation of post-harvest handling for each district were computed. Correlation analysis was undertaken to determine which handling practices were found to be common.

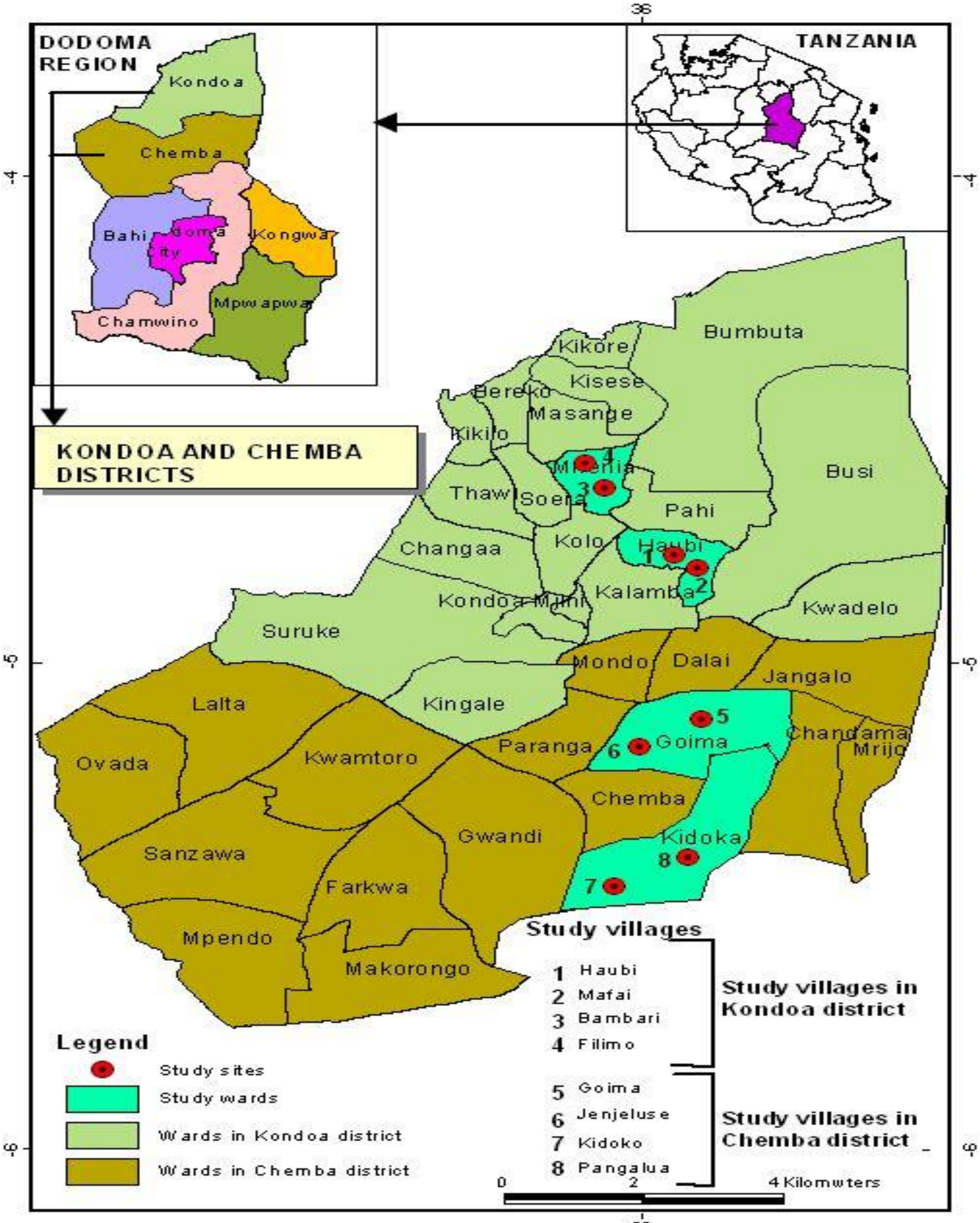

Figure 1. Map showing study sites in Kondoa and Chemba districts.
Source: Author survey (2021).

RESULTS

Demographic characteristics of respondents

The socio-economic and demographic characteristics of the smallholder farmers and their effects on handling of post-harvest maize management technologies were analyzed. Therefore, respondents responding to questions that were related to their gender, age (The actual age of the respondents was recorded during data collection and later categorized into groups), levels of education and land family size. Their responses are

Table 1. Demographic characteristics of respondents (n=120).

