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FOCUSED STUDY: MANAGEMENT OF AFLATOXINS IN MAIZE AND GROUNDNUT CROPS AMONG RURAL HOUSEHOLDS IN ZAMBIA

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MANAGEMENT OF AFLATOXINS IN MAIZE AND GROUNDNUT CROPS AMONG RURAL HOUSEHOLDS IN ZAMBIA

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Prepared by:

Indaba Agricultural Policy Research Institute (IAPRI), Lusaka, Zambia

Authors:
Mary Lubungu, Research Fellow, IAPRI
Fwasa K. Singogo, Research Assistant, IAPRI

Principal investigators:
Mathews Onyango, Chief of Party (SUN LE, Khulisa)
Patricia Sakala, Strategic Information Expert (SUN LE, Khulisa)

Co-principal investigators:
Mike Mwanza, Chief Nutritionist and Head – Training and Collaboration (NFNC)
Mathias Tembo, Agronomist (ZARI)

Submitted by:
Khulisa Management Services, Inc.
4550 Montgomery Avenue, Suite 220
Bethesda, MD 20814, USA
Tel: +1 (301) 951-1835

Cover Photo: Mary Lubungu

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EXECUTIVE SUMMARY

Background: Malnutrition is a multifaceted problem that requires concerted efforts from all the key stakeholders. Household food insecurity and low nutritional dietary intake and diversity are some of the leading causes of malnutrition in Zambia. Increasing the production and consumption of safe, diverse, nutrient-dense foods and promoting improved agricultural practices and technologies can help address this challenge.

Unsafe food (food containing harmful bacteria, parasites and/or chemical substances) causes several non-communicable diseases and mortality. Unfortunately, groundnuts and maize, two highly consumed crops in both rural and urban areas of Zambia, are susceptible to aflatoxin contamination. Groundnuts and maize are also highly consumed by young children in the form of porridge. While these foods may add nutritional value to the children, consumption of aflatoxin-contaminated foods can negatively affect the overall wellbeing and development of young children. Despite evidence of high aflatoxin levels in maize and groundnuts and their related health impacts, there is little evidence about the extent of aflatoxin management practices among rural households in Zambia.

Purpose and objectives: This report aims to provide empirical evidence on aflatoxin awareness and knowledge and practices of aflatoxin management techniques among smallholder farmers involved in groundnut and maize production in the 30 priority Scaling Up Nutrition (SUN) 2.0/ First 1,000 Most Critical Days Programme (MCDP) II districts.

Methodology: A cross-sectional household survey was conducted in 27 rural SUN 2.0/ MCDP II priority districts, excluding three urban districts. The survey targeted 4,100 (20 households x 205 enumeration areas [EAs]) of 7,501 households that had participated in the 2019 SUN 2.0/MCDP II baseline survey that reported having grown maize. Of the 4,100 targeted households, 3,865 were successfully interviewed, translating into a 94.3% response rate. Two hundred thirty-four (234) targeted households were not interviewed due to refusals, non-contacts, dissolved households, and households that moved out of the EA. Data collection was conducted from June 3 to July 11, 2021.

Results: Overall, most households (92.5%) were aware of aflatoxins, although their aflatoxin knowledge was highly skewed towards it being an infection in crops (64.2%) and a fungus (41.4%). Furthermore, few households (less than 2.5%) were aware of the chronic health risks of aflatoxins, besides acute health risks such as stomach pains and diarrhoea (75.7%). When asked what they thought causes aflatoxins, humidity (60.2%), early harvest/high moisture content (46.4%), and poor post-harvest storage (31.5%) were the most common reasons cited. In contrast, poor pre-harvest handling, bad seed and soil, the use of too many chemicals, delayed planting, and the mixture of old and new stock were the least mentioned causes of aflatoxin (0.5% and less).

Overall, 83% of households had received no aflatoxin information from any source. Among the few (17%) households that reported receiving aflatoxin-specific information, most (92.1%) reported applying it. Of the aflatoxin-specific information received, most households cited drying methods (59.1%), proper produce handling (45.1%), and moisture monitoring in storage (31.4%). Very few households received information about stock rotation, human diseases caused by aflatoxins, or facilities that conduct aflatoxin testing. Ministry of Agriculture (MoA) extension officers (35.9%), fellow farmers (20.7%), non-governmental organizations (11.7%), and family members (11.6%) were the most common sources of aflatoxin information for households. The information was disseminated to most households through meetings (47%) and informal conversations (29.7%).

Table 1 presents pairwise correlations between aflatoxin management techniques used by the household

at various stages of production and stunting levels in children under the age of 24 months (derived from the 2019 SUN 2.0/MCDP II baseline survey). The results showed a significant negative relationship between stunting and good aflatoxin management at each production stage. It is, however, worth noting that there are several channels through which aflatoxin affects stunting. Therefore, these findings should be considered as associations rather than direct causation.

Table 1. Correlation findings between aflatoxin management measures and stunting in children under 2 years of age

	Pairwise Correlation Coefficients	
	Maize	Groundnuts
Pre-harvest	-0.0205 (p=0.2084)	-0.0504** (p=0.0339)
Handling	-0.0611*** (p=0.0002)	-0.0168 (p=0.3016)
Storage	-0.0396** (p=0.0147)	-0.0270* (p=0.0960)

*Note: ***, **, * imply significance at 1% (99% confidence interval), 5% (95% confidence interval), and 10% (90% confidence interval), respectively. In parenthesis are the p values.*

In light of these findings, technical guidance needs to be scaled up, particularly in districts with low adherence to aflatoxin management practices, with an emphasis on cost-effective initiatives. Furthermore, integrated management approaches against pre- and post-harvest aflatoxin contamination should be promoted.

Despite the relatively high awareness reported, the need for continued promotion of recommended aflatoxin management measures cannot be understated. Sensitization on aflatoxins, their causes, and their health effects should be scaled up as a critical component of the SUN programme. This should be undertaken using a variety of communication mediums to educate households on aflatoxin management, focusing on channels readily/easily available to low-income households.

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ACRONYMS

CSPro	Census and Survey Processing System software
DALYs	Disability-adjusted life-years
EA	Enumeration Area
ELISA	Enzyme-linked immunosorbent assay
FRA	Food Reserve Agency
Ha	Hectare
IAPRI	Indaba Agricultural Policy Research Institute
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
Kg	Kilogram
MCDP	Most Critical Days Programme
MoA	Ministry of Agriculture
ME&R	Monitoring, Evaluation & Research
NFNC	National Food and Nutrition Commission
NISIR	National Institute for Scientific and Industrial Research
PAR	Population attributable risk
PI	Principal Investigator
QC	Quality Controller
SUN LE	Scaling Up Nutrition Learning and Evaluation
TWG	Technical Working Group
USAID	United States Agency for International Development
USDA-ARS	United States Department of Agriculture - Agriculture Research Service
ZARI	Zambia Agricultural Research Institute

Definition of terms

Term	Definition
Aflatoxicosis	This is the consequence of ingestion of grains or forage containing toxic metabolites produced by certain fungi (Aspergillus flavus, Aspergillus parasiticus or Penicillium puberulum) (Iowa State University, 2022)[1].
Acute Aflatoxicosis	Acute aflatoxicosis manifests in humans or animals, with acute loss of appetite, vomiting, weakness, and lethargy (Benkerroum, 2020)[2].
Chronic Aflatoxicosis	Chronic Aflatoxicosis or long-term exposure may affect all organ systems (WHO, 2018; Benkerroum, 2020)[3].
Cirrhosis	A chronic disease of the liver marked by degeneration of cells, inflammation, and fibrous thickening of tissue (Schuppan, & Afdhal, 2008)[4].
Immune suppression	Means the immune system isn't working properly. This includes any or all the defences that make up the immune system – including the white blood cells and antibodies (Vos & Moore, 1977)[5].
Liver biotransformation	Biotransformation is the process by which substances that enter the body are changed to facilitate elimination from the body. This process usually generates products with few or no toxicological effects (Phang-Lyn & Llerena, 2021)[6].
Modulation of cytokine expression	The term "cytokine" is derived from a combination of two Greek words - "cyto" meaning cell and "kinos" meaning movement. Cytokines are cell-signalling molecules that aid cell to cell communication in immune responses and stimulate the movement of cells towards sites of inflammation, infection, and trauma. Modulation of cytokine expression is the exertion of a changing or controlling influence on immune responses (García Morán GA, et al., 2013)[7].

[1] Iowa State University, 2022. Aflatoxicosis. Retrieved from: https://vetmed.iastate.edu/vdpam/FSVD/swine/index-diseases/aflatoxicosis

[2] Benkerroum N. (2020). Chronic and Acute Toxicities of Aflatoxins: Mechanisms of Action. International journal of environmental research and public health, 17(2), 423. https://doi.org/10.3390/ijerph17020423

[3] WHO. 2018. Aflatoxins. Food safety Digest. Retrieved from: https://www.who.int/foodsafety/FSDigest_Aflatoxins_EN.pdf; Benkerroum N. (2020). Chronic and Acute Toxicities of Aflatoxins: Mechanisms of Action. International journal of environmental research and public health, 17(2), 423. https://doi.org/10.3390/ijerph17020423

[4] Schuppan, D., and Afdhal, N. H. 2008. Liver cirrhosis. The Lancet, 371(9615), pp 838-851, https://doi.org/10.1016/S0140-6736(08)60383-9.

[5] Vos, J. G., and Moore, J. A. 1977. Immune Suppression as Related to Toxicology, CRC Critical Reviews in Toxicology, 5:1, 67-101, DOI: 10.3109/10408447709101342

[6] Phang-Lyn S, Llerena VA. Biochemistry, Biotransformation. [Updated 2021 Aug 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK544353/

[7] García Morán GA, Parra-Medina R, Cardona AG, et al. Cytokines, chemokines and growth factors. In: Anaya JM, Shoenfeld Y, Rojas-Villarraga A, et al., editors. Autoimmunity: From Bench to Bedside [Internet]. Bogota (Colombia): El Rosario University Press; 2013 Jul 18. Chapter 9. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK459450/

1 BACKGROUND

As in many other developing countries, the most vulnerable households in Zambia are in rural areas. These households often depend entirely on rain-fed subsistence farming for their dietary intake. Maize and groundnuts remain the most widely produced and consumed crops in Zambia by smallholder farmers. About 90% and 56% of smallholder farmers cultivate maize and groundnuts, respectively, with over 80% of smallholder farmers consuming maize and groundnuts from their own production. However, the two crops are highly susceptible to aflatoxin contamination, posing a danger to human health and nutrition outcomes.

Aflatoxins are odourless, flavourless toxins produced by the fungi strain Aspergillus and are highly toxic to humans and animals[8]. Aflatoxins grow in soil, decaying vegetation, hay, and grains. They are regularly found in improperly stored commodities such as maize, groundnuts, cassava, millet, peanuts, rice, sorghum, sunflower seeds, wheat, and various spices. Aflatoxins are acutely toxic (causing loss of appetite, vomiting, weakness, and lethargy) but also have immunosuppressive, mutagenic, teratogenic, and carcinogenic properties, posing a danger to human health and nutrition outcomes, including stunting and underweight in children[9]. Zambia is among the countries with the highest prevalence of malnutrition in children under-five years of age, with 35% of children stunted, 12% underweight, and 4% wasted[10]. Figure 1 illustrates the pathways of aflatoxin contamination and its human health effects.

Despite evidence of high aflatoxin levels in maize and groundnuts and the related health impacts, there is little evidence about the extent of aflatoxin management practices among rural households in Zambia. However, there are efforts to mitigate aflatoxin contamination. A recent study on the mitigation effort sought to create awareness on aflatoxin contamination and promote integrated management approaches against pre- and post-harvest aflatoxin contamination among the several objectives.[11] Awareness was conducted through training of trainers' meetings, field days with farmers, extension officers and senior agriculture officers. However, the impacts of these awareness activities are not known as the project is ongoing. Another study sought to evaluate the efficacy of groundnut planting methods through participatory on-farm/ on-station trials[12]. The study found a reduction in aflatoxin contamination when groundnuts were planted on single rows and tied ridges compared to planting on double rows and flatbeds. While these studies provide valuable information on aflatoxin management, they are limited in coverage (focused on in Eastern and Central provinces). In addition, whether the farmers are applying the

[8] Sarma, U. P., Bhetaria, P. J., Devi, P., & Varma, A. (2017). Aflatoxins: Implications on Health. Indian journal of clinical biochemistry: IJCB, 32(2), 124–133. https://doi.org/10.1007/s12291-017-0649-2; and
CRS, 2018. Aflatoxin Management for Smallholder Farmers of Maize and Groundnuts: Practises and Technologies for Detection and Prevention. Technical Brief. Retrieved from: https://www.crs.org/sites/default/files/tools-research/aflatoxin_management_for_smallholder_farmers_of_maize_and_groundnuts_us_final.pdf

[9] Gong, Y. Y., Cardwell, K., Hounsa, A., Egal, S., Turner, P. C., Hall, A. J., & Wild, C. P. (2002). Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross sectional study. *BMJ (Clinical research ed.)*, *325*(7354), 20–21. https://doi.org/10.1136/bmj.325.7354.20

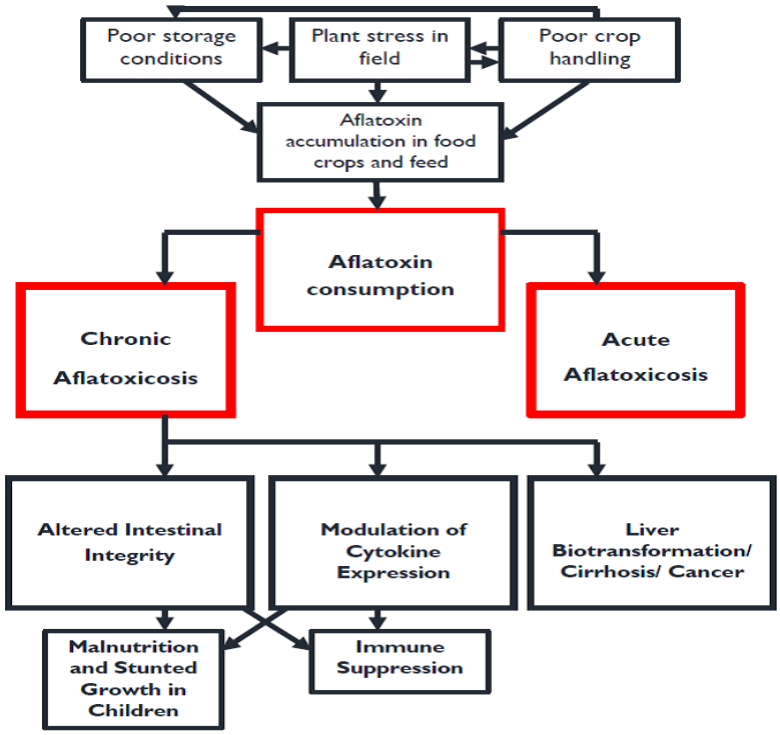
[10] Zambia Statistics Agency (ZSA) [Zambia], Ministry of Health (MoH) [Zambia]. January 2020. Zambia Demographic and Health Survey 2018. Rockville, Maryland, USA. Zambia Statistics Agency, Ministry of Health, and ICF https://dhsprogram.com/pubs/pdf/FR361/FR361.pdf

[11] Annual technical report. 2015. Aflatoxin mitigation using biological control and other management practices in the maize and groundnut value chain to improve public health, increase trade, augment smallholder income, and enhance food security in Zambia. Also see: Mitigation of aflatoxin in maize and groundnuts in Zambia. Retrieved from: https://aflasafe.com/wp-content/uploads/projects/12/Mitigation%20in%20Zambia.pdf

[12] Mukanga, M.,. Matumba, L., Makwenda, B., Alfred, S., Sakala, W., Kanenga, K., Chancellor, T., Mugabe, J., & Bennett, B. (2019). Participatory evaluation of groundnut planting methods for pre-harvest aflatoxin management in Eastern Province of Zambia.Cah. Agric., 28 (2019) 1. DOI: https://doi.org/10.1051/cagri/2019002. Retrived from: https://www.cahiersagricultures.fr/articles/cagri/pdf/2019/01/cagri180066.pdf

aflatoxin mitigation measures is not well known. Thus, this study sought to fill this gap by assessing farmers' awareness of aflatoxin and management measures.