Variable	Description	Frequency n =120	Percentage (%)
Sex	Male	65	54.2
	Female	55	45.8
Marital status	Married	115	95.8
	Single	5	4.2
Level of education	No education	7	5.8
	Primary education	109	90.8
	Secondary education	4	3.3
Age in years	15 - 35	23	19.1
	36 - 55	62	51.7
	55 < above	35	29.2
Size of a farm in an acre (acre)	1 - 5	82	69.3
	6 - 10	24	20
	≥11	14	11.7

Source: Author survey (2021).

illustrated in Table 1.

Postharvest handling practices used by respondents

Table 2 shows the different handling practices done by respondents in the study area. The smallholder farmers in Kondoa and Chemba districts do not have a long chain from harvesting to storage. They only harvest, transport, shell/thresh, clean, dry and finally store for consumption or sale purposes; the grains are typically stored in a living room in the house or a brick and mortar storeroom. Some of the farmers produce only for consumption while others produce as food and cash crop.

Post-harvest practices mostly used by respondents

To establish the extent to which the practice was applied by smallholder farmers, a statement-wise analysis was carried out. The mean score was worked out for each practice and rank positions were assigned based on the mean score obtained after calculation (Figure 2).

Furthermore, the majority of small-holder maize farmers used traditional knowledge in maize handling management (Figure 3), implying that poor postharvest handling practices and low awareness levels among maize farmers. That can lead to postharvest losses due to poor handling practices and improper management, posing a threat to human food safety. This necessitates interventions aimed at improving postharvest practices.

DISCUSSION

Demographic characteristics of respondents

As illustrated in Table 1, majority (95.8%) of the respondents were married and most (90%) of them had primary school education. It is also shown that more than two-thirds (69.3%) of the respondents cultivate one to five acres of land. This is a typical characteristic of the smallholder farmers as reported by Mrutu et al. (2014) which indicates a high dependence ratio. In addition, the study observed that about 54.2% of the farmers surveyed in both districts were males. This concurs with the finding of Ssebaggala et al. (2016) that males were the active people in agriculture activities and they give information about post-harvest handling technology. However, this is contrary to other studies that show majority of the people involved in agricultural activities in SSA are females (FAO, 2013).

The socio - demographics data point to high participation of all age people, dominated by males of relatively little education level in postharvest handling practices. Hence, the information is significant for targeting the design post-harvest technologies to the needs of specific users.

Postharvest handling practices used by respondents

The most common harvesting and post-harvest handling methods were laborious and time-consuming. The analysis of data acquired also reveals ineffective

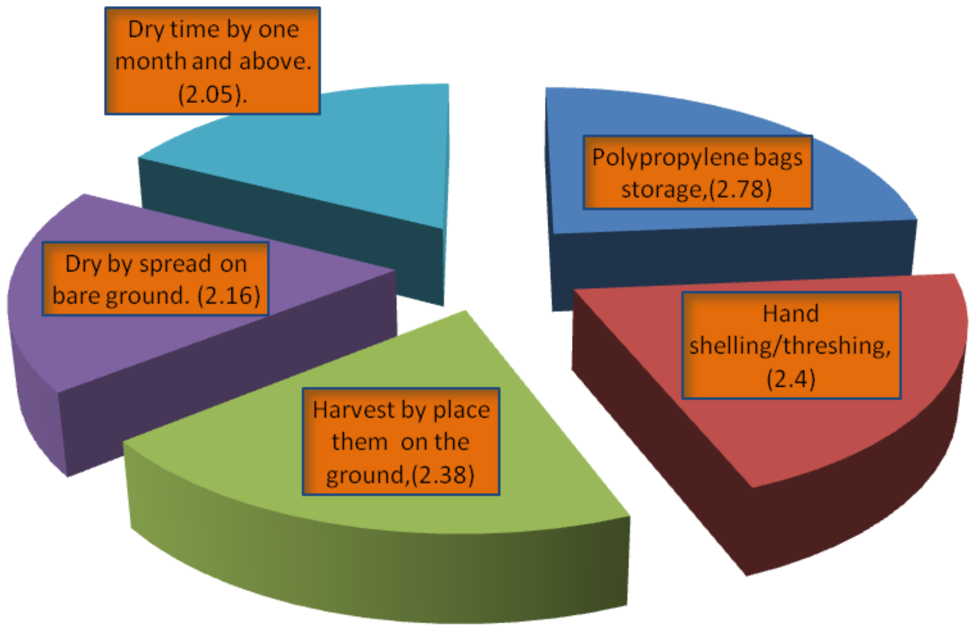

Figure 2. Mean score of post-harvest handling practices done by respondents. Total number respondents = 120, number in brackets are mean score of each handling practice.
Source: Author survey (2021).

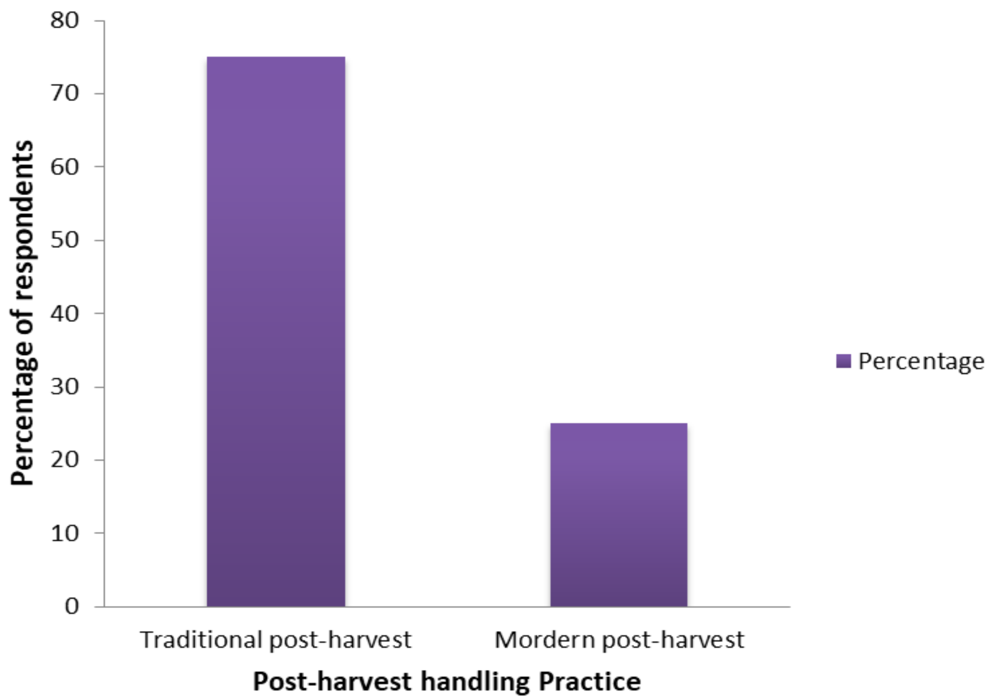

Figure 3. General post-harvest handling practices of small-holder maize farmers.
Source: Author survey (2021).

postharvest procedures that have the potential to degrade food quality. Poor threshing methods, inappropriate storage facilities, improper drying surfaces, placement of crop storage containers directly on the ground during storage, lack of testing for adequate drying, and poor transportation of maize were all discovered to be common. These findings highlight the need for measures that encourage proper postharvest management throughout the maize value chain.

Harvesting

All farmers (100%) harvest maize by hand or manually. Due to the economic situation, most smallholder farmers are unable to engage hired labors or machines for harvesting. This leads to either incomplete harvesting or leaving some maize in the field, hence postharvest losses (Dudi, 2014). The majority of the farmers (85%) keep their maize on the ground after harvest on farm for large farmers and at home for small farmers. This exposes them to pests, soil, and dust that reduce the quality of maize and contributes to postharvest losses. A similar study in Peru reported about 90.1% of farmers laid the harvested crop directly on the ground (Díaz-Valderrama et al., 2020). Likewise in Kenya, Dudi (2014) found over 90% of small scale farmers in Eastern Province kept maize cobs on the ground during harvesting which led to losses of 30-50 percent. Farmers were asked whether they knew how to test for dryness before harvesting; 73% reported using visual assessment while 27% bite them with their teeth. A similar finding was reported in Ghana that, farmers check for maize dryness using their teeth by biting (Akowuah et al., 2015). Also, Mendoza et al. (2017) found that farmers in Guatemala use traditional practices fingernail and mouth tests to check for maize dryness before harvesting. These techniques are not accurate, and therefore, harvested maize may still have high moisture content that attract pests and possible contamination by yeast and molds (Kamala et al., 2016).