Figure 1. Channel of aflatoxin contamination and disease in humans

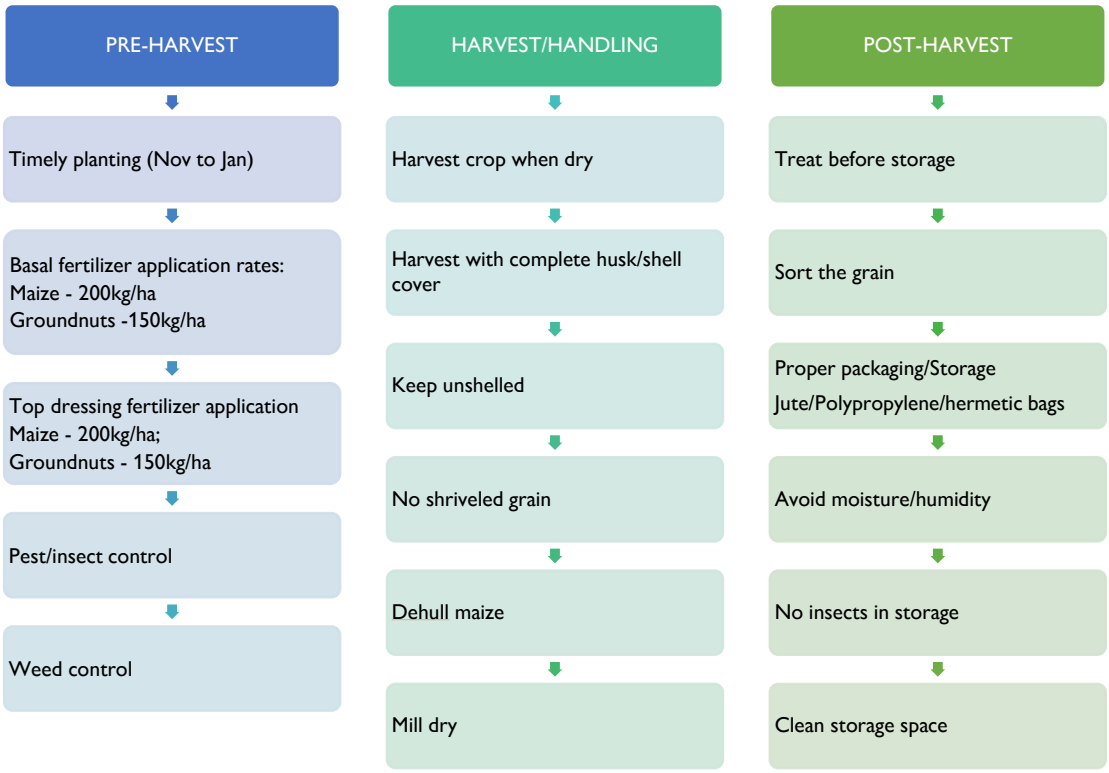


Source: *Bbosa et al., (2013)*[13]

Aflatoxin contamination can occur in the field before, during and after harvest; during curing/handling; and during storage and transportation. However, the mitigation of aflatoxins at pre-harvest is insufficient to prevent aflatoxin contamination. It is, therefore, imperative that aflatoxin management continues post-harvest. Examples of best practices at various maize and groundnut production stages are illustrated in Figure 2. The consistent implementation of these measures could limit crop exposure to aflatoxin.

[13] Bbosa, G. S., Kitya, D., Lubega, A., Ogwal-Okeng, J., Anokbonggo, W. W., & Kyegombe, D. B. (2013). Review of the Biological and Health Effects of Aflatoxins on Body Organs and Body Systems. In Mehdi Razzaghi-Abyaneh, M (Ed). *Aflatoxins – Recent Advances and Future Prospects.* London: IntechOpen https://doi.org/10.5772/51201

Figure 2. Best practices at various stages of maize and groundnut production



Source: *Authors compilation*[14]

This focused study assessed aflatoxin awareness and knowledge at the household level and aflatoxin management practices and techniques among smallholder farmers involved in groundnut and maize production. The adoption of recommended aflatoxin management techniques (Figure 2) will not only contribute to increased productivity among the smallholder farmers but also ensure reduced exposure to aflatoxin among women of reproductive age (15 to 49 years) and children under the age of 2 years in Zambia. Therefore, the study determined the extent to which smallholder households practice recommended aflatoxin management strategies for affected crops produced.

1.1 Study Objectives

The overall objective of this study was to assess the extent of aflatoxin management practices among maize and groundnut-producing smallholder farm households in the 30 priority districts of SUN 2.0/ MCDP II. The study's specific objectives were to:

- Investigate aflatoxin knowledge and awareness levels among households in selected districts
- Examine the practices and methods applied in aflatoxin management from production to storage among households.

[14] Compiled from CRS, 2018. Aflatoxin Management for Smallholder Farmers of Maize and Groundnuts: Practises and Technologies for Detection and Prevention. Technical Brief. Retrieved from: https://www.crs.org/sites/default/files/tools-research/aflatoxin_management_for_smallholder_farmers_of_maize_and_groundnuts_us_final.pdf; CRISAT. 2016. How to Reduce Aflatoxin Contamination in Groundnuts and Maize A Guide for Extension Workers. Patancheru 502 324, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp. Retrieved from: http://www.icrisat.org/wp-content/uploads/2017/02/Aflatoxin_mannual.pdf: Wrather, A., Sweets, L., Bailey, W., Claxton, T., Sexten, J., and Carlson, M. 2010. Aflatoxins in Corn. Retrieved from: https://extension.missouri.edu/publications/g4155; Worley J. W., and Sumner, P. E. 2017. Reducing Aflatoxin in Corn During Harvest and Storage. Retrieved from: https://extension.uga.edu/publications/detail.html?number=B1231&title=Reducing%20Aflatoxin%20in%20Corn%20During%20Harvest%20and%20Storage

- Explore how these management practices are correlated with stunting prevalence in the districts.

1.2 Report Structure

This report is structured as follows:

- Section 1 gives a general introduction,
- Section 2 explains the methodology employed in the study,
- Section 3 summarises the key findings, and
- Sections 4 and 5 sum up the study and provide recommendations, respectively.

2 METHODOLOGY

2.1 Study Design

Study Design: A cross-sectional survey was conducted to assess the extent of aflatoxin management practices among maize and groundnut producing smallholder farm households.

Study sites: Excluding the 3 urban districts, 27 rural districts of the 30 SUN 2.0/ MCDP II priority districts (See Annex 1).

Sample size and target: 4,100 (20 households x 205 enumeration areas [EAs]) of the 7,501 households reached in the 2019 SUN 2.0/MCDP II baseline survey (see Annex 1) were targeted. The households were traced using the GPS coordinates provided during the 2019 baseline survey in which anthropometric measurements were collected for children below two years of age. The study's target households were those that had reported growing maize or groundnuts in the 2019 baseline survey.

Ethical approval: The aflatoxin survey protocol was submitted to ERES CONVERGE IRB for ethical approval, which was granted on February 12, 2021 (Approval Reference number: IRB No. 00005948).

2.2 Fieldwork and Data Analysis

Pre-testing of the Questionnaire: A quality control (QC) meeting was held on May 19, 2021 to review the questionnaire, followed by a pre-test on May 21, 2021.

Recruiting and training of survey teams: The recruitment of data collectors was done in two stages, starting with a review of enumerators' past performance in the 2019 SUN 2.0/MCDP II baseline survey and other nutrition projects at the Indaba Agriculture Policy Research Institute (IAPRI). Those with good performances were considered and contacted for their availability. Since there was a record of past performance, no aptitude test was administered for this recruitment. To ensure the best possible candidates were selected, 50 potential data collectors were engaged to undergo training which included continuous assessment. Of these, 48 (40 enumerators and 8 supervisors) were selected for fieldwork at the end of the training (Annex 3).

Fieldwork training took place at Mika Lodge Kabulonga from May 24-29, 2021. This included a field test in Rufunsa District on May 28, 2021. IAPRI staff – the trainers – led the enumerators through each section of the questionnaire (Annex 4), with some time devoted to role-plays. Participation during this process was mandatory, and any issues identified were addressed. To this effect, simulations in various languages of different scenarios and different possible personalities of respondents were done.

Data collection: Socially distant face-to-face interviews were conducted to collect data in accordance with Government COVID-19 regulations. Data was electronically collected on tablets using the Census and Survey Processing System (CSPro) software. There were eight data collection teams, each with a supervisor and five enumerators. Local language proficiency was the basis of team and province assignments. Throughout the survey, the Survey Manager provided oversight to all teams.

Ethical issues: Before the start of every interview, enumerators identified themselves, the organization they represented (IAPRI), and provided contextual information of the study. Households were assured that the information gathered from them would be kept entirely confidential to the maximum extent permitted by law. Households were further informed that if they chose to participate, they could refuse to answer certain questions or stop participating at any time. Households were then asked to indicate their voluntary consent by accepting to participate in the interview or decline if they did not want to proceed. If households had any further questions about the survey, they were encouraged to contact the

ERES Converge IRB Chairman in Lusaka or the Research Fellow at IAPRI.

Quality control: IAPRI staff oversaw data quality control. The eight supervisors conducted daily logistics and quality control throughout the data collection process by checking the questionnaires and following up where necessary before uploading the questionnaires onto the server. Quality Controllers (IAPRI trainers) provided quality checks on the questionnaires supervisors had reviewed. The principal investigators (PI) and Co-PIs from NFNC, SUN LE, and sector-level individuals provided further oversight and quality control.

Data cleaning: Data were cleaned in Stata software using frequencies to identify illogical responses. These were verified by calling interviewers and, where necessary, households.

Data analysis: The data were analysed using Stata software, and graphs were generated in Microsoft Excel. The analysis mainly involved establishing descriptive values (percentages) and were disaggregated by districts where possible. Correlation coefficients were estimated to test the association between stunting and aflatoxin management practices.

2.3 Study Limitations

The following were the limitations experienced throughout the survey:

Respondent tracking: The data collection teams found it challenging to locate respondents in semi-urban EAs. This was because these are farm arrangements, with most households being workers. In addition, some targeted respondents were also hard to track down as they had moved out of the EAs, while others were not available during the survey period. For example, households in some provinces relocate depending on the season (Luapula Province – fish and farming season; Western Province – dry and rainy/flood periods). For fields that were too far, engaging such respondents became difficult. As such, these households were replaced.

Inaccessible EAs: Three EAs (1 in Mongu and 2 in Zambezi districts) were completely inaccessible due to waterlogging, with no available alternative routes during the survey. Thus, the district-level representativeness of the data for Zambezi District may have been affected due to the decreased response rate of 77.8% (Annex 2).

3 RESULTS

This section presents and discusses the key findings of the study.

3.1 Sample Description

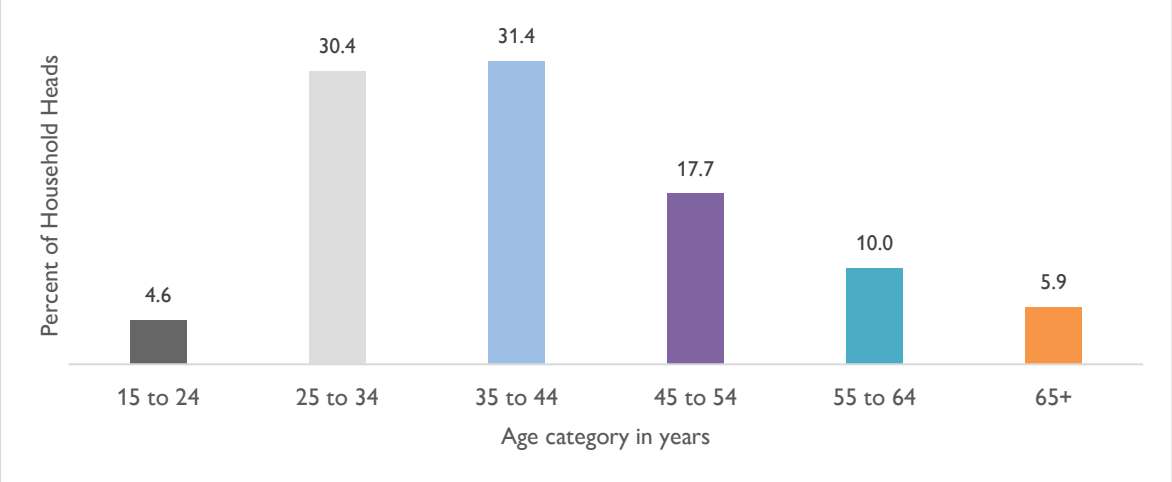
A total of 4,100 households from the 2019 SUN 2.0/MCDP II baseline survey were targeted for the study. Of these, 3,866 households were successfully interviewed, yielding a 94.3% response rate. Of the 4,100 targeted households, 234 were not interviewed due to refusal, non-contact, dissolution, or relocation out of the EA since 2019. Three EAs were completely inaccessible due to waterlogging, with no available alternative routes during the survey. The three EAs amounted to 60 households and are included under the non-contact category (Table 2). In addition, after data cleaning, 1 household questionnaire was excluded from the analysis because of missing information. The households of interest were those who had produced either maize or groundnuts in the 2020/21 agricultural season.

Table 2. Survey response rate

Response Status	Freq.	%
Refusal	1	0.0
Household moved out of EA	82	2.0
Household dissolved	5	0.1
Non-Contact	146	3.6
Dropped questionnaire	1	0.0
Proceed	**3,865**	**94.3**
Total Targeted	4,100	100.0

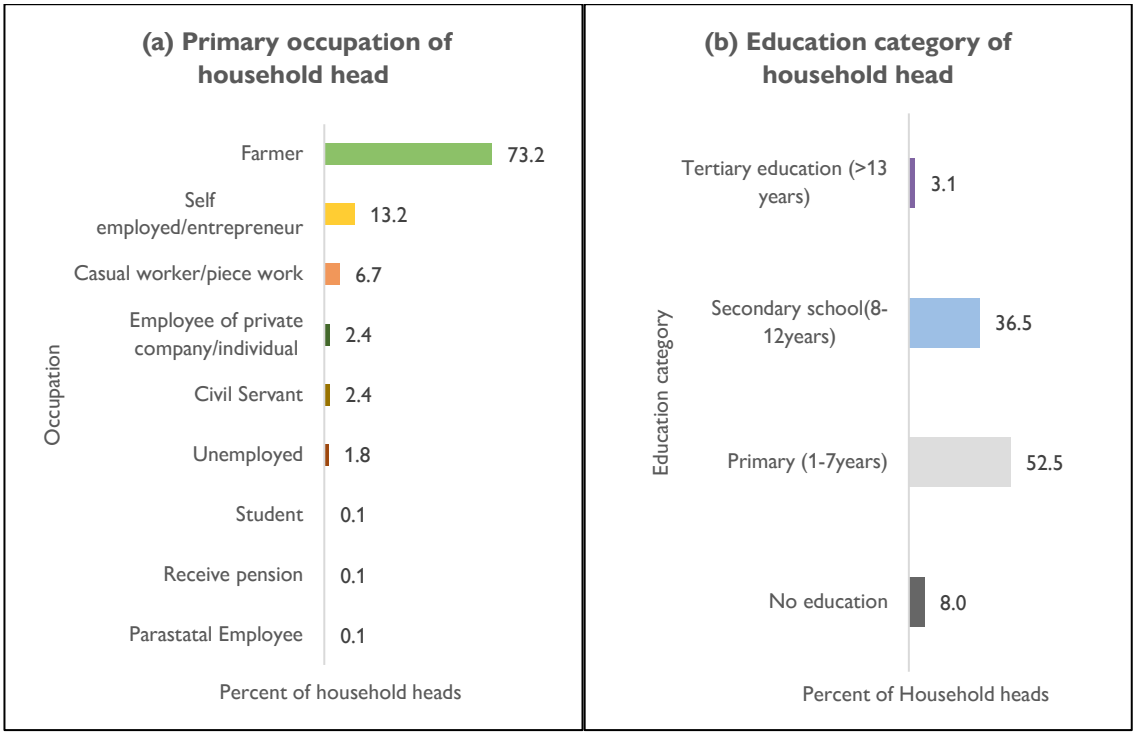
Of the 3,865 households interviewed, 18.1% were female-headed households (FHH), while 81.9% were male-headed households (MHH). In terms of the age distribution of household heads (Figure 3), 31.4% were between 35-44 years, 30.4% were between 25-34 years, and 17.7% were in the slightly older age group of 45-54 years. Households headed by young people (15-24 years) represented less than 5%, while those with household heads above 55 years were 15.9%.