Transportation

For fear of theft, crops were not stored in the field after harvest in surveyed districts. As a result, farmers only harvest the amount of maize they can transport in a single day. The primary mode of transportation from the farm was 35.8% carrying by the head, while 30% use animals such as donkeys and cows and 24% of the respondents use bicycles/motorcycles to transport maize from farm to home.

Except for a few farmers who own more than 5 hectares of land leaving their maize in the field after harvesting, about 6% use tractors truck to transport harvested maize. The use of one method over the others depends on several factors, such as the socio-economic status of the farmer, production capacity, distance, infrastructure and availability of animals. These data suggest that a transportation intervention could help reduce harvest losses before or as crops leave the fields. It is necessary to evaluate the impact of actions aimed at reducing transportation limitations on these field losses. The study supports the findings by Dudi (2014) who found that maize was transported using different means that include wheelbarrows (33.3%), head (25%) and pack animals (donkeys and cows) (20%).

Drying

The study found that all respondents (100%) used open sun drying for drying maize. The study further observed that 65% of respondents dry the maize on bare ground and 12.5% dry on tarpaulin/canvas sheet/mat. In addition, the study found other different ways of drying, like drying on galleries made at home and on top of corrugated iron roofs. Drying maize down on the floor exposes the maize grain to soil contamination, domestic animals and bad weather infection, causing both quality and quantity losses as opposed to air-dryers and electric dryers. A similar result was reported by Njoroge et al. (2019) that about 65.4% of farmers dried on the ground while 21.7% used tarpaulin for drying. It was observed that the majority of the respondents (59.2%) dry their maize within 30 days after harvest and about 40% take more than 30 days for drying. The variation was believed to be due to the intensity of the sun. The findings are contrary to what Díaz-Valderrama et al. (2020) reported that 71% of the farmers' drying process may take at least seven days when the weather is favorable. Farmers experience difficulties in drying maize because sometimes they experience unexpected rain while maize is in open space. All farmers mentioned rain as the challenge during the drying period. This causes discoloration to grain as a result of moulds development, hence aflatoxins contamination. A similar study done by Njoroge et al. (2019) found that over half of farmers were challenged by rain during drying their grains.

Threshing/shelling and cleaning

The result indicates majority (63%) of the farmers use hand shelling or manual shelling of maize. This traditional shelling of maize is done by women and children. It is done either by pressing the grain off the cob by hand, rubbing two cobs together holding one in each hand or beating the cobs in a sack with a stick. Threshing losses happened as a result of spillage, inadequate grain removal, or grain damage during the threshing process. These methods are labor-intensive, time-consuming and may result in broken maize that makes it more susceptible to insect and mould attacks, hence increasing PHLs of maize. These findings highlight the need to adapt existing technologies to improve their performance, or to create new devices that can recover grain more efficiently and with less grain damage. A small number of respondents (26%) use motorized threshers and only 9% use hand-operated machines. Different from the findings

Table 2. Responses on the maize handling practices.

Category	Description	Percentage (%)
Harvesting	Manual	100
Harvesting operations	Bare ground	85.0
	Tarpaulin	12.5
	Plastic/synthetic B.	1.0
	Raised platform	2.0
Action on unexpected rain	Cover	60.0
	Not cover	24.0
	Protected area	15.5
Sort/clean before storage	No	51.7
	Yes	48.3
Drying days (days)	Sun drying	100
	1 - 10	27.5
	11 - 30	32.5
	≥30	40.0
Shelling/thresh	Hand shelling	63.3
	Motorized	26.7
	Hand operated machine	9.2
Mode of transportation	Bicycle/ motorcycle	29.0
	Open vehicle	6.0
	By head	35.8
	Animal and wheelbarrow	30.0
Infestation control practice	No	53.3
Use pesticide	Yes	46.0
Storages	Bin/silo	5.0
	Polypropylene bags	88.8
	PICS	5.8
	Kirindo	3.0

Source: Author's field survey (2021).

of this study, Mutungi et al. (2019) reported that more than half of the smallholder farmers in the Northern Highlands of Tanzania use mechanical threshers for shelling.

Storage

Improved storage practices

The findings in Table 2 reveal that only 5.8% of the respondents use PICS bags and about 5% use silos for storage of maize. Smallholder farmers revealed that bin/silos need space and are expensive to purchase. Maize grains stored in the metal silo are hermetically sealed and inaccessible to rodents, efficient against insects, and sealed against entry of water; therefore, metal silos are excellent grain storage containers for grains. However, they should be guarded against direct sunshine and other sources of heat and stored in a shaded and well-ventilated environment to avoid condensation (Adejumo, 2013). It was narrated by Okoedo-Okoije and Onemolease (2019) that the high initial cost of improved storage such as silo limited usage among the smallholder farmers. Similarly, Kassie *et al*. (2013) reported that the poor adoption of improved storage technologies in India was caused by the high initial cost of the improved storage technologies. This implication is further supported by Ndunguru et al. (2016) who reported that most (86%) small-scale farmers in

Figure 4. Homemade gallery for drying and temporary storage “Haubi" village, Kondoa district
Source: Author survey (2021).

Tanzania have limited knowledge on the use of improved storage methods for proper management of maize grain storage.

Traditional storage technology

The findings (Table.2) show over 80% of the respondents use polypropylene/synthetics bags with or without pesticides to store their maize. The disadvantage of using polypropylene sacks (bags) is that they can be easily destroyed by pests and are not airtight thus grains are prone to insects and fungal contamination. This concurs with the finding of Mendoza et al. (2017) who observe over 81% of farmers upon drying prefer to store maize in polypropylene bags. It was also observed that only 3% of the respondents use traditional storage structures (*Kilindo*) for the storage of maize. This type of storage is locally constructed and was found in store rooms or living rooms. Minority of the respondents (3%) from the study area store maize in a homemade gallery (Figure 4). This finding is similar to what was reported by Gitonga et al*.* (2015) and Abass et al. (2014) that most of the African communities still rely on unimproved storage technologies for maize storage. This is because they are simple and inexpensive to construct but cannot guarantee protection against major storage pests and quality product.

Insect control

The researchers noted that nearly half of farmers (46%) use pest controls, whereby the commonly used was chemical pest control (26%) and traditional pest control (20%); while 54% use sun-drying. This could be due to the cost of storage chemicals which was perceived by respondents as relatively high and therefore not affordable for them to buy. However, the effectiveness of traditional insect control methods such as the use of ash, *Shumba* is not known and needs to be evaluated further.
Few smallholder farmers pointed out that storing their maize in their houses thus making it difficult to apply pesticides or fumigate the living rooms for storage of their maize. These findings are contrary to those of ANSAF (2016) which found that a large proportion of farmers (67.7%) in Dodoma and Manyara districts of Tanzania use storage chemicals. Likewise, Koskei et al. (2020) found that (70.7%) use chemical insecticides while 32.5% use ash to insect control infestation.

Post-harvest practices mostly used by respondents

The highest mean score of mostly used handling practices is 2.78 (Figure 2), that means the storage methods mostly used by respondents “*Polypropylene/ synthetic bags as storage practices”.* These results reveal that stored maize is a very important subject for sustainable food security in the production of maize areas. It helps the farmers on how to store food for future use. However, polypropylene bags are not recommended in post-harvesting practices because they are not airtight; hence, they are susceptible to water and are easily accessed by pests and rodents. Moreover, polypropylene bags are considered as spillage and easy inspection. The study findings revealed that smallholder farmers were highly practicing this practice which has a direct negative effect on the quality of the maize produced.

The second-highest ranked practice used was the way of shelling/threshing of maize*, "that was Hand shelling/ threshing"* demand (2.40) manual shelling (beating maize in bags). The process is done to loosen the edible part of grain from the straw to which is attached after drying to facilitate easy storage of grain. The practice is not recommended because losses were in terms of broken grains. This is followed by "*Harvesting maize and placing on the ground"* (2.38) which ranked third. This practice was highly practiced because the majority of smallholder farmers use local equipment or traditional way in harvesting their maize. The practice is unhygienic because it exposes the maize grain to soil contamination and bad weather infection causing both quality and quantity losses; although it is also considered to be slow and time-consuming.