Figure 3. Age distribution of household heads



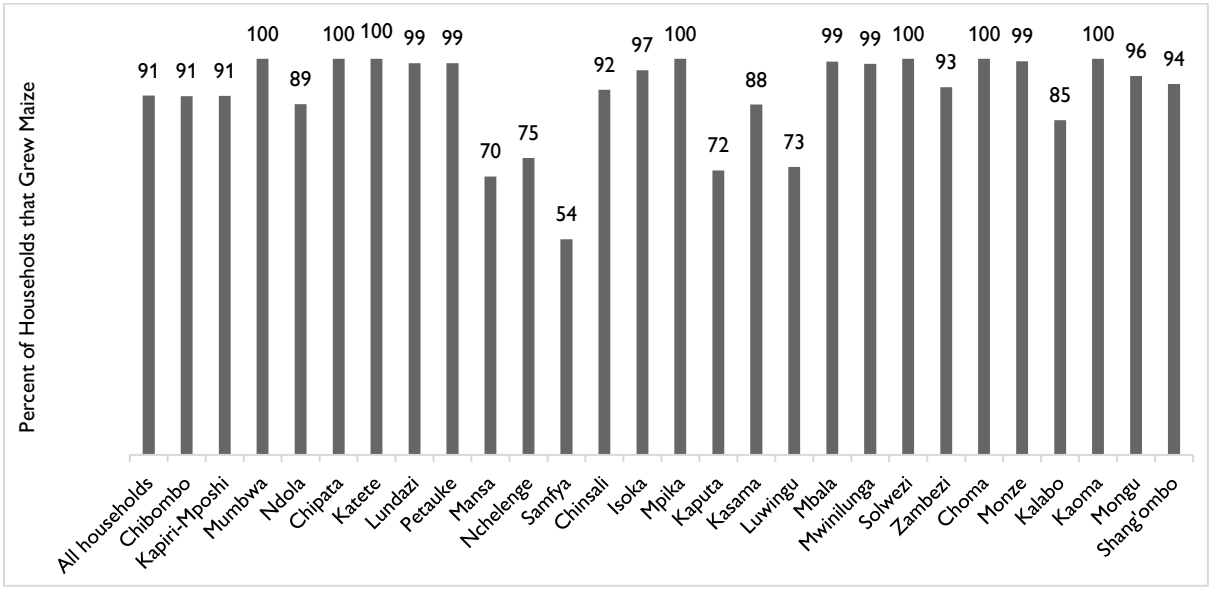
Farming was the primary occupation for most (73.2%) households in this survey. However, self-employment/entrepreneurship was the second most prevalent primary economic activity at 13.2% (Figure 4). In addition, most household heads (52.5%) had attained primary education, while very few (3.1%) had attained tertiary education.

Figure 4. Distribution of household heads' education and occupation



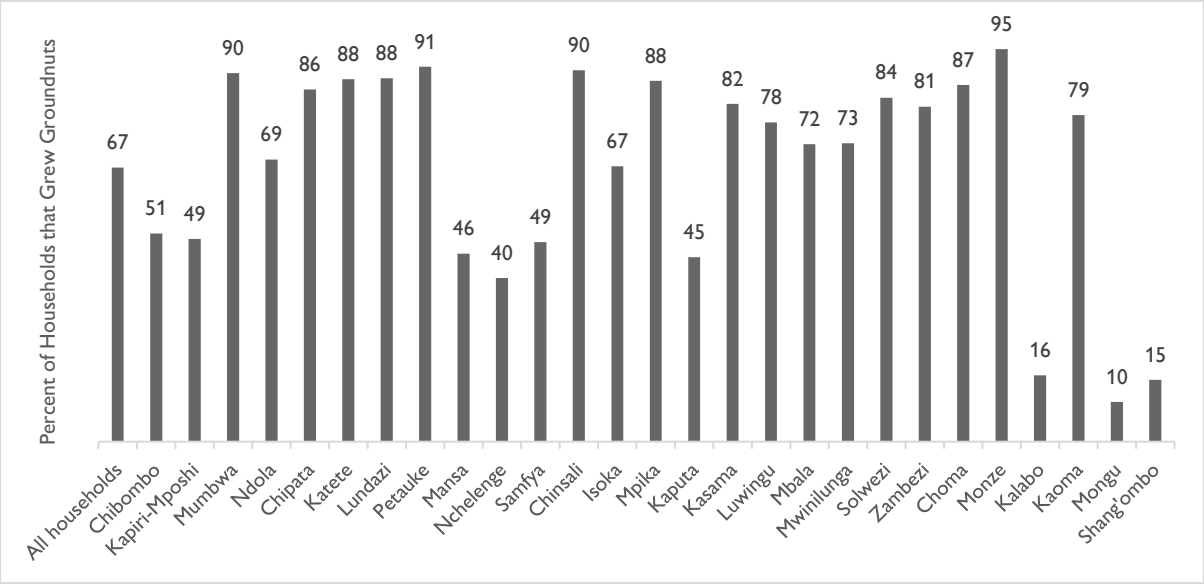
Approximately 90% of households grew maize in the 2020/21 agricultural season (Figure 5). It is worth noting that while maize was widely grown across all the districts of interest, only 54.4% of households grew maize in Samfya.

Figure 5. Households that grew maize



In contrast, only 66.6% of households grew groundnuts (Figure 6). It is worth noting that while groundnuts were widely grown across all the districts of interest, only 9.7%, 15%, and 16.1% of households grew groundnuts in Mongu, Shang'ombo, and Kalabo, respectively.

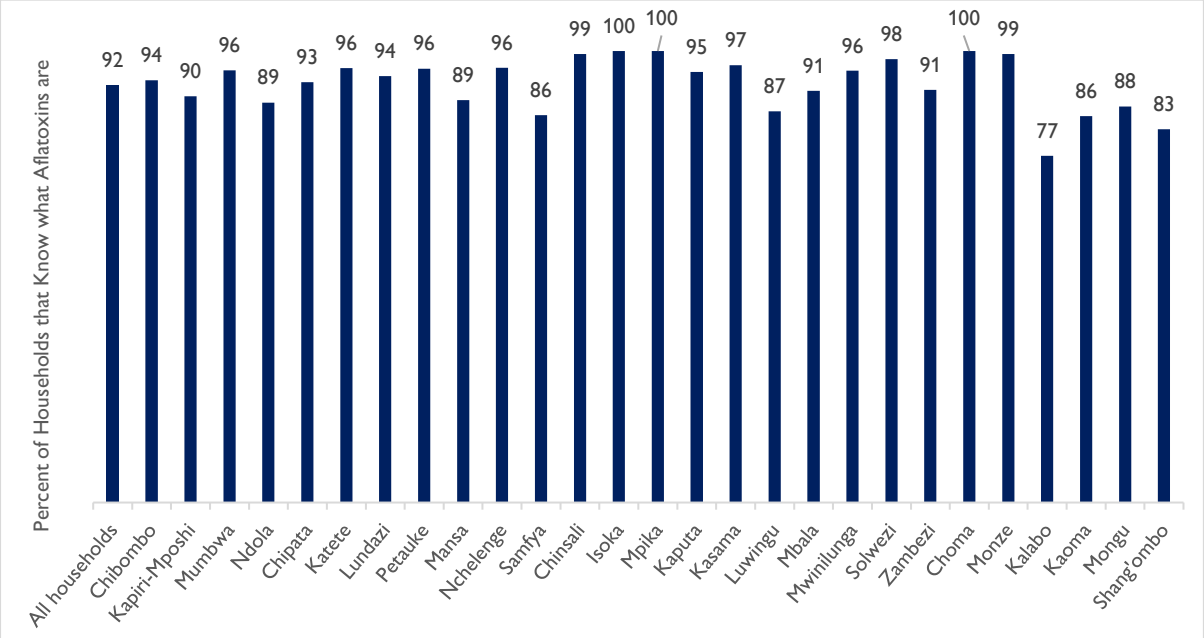
Figure 6. Households that grew groundnuts



3.2 Aflatoxin Knowledge and Awareness

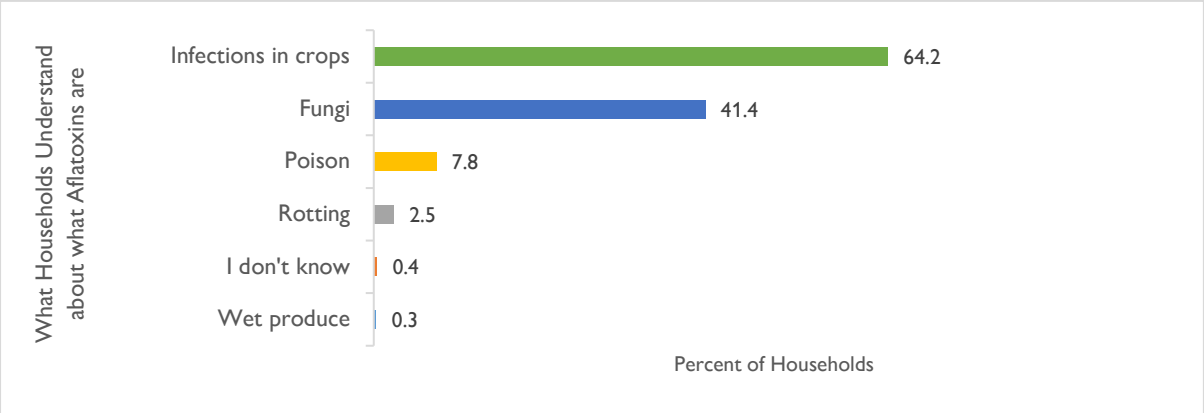
Across all districts, there was a general awareness (not entirely rooted in scientific knowledge but rather generic knowledge/perceptions) of aflatoxins, with 92.5% of households reporting this (Figure 7). However, Kalabo showed a much smaller proportion of households who knew what aflatoxins were (76.8%) compared to households in Isoka, Mpika, and Choma (100%).

Figure 7. Percent of households that know what aflatoxins are



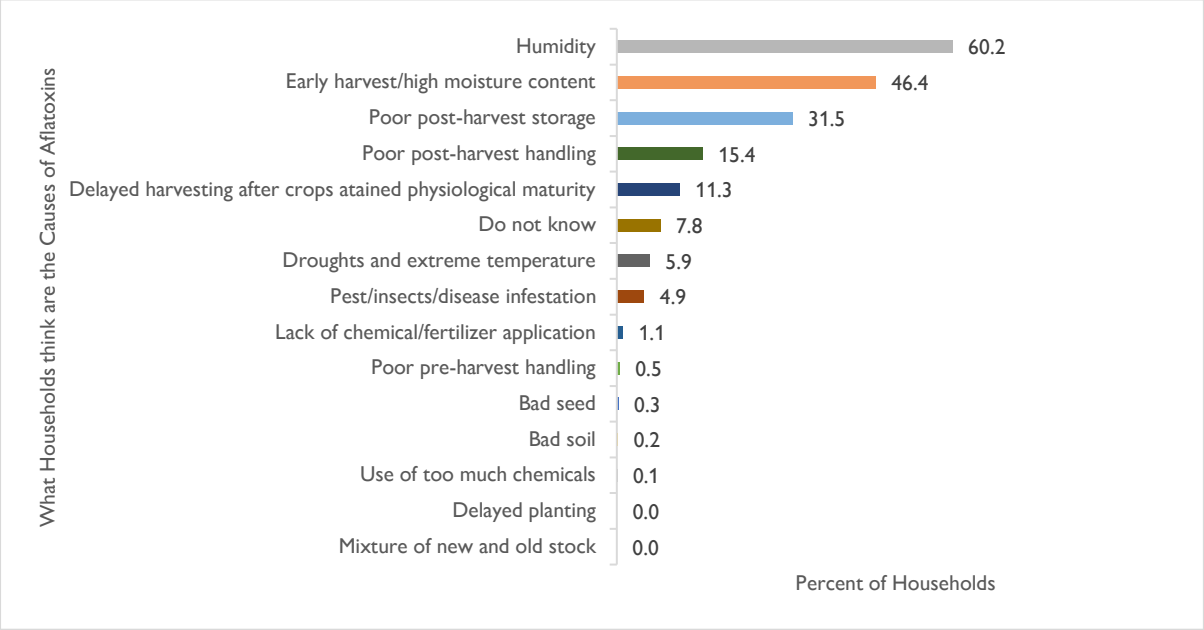
While most households (92.5%) were aware of aflatoxins, their understanding was highly skewed (Figure 8) towards it being an infection in crops (64.2%) and fungi (41.4%). Few households considered aflatoxins as a poison (7.8%) or attributed it to rotting (2.5%) or wet produce (0.3%).

Figure 8. What households understand about what aflatoxins are (percent of households)



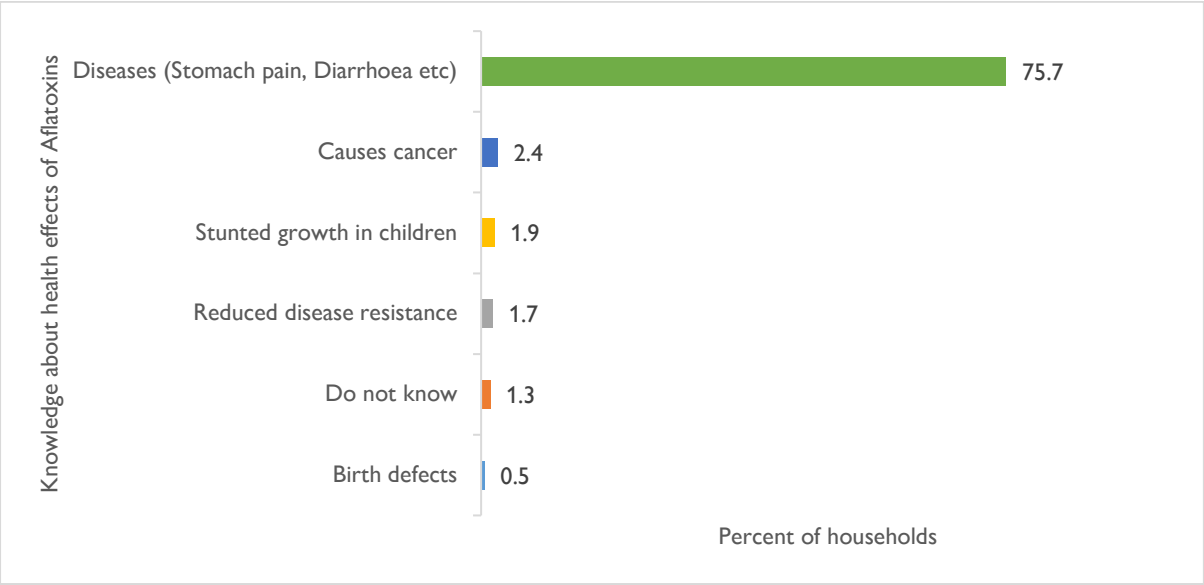
When asked what they thought causes aflatoxins, households gave an array of responses (Figure 9). Humidity (60.2%), early harvest/high moisture content (46.4%), and poor post-harvest storage (31.5%) were the most common reasons attributed to causing aflatoxins. In contrast, poor pre-harvest handling, bad seed and soil, the excessive use of chemicals, delayed planting, and the mixture of old and new stock were the least mentioned (0.5% and less).

Figure 9. What households think are the causes of aflatoxins



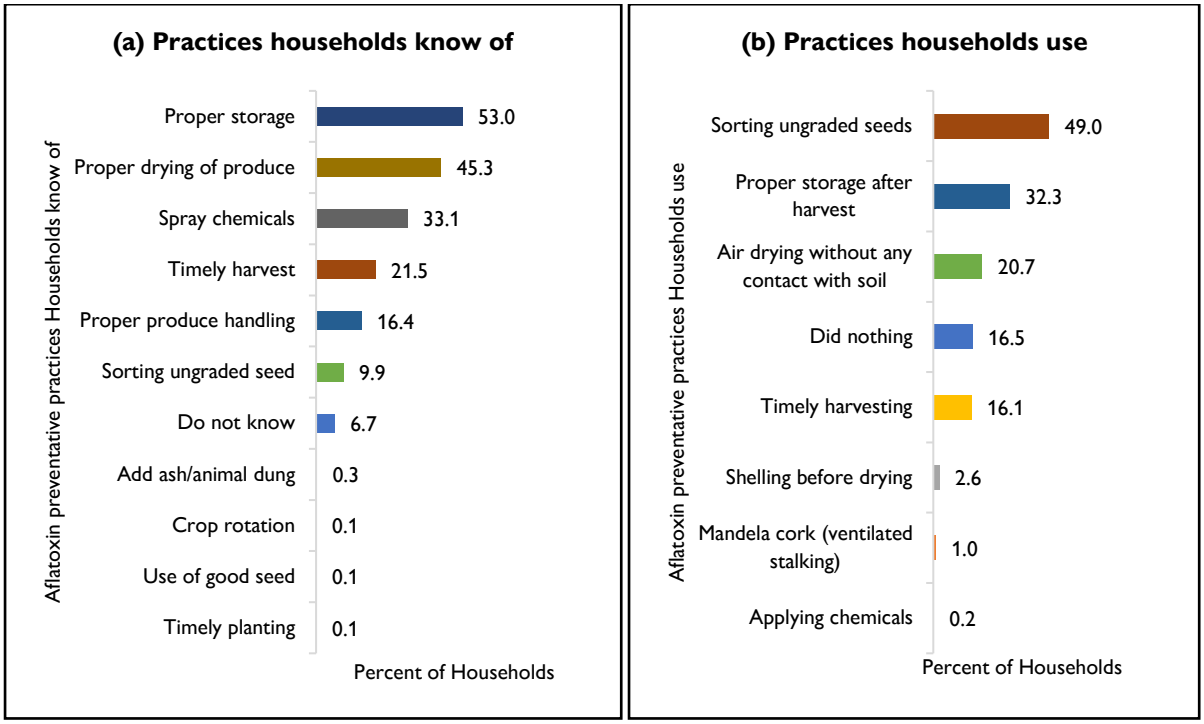
The knowledge of the health effects of aflatoxins was limited among smallholder farmers (Figure 10). Most households' knowledge was predominantly focused on acute disease symptoms (e.g. stomach pain, diarrhoea, etc.) (75.7%). In contrast, less than 2.5% of households knew that aflatoxins could reduce disease resistance, cause cancer, cause stunting, or cause congenital disabilities.