Other practice methods were drying maize "*by spread on the ground*" (2.16), which ranked fourth and "Time used to dry maize more than one month" (2.05) ranked fifth .These practices were highly implemented because majority of smallholder farmers are still using traditional post-harvesting handling practices. Additionally, the findings show that 75% of the respondents had used traditional practice on maize post-harvesting processes and only 25% used modern practice (Figure 3). These results imply that about half of the respondents in the study area practice traditional post-harvesting. Traditional technologies are poor in maintaining the quality and quantity of stored maize but most of the smallholder farmers argue that these traditional practices are easy, inexpensive and it is not safe compared to new post-harvest practices technology. This affects the quality of maize as poor postharvest practices expose the maize grains to contamination that might have health effects on human. Maize is a staple crop for many farmers in the country. There is a need to improve and promote postharvest handling procedures, including the use of modern technology like moisture meters, portable dryers, and hermetic storage devices. Therefore, it is necessary to awake farmers about appropriate post-harvesting techniques to reduce the amount of post-harvest losses in maize production and thus contribute to food security and poverty reduction.

Conclusion

Postharvest loss is a complicated issue and its scale varies with different crops, handling practices, climatic conditions, and countries' economy. Many of the harvested maize grains are held in traditional storage structures, which are insufficient in preventing insect infestation and mold growth during storage, resulting in significant losses. Generally, the respondents' postharvest behaviors were linked to postharvest losses, indicating that they lack awareness of optimal postharvest techniques. However, few of the farmers were aware of improved post- harvest technologies, but cannot afford to buy as it is sold at a high price, since their income is very low. Storage losses account for the bulk of all postharvest losses for maize grains in the study area, hence have a negative influence on farmers' livelihoods. Reduced postharvest losses and increased farmer revenues can be aided by technological interventions and improved storage structures.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Abass A, Ndunguru G, Mamiro P, Alenkhe B, Mlingi N, Bekunda M (2014). Post-harvest food losses in a maize - based farming system, semi-arid savannah area of Tanzania. Journal of Stored Products Research 57(1):49-57.

Adejumo O, Atanda O, Raiola A, Somorin Y, Bandyopadhyay R, Ritieni A (2013). Correlation between aflatoxin M1 content of breast milk, dietary exposure to aflatoxin B1 and socioeconomic status of lactating mothers in Ogun State, Nigeria. Food and Chemical Toxicology 56:171-177.

Akowuah JO, Mensah LD, Chan C, Roskilly A(2015). Effects of practices of maize farmers and traders in Ghana on contamination of maize by aflatoxins: A case study of Ejura-Sekyeredumase Municipality. African Journal of Microbiology Research 9(25):1658-1666.

Agriculture Non-state Actor Forum (ANSAF) (2016). A study on farmers' access to postharvest technologies in Tanzania. Available at http://ansaf.or.tz/post-harvest-management/.

DEPRP (2012). Kondoa District Emergency preparedness and response plan Report: Prime Minister's Office report. Available at https://ijisrt.com/wp-content/uploads/2019/ 04/IJISRT19MA167.pdf.

Díaz-Valderrama JR, Njoroge AW, Macedo-Valdivia D, Orihuela-Ordóñez N, Smith BW, Casa-Coila V, Baributsa D(2020). Postharvest practices, challenges and opportunities for grain producers in Arequipa. Peru. Plos One 15(11):1-18.

Dudi JA (2014). Assessment of post-harvest grain management operations and their effects on food security of smallholder households in Kisumu County, Kenya. Thesis for Award of PhD Degree at University of Nairobi, Kenya P 109.

Etikan I, Bala K (2017). Sampling and sampling methods. Biometrics and Biostatistics International Journal 5(6):1-4.

FAO(2013). Missing Food: The Case of Postharvest Grain Losses in Sub-Saharan Africa. Food Agriculture Organization, Rome P 11.

Global Knowledge Initiative (2014). Dairy Value Chain Collaboration Colloquium: After-Action Report. Global Knowledge Initiative, Kampala, Uganda P 47.

Gitonga Z, De Groote H, Tefera T (2015). Metal silo grain storage technology and household food security in Kenya. Journal of Development and Agricultural Economics 7(1):22-23.

Kachapulula PW, Akello J, Bandyopadhyay R, Cotty PJ (2017). Aflatoxin contamination of groundnut and maize in Zambia: Observed and potential concentrations. Journal of Applied Microbiology 122(6):1471-1482.

Kamala A, Kimanya M, Haesaert G, Tiisekwa B, Madege R, Degraeve S, De Meulenaer B(2016). Local post-harvest practices associated with aflatoxin and fumonisin contamination of maize in three agro ecological zones of Tanzania. Food Additives and Contaminants 33(3):551-559.

Kassie M, Jaleta M, Shiferaw B, Mmbando F, Mekuria M (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. Technological Forecasting and Social Change 80(3):525-540.

Koskei P, Bii CC, Musotsi P, Muturi Karanja S (2020). Postharvest storage practices of maize in rift valley and lower eastern regions of Kenya: a cross-sectional study. International Journal of Microbiology 2020:1-10.

Massomo SM (2020). Aspergillus flavus and aflatoxin contamination in the maize value chain and what needs to be done in Tanzania. Scientific African 10:1-17.

Maziku P(2019). Determinants for post-harvest losses in maize production for small holder farmers in Tanzania. African Journal of Applied Research 5(1):1-11

Mejia D (2013). Maize. Post-Harvest Operations. Inpho-Post-Harvest Compendium. Food and Agriculture Organization of the United Nations, Rome, Italy P 100.

Mendoza JR, Sabillón L, Martinez W, Campabadal C, Hallen-Adams HE, Bianchini A(2017). Traditional maize post-harvest management practices amongst smallholder farmers in Guatemala. Journal of Stored Products Research 71:14-21.

Mrutu BA, Tileye F, Ndunguru J (2014). Assessment of genetic diversity of maize inbred lines and hybrids in the Southern Highlands of Tanzania by using random amplified polymorphism markers. American Journal of Research Communication 2(4):84-98.

Mutungi C, Muthoni F, Bekunda M, Gaspar A, Kabula E, Abass A (2019). Physical quality of maize grain harvested and stored by smallholder farmers in the Northern highlands of Tanzania: Effects of harvesting and pre-storage handling practices in two marginally contrasting agro-locations. Journal of Stored Products Research 84:101517.

Ndunguru A, Letaa E, Katungi EC, Kabungo C (2016). Impact of improved common bean varieties on household food security on adopters in Tanzania. African Crop Science Journal 23(3):261-277.

Njoroge A W, Baoua I, Baributsa D (2019). Postharvest management practices of grains in the Eastern region of Kenya. Journal of Agricultural Science 11(3).

Okoedo-Okoije DU, Onemolease EA (2009). Factors affecting the adoption of yam storage technologies in the Northern Ecological Zone of Edo State, Nigeria. Journal of Human Ecology 27(2):155-160.

Suleiman RA, Kurt RA (2015). Current Maize Production, Postharvest Losses And The Risk of Mycotoxins Contamination in Tanzania. In: Annual International Meeting. American Society of Agricultural and Biological Engineers, Michigan, USA P 127.

Suleiman RA, Rosentrate KA, Chove B (2017). Understanding postharvest practices, knowledge, and actual mycotoxin levels in maize in three agroecological zones in Tanzania. Journal of Stored Products and Postharvest Research 8(7):7-84.

Ssebaggala GL, Kibwika P, Kyazze B (2016). Farmers' Perceptions and Their Implications on the Use of Rice Postharvest Handling Technologies and Practices in Eastern Uganda. Working Paper No. 9245. RUFORUM, Kampala, Uganda P 9.

Twilumba JK, Ahmad AK, Shausi GL. (2020). Factors influencing use of improved postharvest storage technologies among small scale maize farmers: A Case of Kilolo district, Tanzania .Tanzania Journal of Agricultural Sciences 19(1):11-21.

URT (2012). National Strategic for Growth and Reduction of Poverty II. Ministry of Finance and Economic Affairs, Dar es Salaam, Tanzania P 217.

URT (2017). Budget Speech 2017/2018. Ministry of Agriculture Livestock and Fisheries, Dar es Salaam, Tanzania P 75.

URT (2019). National Sample Census of Agriculture 2019/20. Ministry of Agriculture. Dar es Salaam, Tanzania P 45.

Zorya S, Morgan N, Diaz –Rios L, Hodges R, Bennett B, Stathers T, Lamb J (2011). Missing Food, the Case of Postharvest Grain Losses in Sub-Saharan Africa. Report No. 60371. The World Bank, Washington DC. pp10. https://www.nbs.go.tz/index.php/en/tanzania-in-figures/641-tanzania-in-figures-2020