Figure 10. Knowledge about health effects of aflatoxins



Households were then asked what practices could reduce the prevalence of aflatoxins in their crops and which practices they used (Figure 11). Of the practices households knew could reduce the prevalence of aflatoxins in their crops, post-harvest practices were the most common. These included proper storage (53%), proper drying of produce (45.3%), proper produce handling (16.4%), and the sorting of ungraded seed (9.9%). This contrasts with the pre-planting stage, where only 0.1% either practiced crop rotation, used good seeds or planted on time. Similarly, post-harvest practices were the most common practices households used to reduce the prevalence of aflatoxins in their crops (Figure 11b).

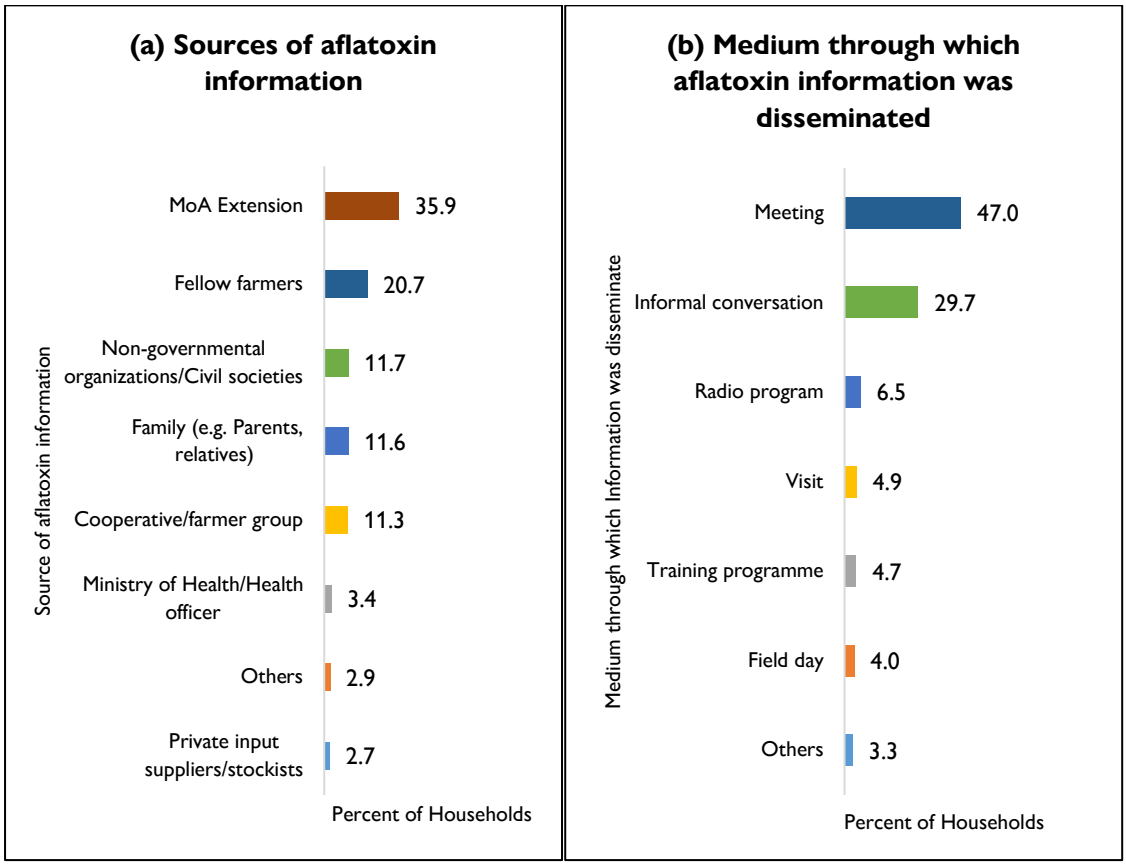
Figure 11. Common aflatoxin practices households know of and use



3.3 Sources of Aflatoxin Information

Ministry of Agriculture (MoA) extension officers (35.9%), fellow farmers (20.7%), non-governmental organizations (11.7%), and family members (11.6%) were the most common sources of aflatoxin information for households (Figure 12a). The information was disseminated to most households through meetings (47%) and informal conversations (29.7%) (Figure 12b).

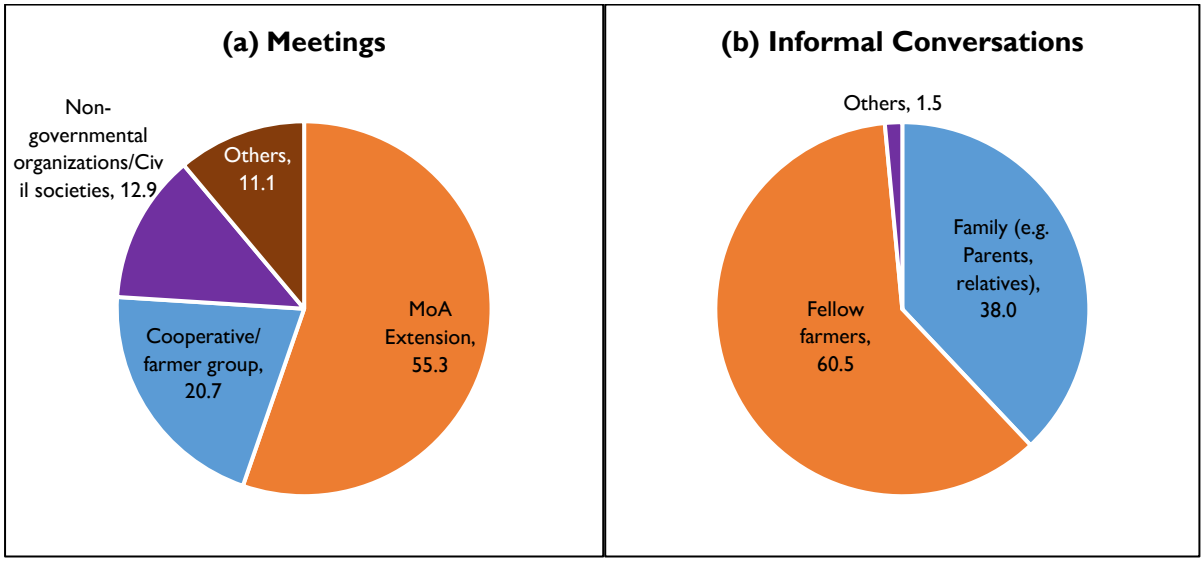
Figure 12. Sources of agricultural information and the medium of dissemination



When aflatoxin information was shared in meetings (47% of respondents), more than half (55.3%) of respondents reported receiving information from MoA extension officers, cooperative/farmer groups (20.7%), or non-governmental organizations/civil societies (12.9%), while 11.1% reported receiving information from a wide range of other sources (e.g. church groups, UN Agencies, Food Reserve Agency (FRA) cooperative, locally organized group, private input suppliers/stockists, Ministry of Health officer, family members (e.g. parents, relatives), or fellow farmers) (Figure 13a).

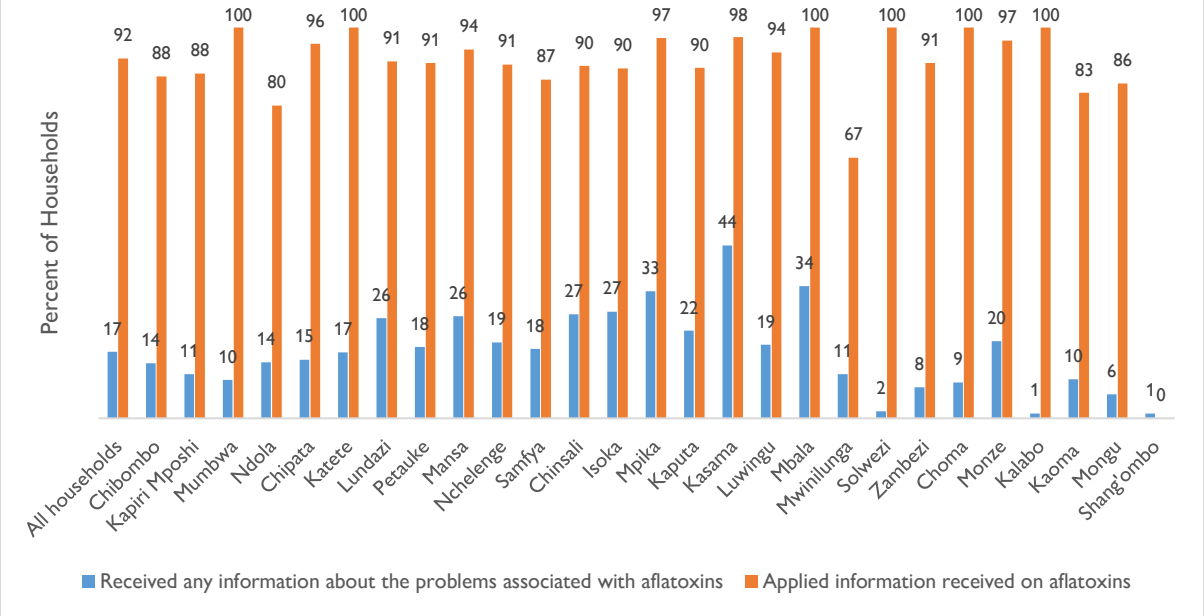
On the other hand, of the 29.7% who received their information through informal conversations, most entail interactions with fellow farmers (60.5%) and family members (38%). Very few (1.5%) receive aflatoxin information informally from other sources (e.g. private output traders, Ministry of Health/Health officer, and MoA Extension) (Figure 13b).

Figure 13. Medium through which information was received disaggregated by source (percent of households)



The above results apply, however, only to a minority of households. Only a few households (17%) received aflatoxin-specific information (Figure 14), while the vast majority (83%) never received aflatoxin information from any source. The district with the most households recorded to have received information was Kasama (44.2%). In contrast, less than 2% of households in Solwezi, Kalabo, and Shang'ombo reported receiving any information on aflatoxin prevention/management practices.

Figure 14. Households that received aflatoxin information and applied the information

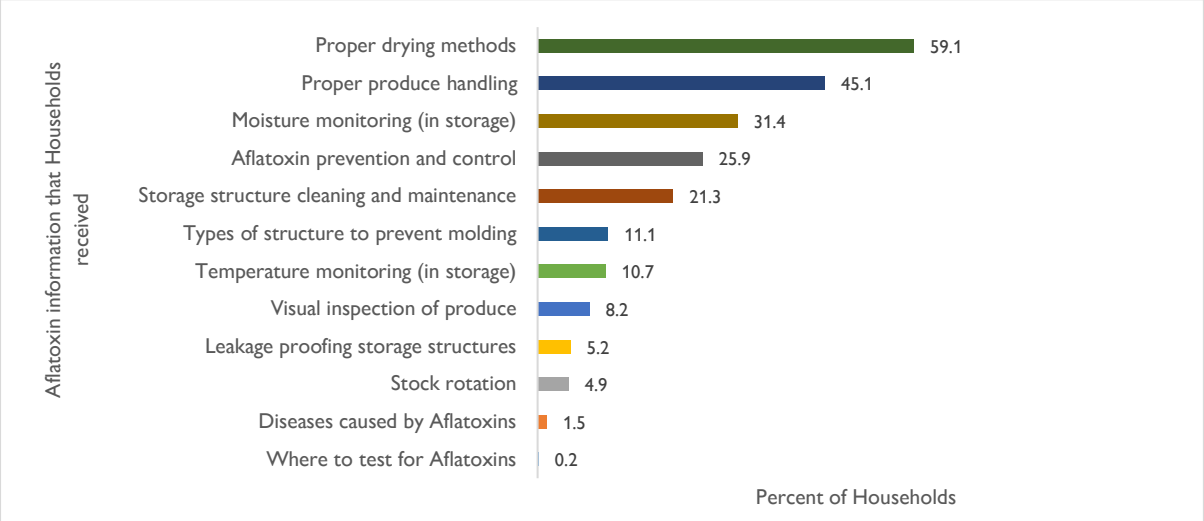


Among the few households (17%) who reported receiving aflatoxin-specific information, most of them (92.1%) reported applying it (Figure 14). However, no households in Shang'ombo applied the information they received, as they indicated they did not understand the information. This contrasted with Mumbwa, Katete, Mbala, Solwezi, Choma, and Kalabo where all households that received

information reported applying it.

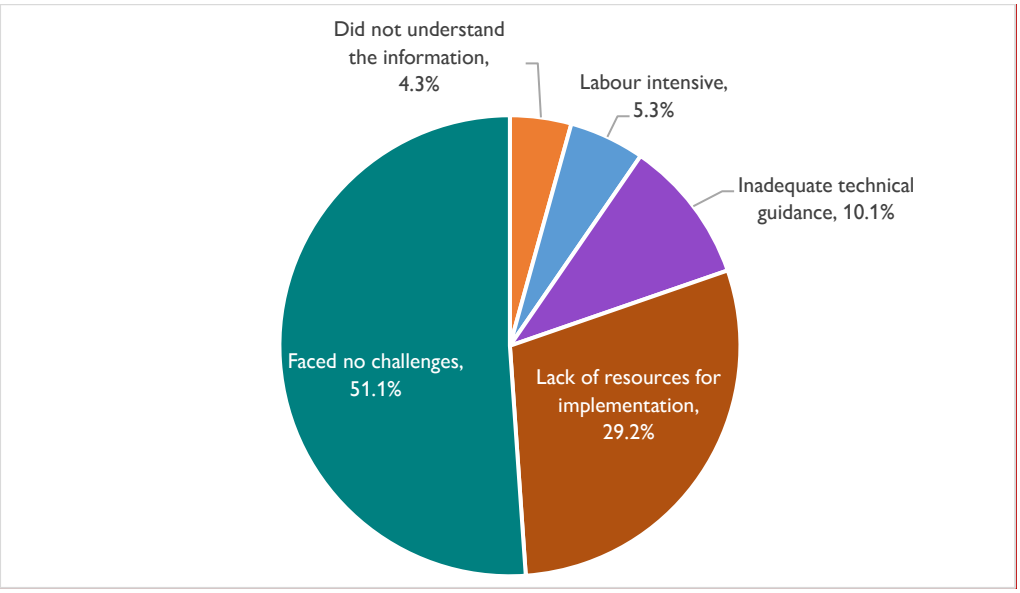
Of the aflatoxin-specific information received, the topics cited by most households were drying methods (59.1%), proper crop handling (45.1%) so as to avoid damage during harvest and storage, and moisture monitoring in storage (31.4%) to ensure the crop does not get wet or retain moisture (Figure 15). Much of the information disseminated appeared to be skewed towards post-harvest practices. Very few households reported receiving information about stock rotation, diseases caused by aflatoxins, and where to test for aflatoxins.

Figure 15. Aflatoxin information received



When asked about the hurdles faced in applying the information received, households most cited a lack of resources (29.2%) and inadequate technical guidance (10.1%) (Figure 16). The practices most challenging in terms of both inadequate technical guidance and lack of resources were 'storage structure cleaning and maintenance', 'aflatoxin prevention and control', 'moisture monitoring' (in storage), 'proper produce handling', and 'proper drying methods'.

Figure 16. Percent of households facing challenges applying the aflatoxin information received



3.4 Households Practising Recommended Aflatoxin Management Practices

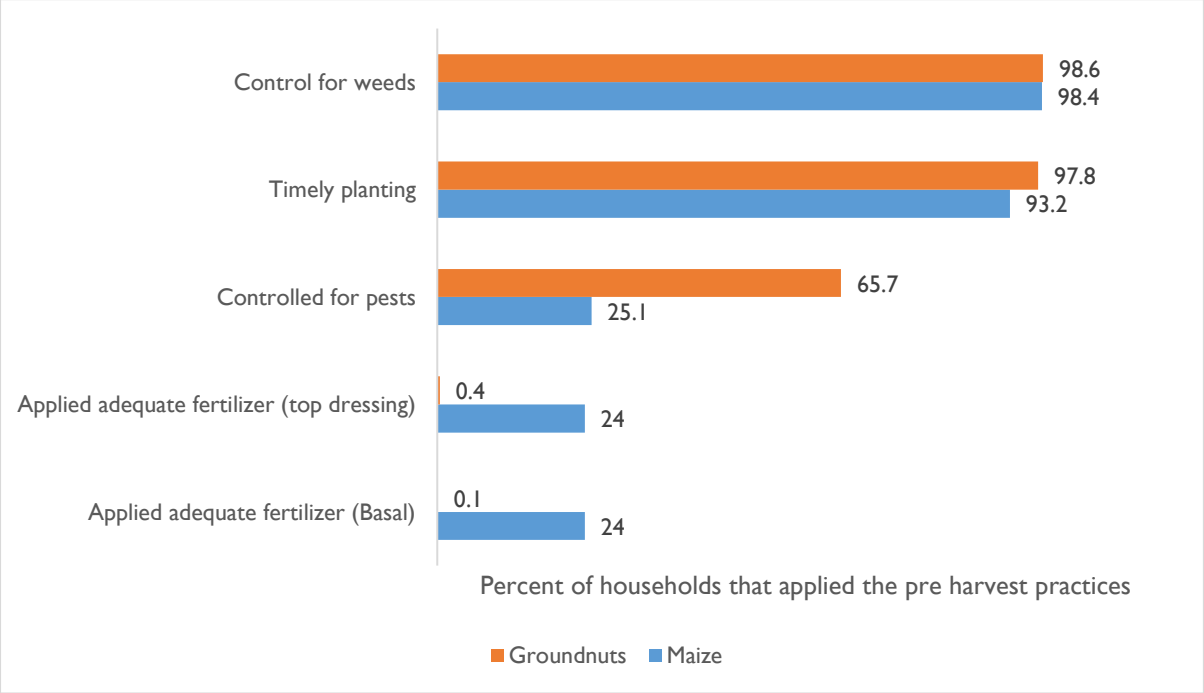
The study examined the extent to which households followed the various recommended practices as presented in Figure 2 on page 3.

Pre-harvest management techniques

The pre-harvest techniques interrogated were: controlling for weeds, controlling for pests, applying adequate basal, applying top-dressing fertilizer, and timely planting (Figure 17). While most households controlled for weeds (approximately 98%) and planted on time in maize or groundnut fields (above 90%), few applied adequate basal and top-dressing fertilizer. It is worth noting that even though manure application tends to fertilise the soil, there is no standard application rate. However, the analysis showed that only 9.2% of households used manure in their maize production while only 0.4% applied manure in their groundnut fields[15].

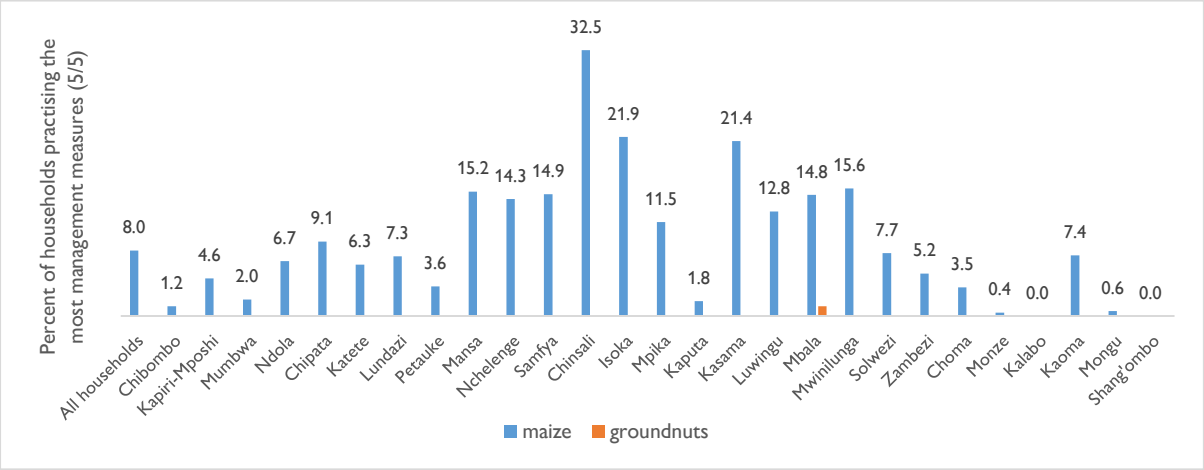
In the case of maize, few households (8%) practised all five pre-harvest management measures, with households in Chinsali (32.5%) being the highest while none did in Kalabo and Shang'ombo (Figure 18). In the case of groundnuts, effectively no households practised all five pre-harvest management measures.

Figure 17. Households that applied pre-harvest practices for maize production



[15] Sanitizing the field before planting is an important aspect of reducing aflatoxin contamination. This also include good management practices and maintaining soil health. A key component to ensuring soil healthy is applying recommended fertilizers according to soil type, and any manure that will increase soil fertility.

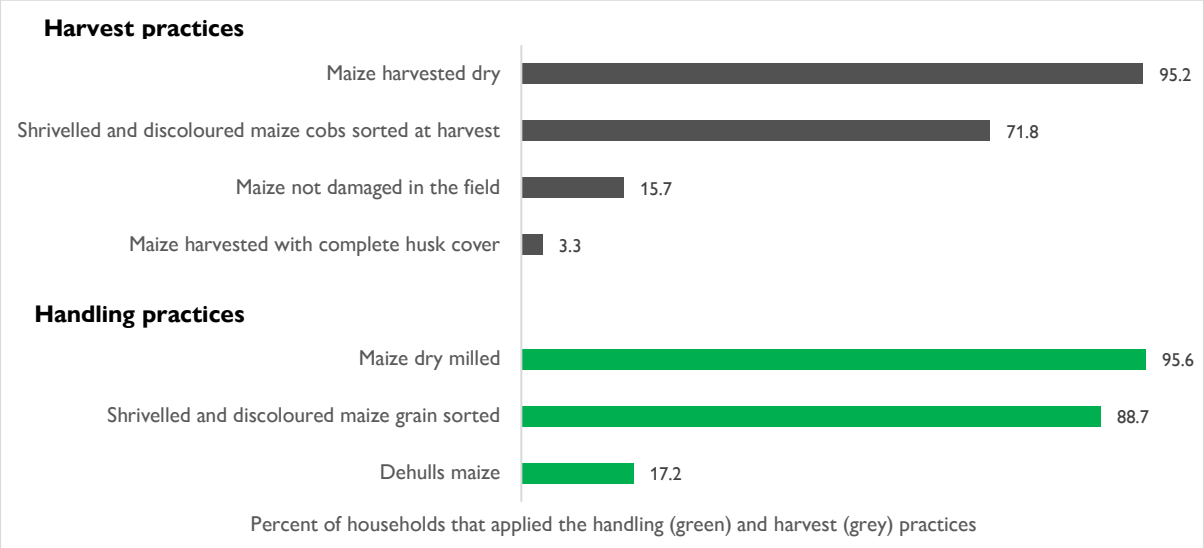
Figure 18. Households that practised all 5 pre-harvest management measures for maize or groundnuts by district



Harvest and Handling management practices

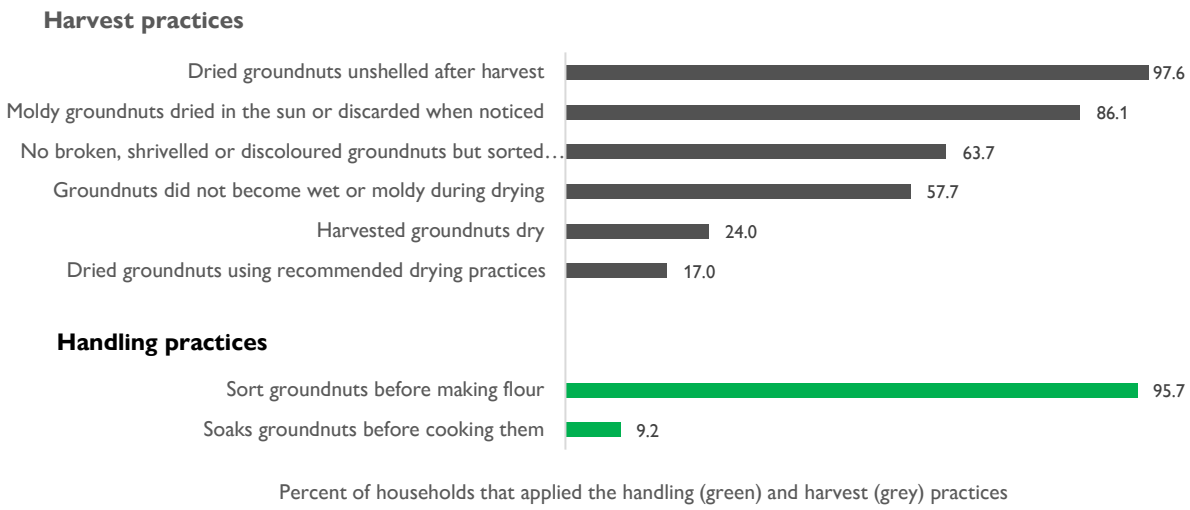
For maize, the most common harvest management practices were drying (95.2% of households) and sorting at harvest (71.8%), while the most common handling practices were dry milling maize (95.6%) and sorting before storage and processing (88.7%) (Figure 19).

Figure 19. Households that applied harvest and handling practices for maize production



For groundnuts, most households (97.6%) dried their groundnuts unshelled after harvest, and sun-dried or discarded mouldy groundnuts (86.1%) while sorting before making flour (95.7%) was the most common handling practise used by households (Figure 20).

Figure 20. Households that applied harvest and handling practices for groundnut production



The combined application of best practice measures for maize in a single household is rare – only 2.4% of households practised three of four maize harvest management measures. The highest rates were in Petauke District (14.9% of households), but no households did so in 15 of 27 districts (Figure 21).

With regards to handling techniques, few households (12.7%) practised all three maize handling management measures, with Petauke again having the highest percentage of households (49.7%) and none in Mwinilunga and Solwezi (Figure 22).

Figure 21. Percent of households that practised three or more harvest management measures for maize

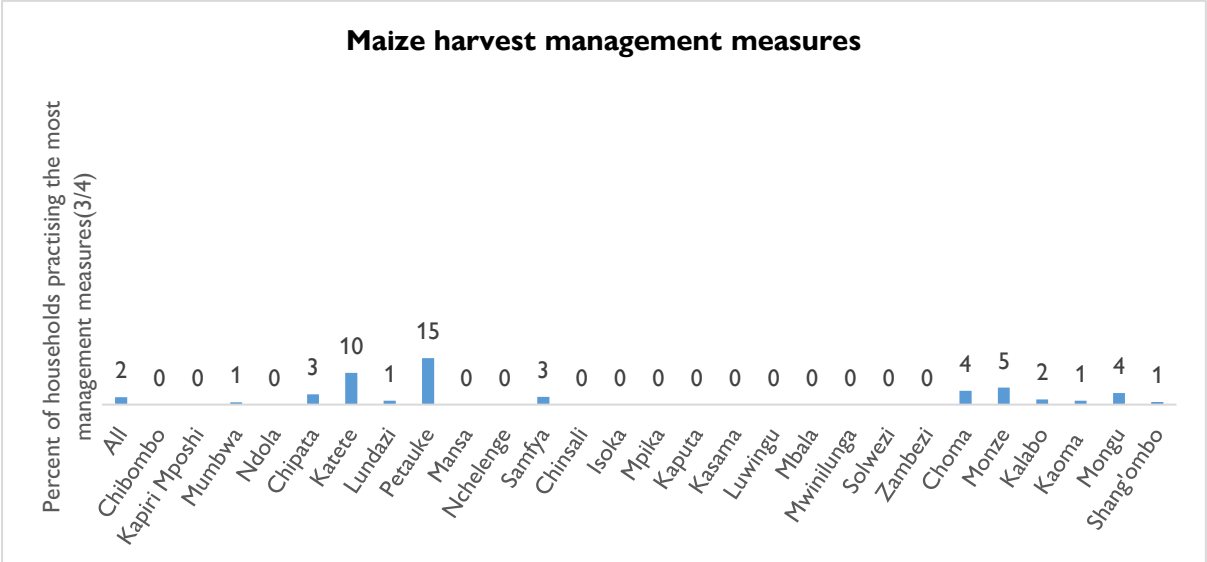
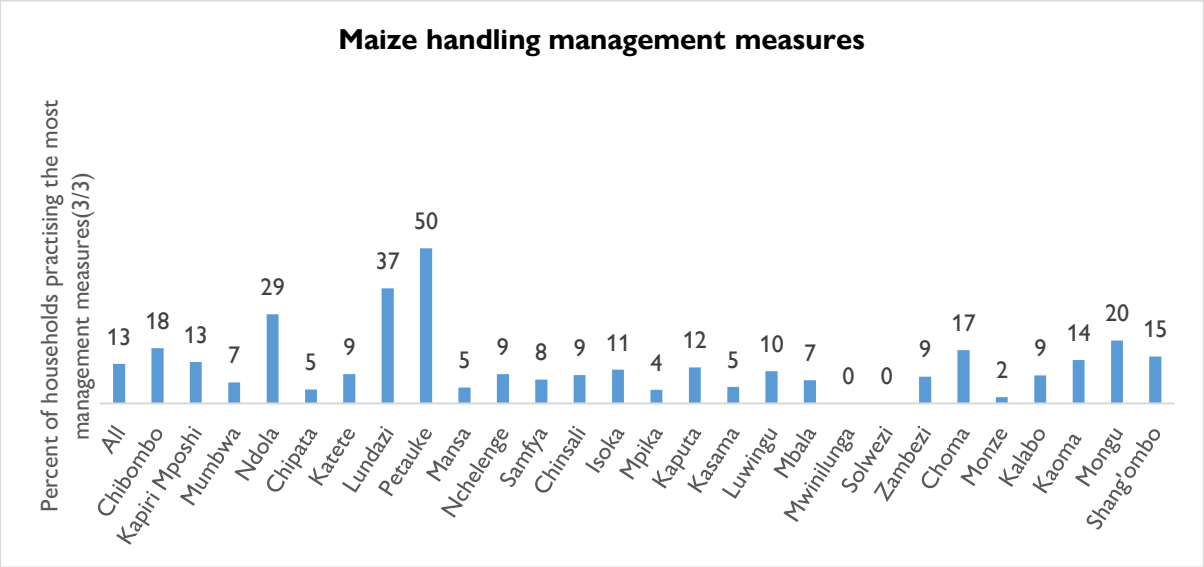


Figure 22. Percent of households that practised the three handling management measures for maize



Similarly, very few households (10.1%) practised at least 4 of the 6 groundnuts harvest management practices, with households in Chinsali (30.4%) being the highest while none did so in 6 districts (Figure 23). Only 5.6% practised both groundnut handling management measures, with households in Katete (16.3%) being the highest and households in Shang'ombo (0.6%) being the least (Figure 24).

Figure 23. Percent of households that practised the most harvest management measures for groundnuts

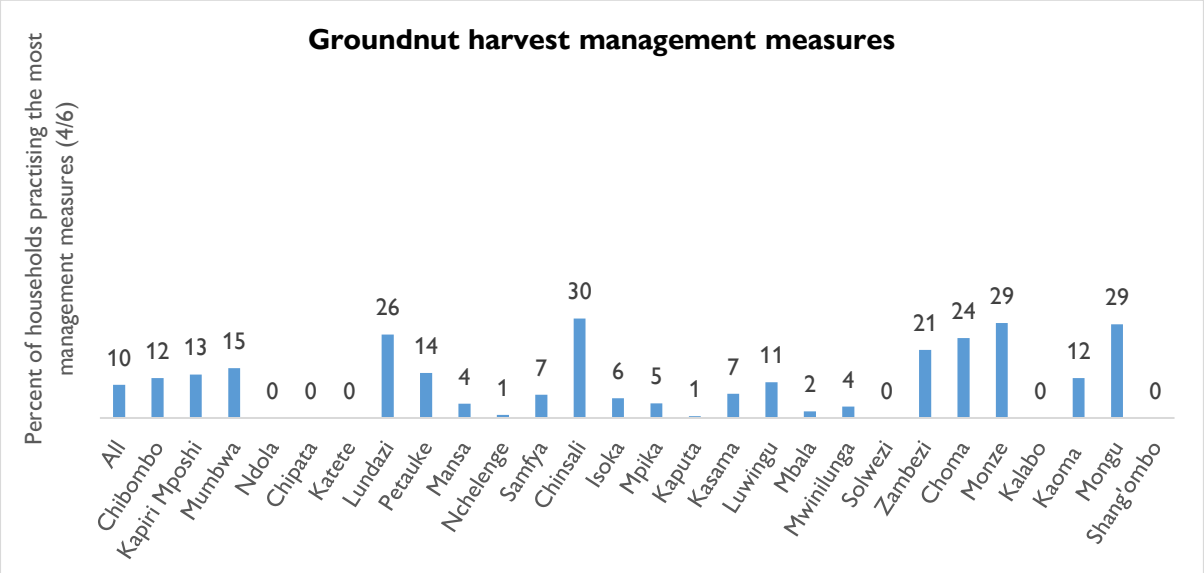
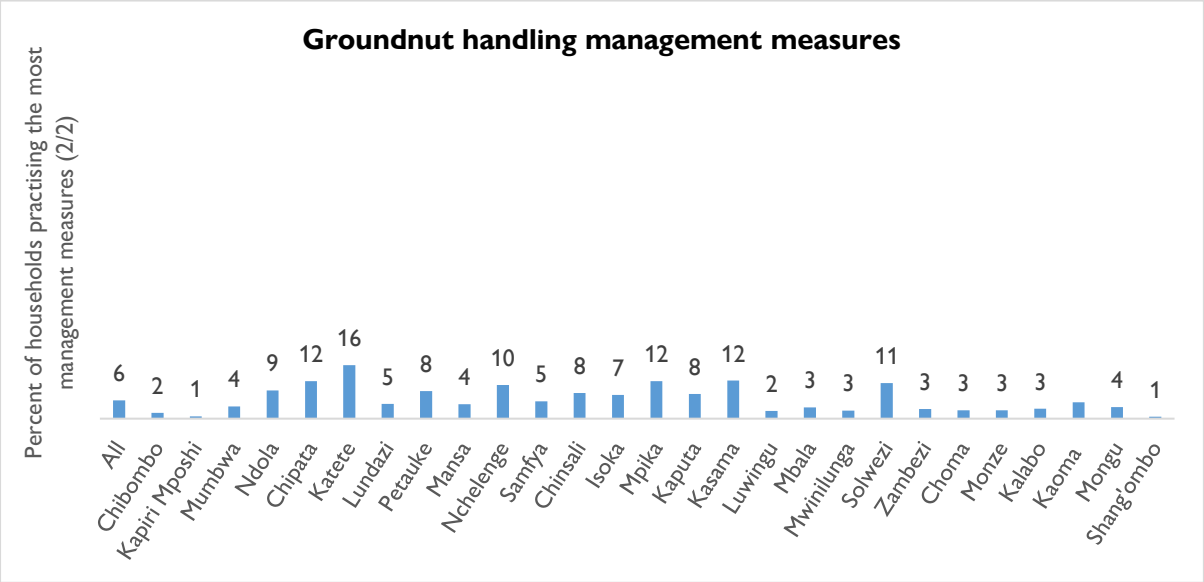


Figure 24. Percent of households that practised the most handling management measures for groundnuts



Post-Harvest Practices (and Observations)

Post-harvest and storage techniques were far more commonly practised among households. The most common practices were the use of recommended material for storage (jute/polypropylene/hermetic bags) and recommended structures for long-term storage (Figure 25). However, practically no households practised all six post-harvest and storage management measures (Figure 26).

Figure 25. Percent of households that applied post-harvest and storage practices

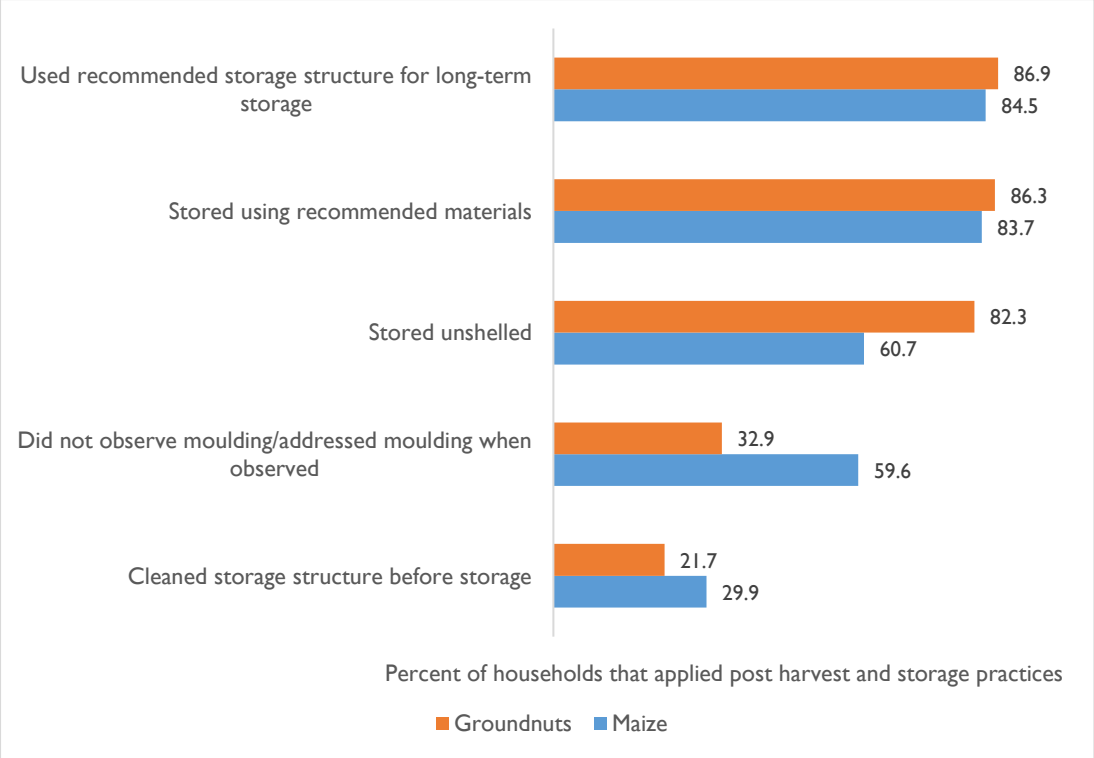
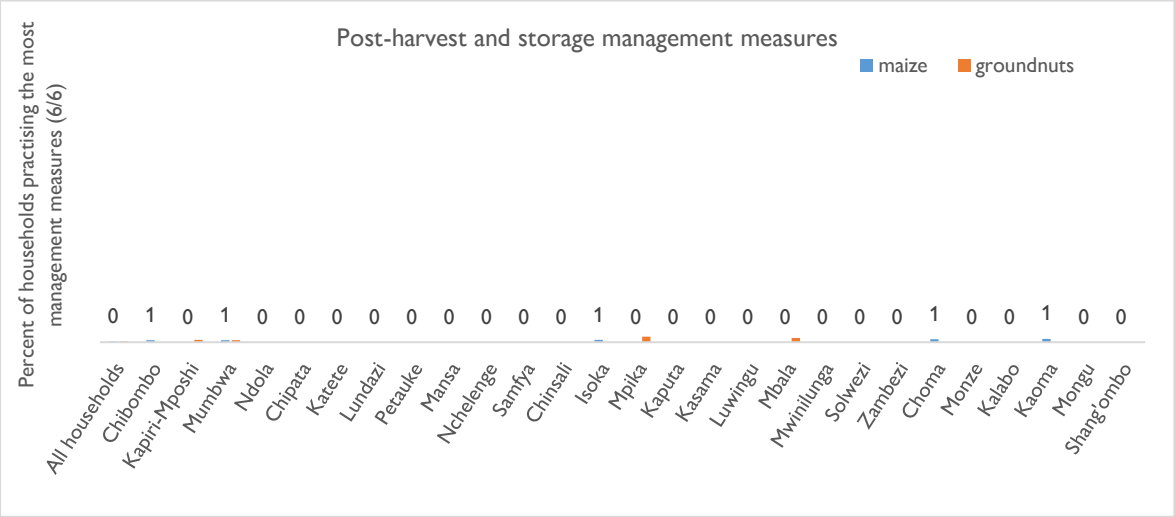


Figure 26. Percent of households that practised all post-harvest and storage management measures



In addition to asking about a household's reported practise, data collectors also observed crop storage and handling. Most households did not have maize or groundnuts that felt wet to the touch in storage or during the drying process. However, very few households treated their maize or groundnuts (Figure 27 and Figure 28).

Figure 27: Percent of households observed to have applied storage practices for maize production

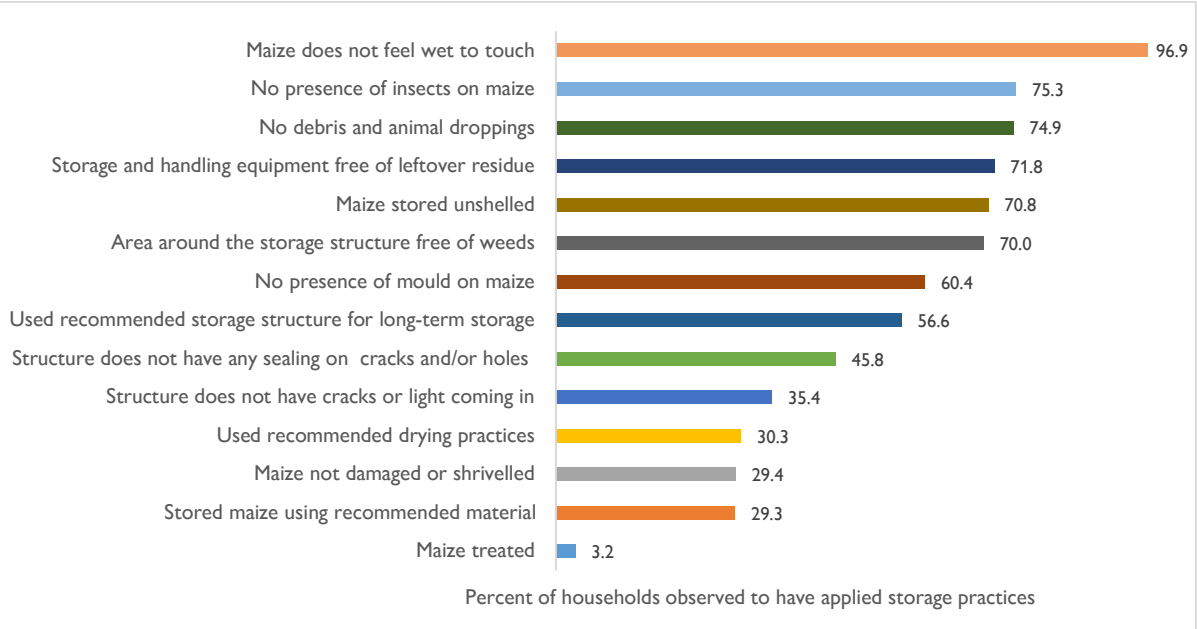
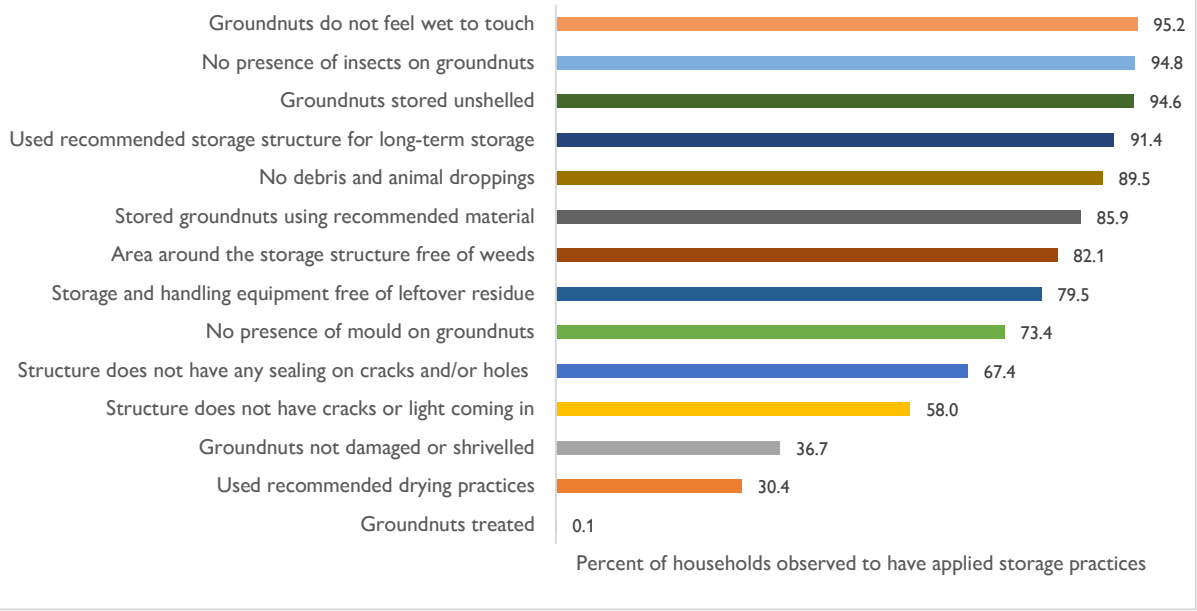


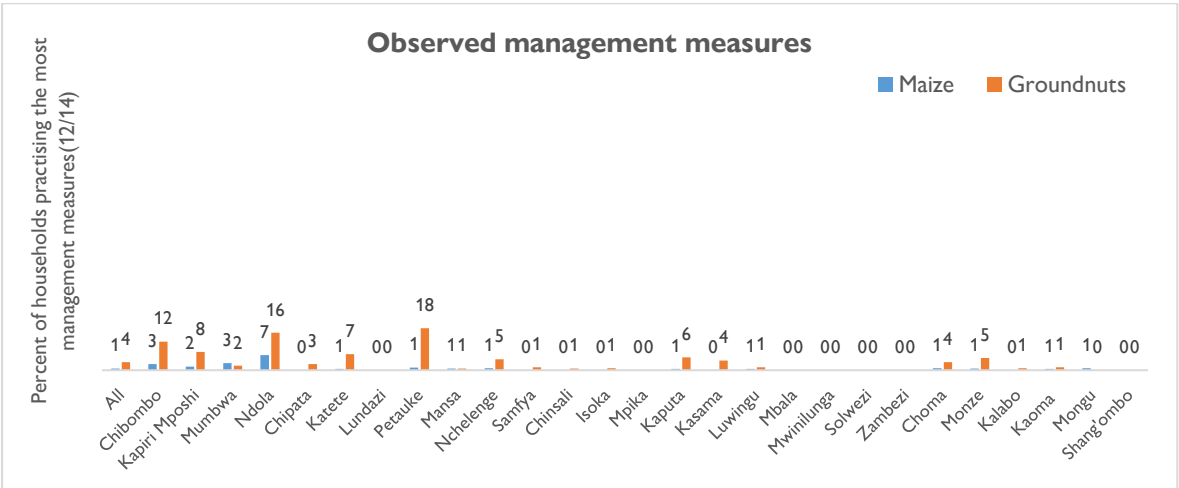
Figure 28. Percent of households observed to have applied storage practices for groundnut production



All Measures

Because aflatoxin contamination can occur at any point along the production chain, it is recommended that households practise as many management measures as possible. When looking at the combination of practices, very few households (0.7% for maize and 3.5% for groundnuts) were observed to practise at least 12 of the 14 recommended measures (Figure 29).

Figure 29. Percent of households observed to practise 12 of 14 aflatoxin management measures



Ranking of Aflatoxin Management Practices based on Adherence

Table 3 summarises the extent of households' adherence to the range of aflatoxin practices that could curb aflatoxin exposure and or contamination. If 60% or more households adhered to a practise, we classified it as "performing (relatively) well". Otherwise, it was classified as "performing poorly".

It is worth noting that not all aflatoxin management practices adhered to could be attributed to households receiving aflatoxin-specific information (per Figure 14, only 17% received aflatoxin-specific information) or as a result of households knowing that these measures limit aflatoxin exposure and or contamination, but rather because some of these are generally good agricultural practices.

Table 3. Ranking of aflatoxin management practices

	Performing (Relatively) Well (≥ 60% of households)	**Performing Poorly** (≤ 59% of households)
Pre-Harvest Management	• Control for weeds • Plant on Time • Control for pests (for groundnuts)	• Control for pests (for maize) • Fertilizer application (basal and top dressing)
Harvest Management Practices	• Harvest maize dry • Sort shrivelled and discoloured maize cobs • Dry groundnuts unshelled after harvest • Discard/dry mouldy groundnuts • Sort for shrivelled and discoloured groundnuts	• Maize not damaged in the field • Maize harvested with complete husk cover • Harvest groundnuts dry • Dry groundnuts using recommended practices • Groundnuts become wet and mouldy during drying
Handling Management Practices	• Dry mill the maize • Sort for shrivelled and discoloured maize • Sort groundnuts before making flour	• De-hull maize • Do not soak groundnuts before cooking
Post-Harvest Practices	• Store using recommended material • Use recommended storage structures for long-term storage • Store groundnuts unshelled	• Observe for moulding and do something about it • Treat crops before storage • Clean storage structure before use • Store maize unshelled
Observations	• Crops do not feel wet to touch • No presence of insects • No debris and animal droppings • Storage and handling equipment free of left-over crops • Store crops unshelled • Area around storage structure free of weeds • No presence of mould • Use of recommended long-term storage structure for groundnuts • Store groundnuts using recommended material	• Use recommended long-term storage structure for maize • Maize and groundnut storage structures with no sealing of cracks and/or holes or light coming in • Use of recommended practices to dry crops • Sort for damaged and or shrivelled crops • Store maize using recommended material • Treat crops (in storage)

Table 3 demonstrates considerable gaps in households' implementation of aflatoxin measures along the stages of production. Households did not sufficiently adhere to controlling pests or applying adequate fertilizer at the pre-harvest stage. At harvest stage, few harvest maize with complete husk cover, kept crops from getting wet and mouldy while drying or dried crops with recommended practices. Observing for mould and taking action (sorting and throwing infected grains away), treating crops before storage, cleaning storage structures before use, and storing unshelled crops were not followed adequately post-harvest. In terms of actual observation, most households did not: use recommended long-term storage structures, storage structures with no cracks or light coming in, use recommended drying practices, store crops using recommended material, and treat crops in storage. It was also observed that most households had damaged or shrivelled crops.

3.5 Association of Aflatoxin Management Techniques with Stunting

Pairwise correlations between aflatoxin management techniques at each crop production stage and stunting levels of children under 2 years of age from the 2019 baseline survey were tested (Table 4). The management measures at each production stage were computed as a dummy variable equal to 1 if the household adhered to all practices and zero otherwise. Equally, stunting was generated as a categorical variable, with 1 if the child was stunted and zero otherwise. While households should ideally practise all or most of the management measures discussed in earlier sections, this was not the case. Some households practised all the measures while others only practised a fraction.

Pairwise correlations between the various indexes of management measures and stunting levels were tested. In addition, correlations between individual measures along the different stages of production and stunting levels were estimated and tested.

The results show a negative correlation between stunting and reporting of appropriate aflatoxin management practices at each stage. The pairwise correlations between individual measures and stunting levels were found to generally be negatively correlated and significant for pest control, mould control, de-hulling, and how the crops were harvested and stored (Table 4)[16]. These imply that increasing household adoption of recommended aflatoxin management practices will likely reduce childhood stunting. However, it is worth noting that there are several pathways through which aflatoxins can affect stunting, as illustrated in Figure 1. Thus, the correlation coefficient estimated should be understood as a mere association and not causation.

Table 4. Correlation between aflatoxin management measures and child stunting under 2 years of age

Production Stages	Pairwise Correlation Coefficients	
	Maize	Groundnuts
Pre-harvest (composite index)	-0.0205 (0.2084)	-0.0504** (0.0339)
Individual pre-harvest measures		
Pest control	-0.0387** (0.0176)	-0.0577** (0.0150)
Harvest (composite index)	0.0186 (0.3000)	-0.0632*** (0.0028)
Individual harvest measures		
Harvested mainly fresh/dry	0.0342* (0.0596)	
Avoid crops getting wet or mouldy during drying		-0.0411* (0.0906)
Sorting for broken or shrivelled crops		-0.0449** (0.0338)
Handling (composite index)	-0.0611*** (0.0002)	-0.0168 (0.3016)
Individual handling measures		
De-hulling	-0.0532*** (0.0018)	
Storage (composite index)	-0.0396** (0.0147)	-0.0270* (0.0960)

[16] The pairwise correlations between individual measures and stunting levels not included in Table 5 were found to be insignificant.

Production Stages	Pairwise Correlation Coefficients	
	Maize	Groundnuts
Individual storage measures		
Observe for moulding and/or do something about it	-0.0317* (0.0504)	
Groundnuts stored unshelled		-0.0702** (0.0114)
Storage structure used for long-term		-0.0626** (0.0241)

*Note: ***, **, * imply significance at 1% (99% confidence interval), 5% (95% confidence interval) and 10% (90% confidence interval) respectively. In parenthesis are the p values.*

Evidence elsewhere has shown that aflatoxin negatively affects children's nutrition. For example, a study in Nampula Province, Mozambique, using biomarkers/serum samples (aflatoxin levels and anthropometric measurements e.g. weight and height) to investigate the relationship between aflatoxin exposure and chronic malnutrition[17], found an association between stunting and aflatoxin, with the association stronger in older children. The authors concluded that households with better agricultural practices (for maize and groundnuts) had lower aflatoxin levels. However, aside from drying and storage practices, the study did not look at the other practices or stages of production.

Similarly, Rasheed *et al.* estimated the health burden of aflatoxin-attributable stunting among children in four African countries (Benin, Gambia, Tanzania, and Togo)[18]. Using biomarker-based exposure data and anthropometric data from surveys done over 12 years (2001 – 2012), the study calculated population attributable risk (PAR), lifetime disease burden for children under five, by comparing two groups of stunted children using both prevalence and incidence-based approaches. The prevalence estimates were combined with a disability weight, measuring childhood stunting and co-occurrence of stunting-underweight to produce years lived with disability. A probabilistic model was used to estimate the associations. The study found more significant stunting in countries with higher aflatoxin exposure.

Other studies that have found a significant association between aflatoxins and nutrition outcomes include studies by Shuaib et al. (2010)[19] and Smith et al. (2019)[20] . They investigated the presence of aflatoxin and the levels of aflatoxins in pregnancy on birth outcomes.

Though such strong conclusions cannot be drawn from the analysis in this study, such an association is observed (Table 4). Thus, it can be inferred that adherence to agricultural best practices could lower aflatoxin levels and, in turn, improve child nutrition/development in Zambia.

[17] Malave, M., Costa, S., Salavessa, J., Appel, K., and Ghosh, S. 2021. The relationship Between Aflatoxin Exposure and Chronic Malnutrition in Nampula Province, Mozambique. USAID; Feed the Future. https://www.advancingnutrition.org/sites/default/files/2021-06/tagged_Relationship_Aflatoxin_Exposure_and_Chronic_Malnutrition_webinar_transcript.pdf

[18] Rasheed, H., Xu, Y., Kimanya, M.E. *et al.* Estimating the health burden of aflatoxin attributable stunting among children in low income countries of Africa. *Sci Rep* **11,** 1619 (2021). https://doi.org/10.1038/s41598-020-80356-4

[19] Shuaib, F.M.B., Jolly, P.E., Ehiri, J.E., Yatich, N., Jiang, Y., Funkhouser, E., Person, S.D., Wilson, C., Ellis, W.O., Wang, J.-S. and Williams, J.H. (2010), Association between birth outcomes and aflatoxin B_1 biomarker blood levels in pregnant women in Kumasi, Ghana. Tropical Medicine & International Health, 15: 160-167. https://doi.org/10.1111/j.1365-3156.2009.02435.x

[20] Smith, L. E., Prendergast, A. J., Turner, P. C., Humphrey, J. H., & Stoltzfus, R. J. (2017). Aflatoxin Exposure During Pregnancy, Maternal Anemia, and Adverse Birth Outcomes. *The American journal of tropical medicine and hygiene*, *96*(4), 770–776. https://doi.org/10.4269/ajtmh.16-0730

4 CONCLUSION

A considerable proportion of rural Zambian households knew what aflatoxins were and what caused them. However, most households did not know that the rotting of crops indicated aflatoxin and/or aflatoxin contamination. In addition, households were unaware of the aflatoxin chronic health risks (such as stunting and cancer) apart from acute health risks such as stomach pains and diarrhoea.

Very few households (17%) received aflatoxin-specific information (good farming and storage practices), most commonly through meetings and informal conversations. While nearly all these households reportedly applied the information they received, lack of technical guidance and resources were cited as challenges to implementation.

There is mixed adherence to aflatoxin management measures across districts and households. Few households reported applying all the recommended management practices, which was confirmed through observations. Thus, most maize and groundnut crops were susceptible to aflatoxin contamination. At the pre-harvest and handling stage, some households practised almost aflatoxin management measures for maize, but fewer households did so for groundnuts.

At the post-harvest stage, virtually no households practised all management measures for both maize and groundnuts. Household practices were primarily limited to sorting produce and drying. Treating crops post-harvest was rarely adhered to. In addition, many households had compromised storage structures, and their produce had the presence of mould and insects. Furthermore, few households used appropriate bags for storage (jute, hermetic, and polyethylene bags). Thus, most household crops were potentially susceptible to aflatoxin contamination.

The high consumption of aflatoxin-susceptible crops, and the low adherence to management techniques, are causes for concern, particularly as the study found a negative and significant correlation between young child stunting and aflatoxin management practices.

5 RECOMMENDATIONS

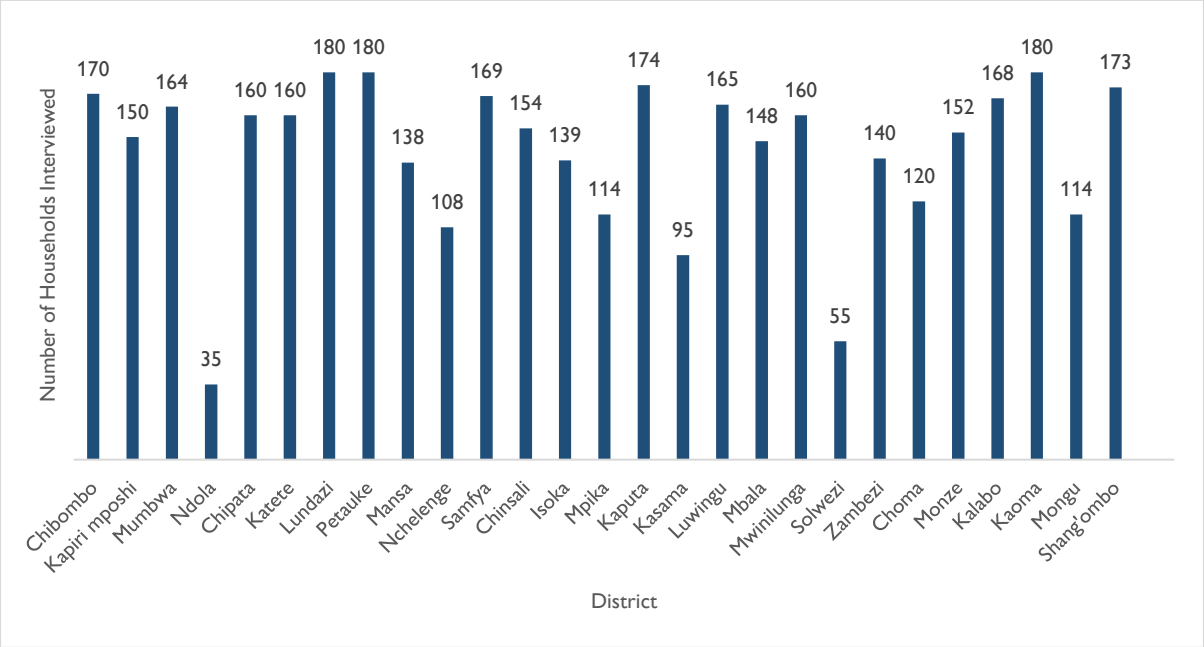
Based on the findings, the following recommendations are proposed:

- There is a need for more intensive sensitization (inclusive of demonstrations) on aflatoxins, their causes, and their health effects. Sensitization and training on the various aflatoxin management measures are necessary, given the low adherence to ideal management measures at the household level. Most agricultural information is delivered by Agriculture extension officers. Thus, existing education efforts need to be upscaled, emphasizing aflatoxin-specific information to be delivered through mediums of communication readily available to rural households.
- Scale up technical guidance efforts, particularly in districts with the lowest adherence to aflatoxin management practices. The Ministry of Agriculture, and its implementation partners, should emphasize educating farmers in the management practices least practised at each stage of production. Interventions focused on cost-effective management practices are required, as households expressed cost concerns around current recommended practices. Integrated management approaches (pre and post-harvest) against aflatoxin contamination should be promoted, including use of good seeds, sorting grains, and pest and insect control.
- Consider future research that includes aflatoxin biomarkers in crops and women and children to ascertain aflatoxin levels, as well as anthropometric measurements of children and women. Such data can be used to explore the association between aflatoxins and nutrition outcomes. The findings should then be tested against aflatoxin preventative measures.
- Lastly, consider future aflatoxin studies that include cassava, a widely consumed crop in areas such as Luapula, Northwestern, Northern, and Western provinces. Otherwise, efforts to reduce aflatoxin exposure in maize and groundnuts will have little impact in addressing children's nutrition outcomes in these geographic areas.

ANNEX 1. Distribution of Households by District

District	Number of Households Targeted	Number of Households Interviewed	Response Rate (%)
Chibombo	180	170	94.4
Kapiri Mposhi	160	150	93.8
Mumbwa	180	164	91.1
Ndola	40	35	87.5
Chipata	160	160	100.0
Katete	160	160	100.0
Lundazi	180	180	100.0
Petauke	180	180	100.0
Mansa	140	138	98.6
Nchelenge	120	108	90.0
Samfya	180	169	93.9
Chinsali	160	154	96.3
Isoka	140	139	99.3
Mpika	120	114	95.0
Kaputa	180	174	96.7
Kasama	100	95	95.0
Luwingu	180	165	91.7
Mbala	160	148	92.5
Mwinilunga	160	160	100.0
Solwezi	60	55	91.7
Zambezi	180	140	77.8
Choma	120	120	100.0
Monze	160	152	95.0
Kalabo	200	168	84.0
Kaoma	180	180	100.0
Mongu	120	114	95.0
Shang'ombo	200	173	86.5
Total	**4100**	**3865**	**94.3**

ANNEX 2. Distribution (Number) of Households Interviewed by District



ANNEX 3. List of Quality Controllers, Enumerators, and Supervisors

Quality Controllers

	NAME	GENDER
1	Chishimba, Mwamba	M
2	Malambo, Miyanda	F
3	Singogo, K. Fwasa	M
4	Subakanya, Mitelo	F

Supervisors

	NAME	GENDER
1	Banda, Harrison	M
2	Kayula, Makasa	M
3	Mapulanga, Leeroy	M
4	Mbusopo, Francis	M
5	Pele, Winnie	F
6	Sambo, Jairos	M
7	Saunders, Robin	M
8	Sikananu, Sikananu	M

Enumerators

	NAME	GENDER
1	Banda, T Mary	F
2	Banda, Emelia	F
3	Banda, Monica	F
4	Bangwe, Ngosa	F
5	Chalwe, Petronella	F
6	Chama, Precious	F
7	Chapula, Staric	M
8	Chilenga, Moono	F
9	Chilufya, Ronald	M
10	Chipili, Maxus Bweupe	M
11	Chungulo, Matria	F
12	Hakoola, Mudenda	F
13	Jama, Nandi	F
14	Kangwa, Maureen	F

	NAME	GENDER
15	Kasweshi. Mayeba Milcah	F
16	Kilele, Ndaona	F
17	Lisulo, Namenda	F
18	Ilwange, Mwala	M
19	Maunga, Janet	F
20	Mbewe, Christabel	F
21	Mhango, Khondwani	M
22	Mukuma, Sombo	F
23	Muletambo, Sylvia	F
24	Mutale, Mulenga	F
25	Mutanga, Maimbolwa	F
26	Muyobela, Theresa	F
27	Mweemba, Nature	F
28	Mweengwe, Shafwuluma	F
29	Mwepwe, Clifford	M
30	Mwila, Natasha	F
31	Ng'ambi, Chaka Collins	M
32	Ngulube, Munsele Gift	M
33	Nkumbu, Cyrus	M
34	Phiri, Grace	F
35	Phiri, Weluzani	M
36	Phiri, Zewelanji	M
37	Sakala, Dorinda	F
38	Shawa, Mary	F
39	Shumba, Elidah	F
40	Silishebo, Nalikando	F

ANNEX 4. Survey Instrument

SECTIONS OVERVIEW

A. INFORMED CONSENT FORM
B. HOUSEHOLD IDENTIFICATION
C. HOUSEHOLD ROSTER AND DEMOGRAPHICS
D. FARMLAND AND USE
E. CROP PRODUCTION, HARVEST AND MANAGEMENT
F. STORAGE PRACTICES
G. AFLATOXIN MANAGEMENT PRACTICES DURING FOOD PROCESSING FOR CONSUMPTION
H. KNOWLEDGE ON AFLATOXINS
I. SOURCES OF INFORMATION ON AFLATOXINS
J. OBSERVATIONS

A. INFORMED CONSENT FORM

This survey is part of a team effort to gain knowledge on practices in aflatoxin management among rural households in Zambia. The study will contribute to shaping policy interventions on aflatoxin management particularly in maize and groundnuts in Zambia and subsequently learning on how best to reduce child malnutrition outcomes linked to aflatoxins. Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you confirm your participation, you are still free to skip questions that may deem personal or otherwise, you are also free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be permanently destroyed. You indicate your voluntary consent of participating in this interview by giving verbal consent. If you have questions about this survey, you may contact the IAPRI Research Fellow Dr Mary Lubungu on +260 975901466 or the ERES Converge IRB Chairman, Dr Jason Mwanza on +260 955155633. May we begin?

B. HOUSEHOLD IDENTIFICATION

Province		**PROV**	
District	_____	**DIST**	
Constituency	_____	**CONST**	
Cluster	_____	**CLUSTER**	
Region	**1= Rural**	**REGION**	
Combined Statistical Area (CSA)	_____	**CSA**	
Standard Enumeration Area (SEA)	_____	**SEA**	
Village/ Section		**VIL**	
Household Serial Number		**HHID**	
Is the Respondent the Household Head	**1 = Yes** **2 = No**……		
If No, what is the name of Respondent_____			
Respondent's Phone Number	_____		
Response status	**1 = Refusal 2 = Non-contact 3 = Proceed**		
Name of Supervisor	**SUPCODE**		
Name of Enumerator	**ENCODE**		

ASSIGNMENT RECORD			
a. Name of Enumerator		**ENCODE**	
b. Name of Supervisor		**SPCODE**	
c. Name of QC		**QCCODE**	
	Date of Interview – Beginning	*Click on the button to insert date and time*	**GET TIME**

C. HOUSEHOLD ROSTER AND DEMOGRAPHICS

Table 1: Demography

Hh_size	How many people currently live in your household?	Integer
Hh_U5	Of this number, how many people below 5 years live in your household?	Integer
Hh_child	Of this number, how many people ages below 12 live in your household?	Integer
Hh_adult	Of this number, how many people ages 12 or older live in your household?	Integer
Hh_income	How many people ages 12 or older earned income from work activities, such as SALARY, INFORMAL WAGE LABOR, PENSIONS, OR IN-KIND WAGES between May 2020 and April 2021?	Integer

Enumerator: List only the household head and/or spouse starting with the household head. Remember to use capital letters and all names to start with surnames

ID	Name **(Enumerator: List only the household head and/or spouse)**	Record the month and year of birth. In which month and year was …… born? **Month (see codes below)**	**Year**	What is the sex of …….. ? **1=male 2=female**	What is the relationship of ……to the current head? **(see code below)**	What is the marital status of …..? **(see code below)** **(If born after 2008) go to next member**	What is the highest level of formal education …. completed? **(see codes below)** **(if born after 2008, go to next member)**	Primary occupation of household member **(see codes below)** **(if born after 2008, go to next member)next member)**
MEM	**NAME**	**DA01a**	**DA01b**	**DA02**	**DA03**	**DA04**	**DA05**	**DA06**
1	**SURNAME FIRST NAME**							
2								

Month of birth (DA01a)	Relation to head (DA03)	Marital Status (DA04)	Education levels (DA05)		Primary Occupation (DA06)
1=January	1= head	1 = never married	-9=Do not know	11= Form 4; Grade 11	1 = Farmer
2=February	2= spouse	2 = monogamously married	00=None	12= Form 5; Grade12	2 = Student
3=March	3= child (own/step)	3 = polygamously married	01=Sub-standard A; Grade 1	13= Form 6 Lower	3 = unemployed
4=April	4= parent/parent-in-law	4 = divorced	01=Sub-standard B; Grade 1	14= Form 6 Upper	4 = Civil servant
5=May	5= brother / sister	5 = widowed	02=Standard 1; Grade 2	15= College Student	5 = Parastatal employee
6=June	6= other relatives	6 = separated	03=Standard 2; Grade 3	16=Undergraduate student	6 = Employee of private company/individual
7=July	7= unrelated	7 = cohabiting	04=Standard 3; Grade 4	17=Certificate/Diploma	7 = casual worker/piecework
8=August			05=Standard 4; Grade 5	18= Bachelors Degree	8 = Receive pension
9=September			06=Standard 5; Grade 6	19= Masters degree & above	9= Self-employed/Entrepreneur
10=October			07=Standard 6; Grade 7		10=Housewife
11=November			08=Form 1; Grade 8		
12=December			09=Form 2; Grade 9		
-9=Do not now			10=Form 3; Grade 10		

D. FARMLAND AND USE

During the 2020/2021 agricultural season, did the household have any field?

..... F00 1=Yes 2=No skip to Section 4

How many fields did you have in the 2020/2021 agricultural season? (include non-cropped fields)

F01 _____

Enumerator, SKETCH ALL THE FIELDS and their use during the 2020/2021 agricultural season

Table 1: Fields

Field ID	What was the use of this field in the 2020/2021 agricultural season? **(see codes below)**	Enumerator: What was the size of field ……..?		What was the main crop grown in this field? **(responses required only if F02=4, 9 or 10)**	Was this field mono cropped? 1=Yes (skip to F05) 2=No	What other crop(s) was grown in this field?	Enumerator: What was land size for the other crop that was planted in this field ……..?		Who made the primary decision about what to grow in this field? **(see codes below)**
		Area of field	**Unit 1= Lima 2 = Acre 3 = Hectare 4 = Square meter**				**Area of field**	**Unit 1= Lima 2 = Acre 3 = Hectare 4 = Square meter**	
FIELD	**F02**	**F01a**	**F01b**	**F03**	**F03a**	**F03b**	**F04a**	**F04b**	**F05**
1									
2									
3									

Land Use (F02)		**Crop grown (F03)**			**Primary decision maker (F05)**
1= Vegetable garden	9 = Rented in	1= Maize	13=Bambara nuts	21=Other crop (specify)	1=Male head of household
2= Grazing land	10= Borrowed in	2 = Sorghum	14=Cowpeas	23=Garden	2=Female head of household
3= Forest land	11= Rented out	3 = Rice	15=Velvet beans	24=Natural fallow 25=Improved fallow	3= Other male household member
4= Own cultivated field	12= Borrowed out	4 = Millet	16=Coffee	26=Rented/borrowed out	4= Other female household member
5= Orchard		5 = Sunflower	17=Sweet potato-	27=Orchard	5=Non-household male relative
6= Fallow		6 = Groundnuts	white or yellow-	28=Virgin	6=Non-household female relative
		7 = Soya beans	fleshed	50=New field	
7-Virgin land		8 = Seed cotton	57=Sweet potato-	51=Don't know/Not available	7=Non-household male non-relative
8= Personal woodlot		9 = Irish potato	orange fleshed	52=Did not borrow/rent in/use field	8=Non-household female non-relative
		10 = Virginia tobacco	18=Cassava	53=Woodlot	9=Both head and spouse
		11 = Burley tobacco	19=Kenaf	60=Popcorn	
		12 = Mixed beans	20=Cashew nut	61=Sugarcane	
			22=Paprika	64=Pigeon peas	
				66=Sesame seed	

E. CROP PRODUCTION, HARVEST AND MANAGEMENT

Enumerator: Please ask if F03=1 or F03B=1

Table 3.1 – Maize fields and production

Field ID (enter appro-priate field number from Table 2)	What main seed variety did the household plant (for each field)? (see codes below)	What was the quantity of seed planted?		Where did you mainly source your maize seeds (for each field)?	How far from the homestead was the seeds for planting material obtained from?		Did the HH apply animal manure and/or plant manure/ compost to the field?"	How many bags of manure/compost did the household use?		Did the HH apply fertilizer to the field?"	What type of basal fertilizer was mostly used? (see codes below?)	How many bags of basal fertilizer did the HH use?		What type of top dressing fertilizer was mostly used? (see codes below?)	How many bags of top dressing fertilizer did the HH use?		Which month did the household finish the first planting of this crop? (for each field	Which week of the month did the household finish the first planting of this crop? (for each field)	Did the household find any insects, pests or diseases in the field? 1=Yes 2=No (skip to M17a)	How did the household control the observed insects, pests or disease? 1=Did nothing 2=Pesticides 3=Traditional methods 4=Other (specify)	How did the household control weeds in the maize field? 1=Did nothing (skip to M18) 2=Manual weeding 3=Herbicides 4=Both Manual and herbicide	How many complete weedings (manual or with herbicide) did the household do in this field? (Enter 0 if no complete weeding of the whole field was done)	What did the household plant in this field in the previous (2019/2020) agricultural season? (see codes below)
		Amount	Quantity (See codes below)		Distance	Unit 1=minutes 2= hours 3= meters 4=kilometers	0=None (skip to M11) 1=Yes, animal manure 2=Yes, plant manure/ compost 3=both	Amount	Unit 1=Kilograms	0=None (skip to M14a) 1=Yes, basal dressing 2=Yes, top dressing 3=both		Amount	Unit 2=50kg bag 3=25kg bag 4=10kg bag 5=20 ltr tin 12=Meda 20=kg 21=5kg 22=litre 23=Militer		Amount	Unit 2=50kg bag 3=25kg bag 4=10kg bag 5=20 ltr tin 12=Meda 20=kg 21=5kg 22=litre 23=Militer	Month (see codes below)	Week					

FIELD	M03	M04a	M04b	M05	M06a	M06b	M09	M10a	M10b	M11	M12	M13a	M13b	M12.2	M12.2a	M12.2b	M14a	M14b	M16a	M16b	M17a	M17b	M18

Seed Variety (M03)	Seed Quantity (M04b)	Source of Seed (M05)	Fertilizer type (M12)	Month (M14b)	Crops planted in the previous season (M08, M18)	
1=Zamseed 2=Pioneer 3=SeedCo 4=Panner 5=MRI/Syngenta 6=Klein Karoo 7=Other (specify) 8=Local maize 9=hybrid maize –non specific 10=Recycled hybrid maize 11=OPV maize 12=ZARI MoA 14=KAMANO 16=Progene Seed 18=Advanta 19=Capstone seeds 21=Carnia Seed 22=GTZ 23=DK/Bayer -9=Do not know	2=50kg bag 3=25kg bag 4=10kg bag 5=20lt tin 11=5lt gallon 12=MEDA 20=kilogram	1=Private retailer/agro-dealer - boma 2=Private seed company 3=Govt Food Security Pack 4= Govt Farmer Input Support Program 5=Another farmer 6=Own harvest 7=Out-grower/input credit 8=Private retailer/agro-dealer outside boma 9=Local seed producer 10=Cooperative/farmer group Lima credit or others) 11= Friends or relatives 12= Other (specify)	1=Compound D 2=Compound X 3=Compound S 4=Triple Super Phosphate (TSP) 5=Single Super Phosphate (SSP) 6=Compound R 7=Compound WV 8=Di-grow (foliar) 9=Wonder (foliar) 10=Vegetative (foliar) 11=Urea 12=Ammonium Nitrate 13=CAN 14=Allwin top 15=Flower&Plant (foliar) 16=Compound B 17=Solubar 18=Do not know 99=Other specify	1=January 2=February 3=March 4=April 5=May 6=June 7=July 8=August 9=September 10=October 11=November 12=December	1= Maize 2 = Sorghum 3 = Rice 4 = Millet 5 = Sunflower 6 = Groundnuts 7 = Soya beans 8 = Seed cotton 9 = Irish potato 10 = Virginia tobacco 11 = Burley tobacco 12 = Mixed beans 13=Bambara nuts 14=Cowpeas 15=Velvet beans 16=Coffee 17=Sweet potato-white or yellow-fleshed 57=Sweet potato-orange fleshed 18=Cassava 9=Kenaf 20=Cashew nut 21=Other crop (specify)	22=Paprika 23=Garden 24=Natural fallow 25=Improved fallow 26=Rented/borrowed out 27=Orchard 28=Virgin 50=New field 51=Don't know/Not available 52=Did not borrow/rent in/use field 53=Woodlot 60=Popcorn 61=Sugarcane 64=Pigeon peas 66=Sesame seed

3.2 Maize harvest and management

When did the household start harvesting maize? **(see codes below)**	Was the maize harvested mostly when fresh or dry? **1=Fresh 2=Dry**	How did the household harvest the maize? **1=With husks 2=Without husks (skip to MH04b)**	Did any of the harvested maize have incomplete husk cover? **1=Yes 2=No**	Was there any maize damaged in the field at the time of harvest? **1=Yes 2=No (Skip to MH06 3=Not yet harvested**	Did the household sort any damaged or shrivelled cobs/grains? **1=Yes 2=No 3=Not yet harvested**	What was the TOTAL quantity of maize harvested from all the maize fields in the 2020/2021 agricultural season		Was the area harvested equal to the area planted? **1=Yes (skip to Table 3.3) 2=No**	What was the main reason for not harvesting the whole area planted? **(see codes below)**	How did the household dispose of the crop residue after harvest? **1=Burning 2=Cleared and removed from the field 3=Left to rot in field 4=Other (specify)**
						Amount	**Quantity (see codes below)**			
MH01	**MH02**	**MH03**	**MH04a**	**MH04b**	**MH05**	**MH06a**	**MH06b**	**MH07a**	**Mh07b**	**Mh08**

Month (MH01)		**Reason for not harvesting total area planted (MH07b)**				**Harvest unit code (MH06)**	
1=January	**7=July**	**1 = water logging**	**7 = theft**	**13= not enough labour**	**19 = witch weed / striga**	1=90 kg bag	14=MUCHUMBU
2=February	8=August	**2 = wilting due to drought**	**8 = floods, heavy rain**	**14= failed germination due to drought**	**20 = do not know**	2=50kg bag	15=ka B.P.
3=March	9=September	**3 = animal/bird destruction**	**9 = soils generally bad**	**15= failed germination due to bad seed**	**21= other (specify) .....**	3=25kg bag	16=crates
4=April	10=October	**4 = field not weeded, weeded late**	**10=lack of fertilizer**	**16=due to bad seed**		4=10kg bag 5=20lt tin	17= tonnes
5=May	11=November	**5 = pests and diseases pests and diseases**	**11= lack management experience**	**17= planted late**		6=90kg bag unshelled	18=boxes
6=June	12=December	**6 = fire**	**12= received bad advice**	**18= eaten fresh**		7=50kg bag unshelled	19=number/cuttings/ seedlings
	13=Did not harvest (skip to MH08)					8=25kg bag unshelled	20=kilogram 21=cup
						9=10 kg bag unshelled	22=meda unshelled
						10=20lt tin unshelled	23=ka B.P. unshelled
						11=5lt gallon	
						12=MEDA	
						13=bunches	

Enumerator: Ask if F03=6 OR F03B=6

Table 3.3 Groundnut fields and production

Field ID (enter appro-priate field number)	What main seed variety did the household plant (for each field)? (see codes below)	Where did you mainly source your groundnut seeds (for each field)? (see codes below)	What was the quantity of seed planted?		How far from the homestead was the location where the household got the seed/planting material? Enter 0 if own harvest Reference to time based on walking		Did the HH apply animal manure and/or plant manure/ compost to the field?" 0=None (skip to G10a) 1=Yes, animal manure 2=Yes, plant manure/ compost 3=both	How many bags of manure did the household use?		Did the HH apply fertilizer to the field?" 0=None (skip to M14a) 1=Yes, basal dressing 2=Yes, top dressing 3=both	What type of basal fertilizer was mostly used? (see M12 codes)	How many bags of basal fertilizer did the HH use?		What type of top dressing fertilizer was mostly used? (see M12 codes)	How many bags of top dressing fertilizer did the HH use?		Which month did the household finish the first planting of this crop? (for each field) (See codes below)	Which week of the month did the household finish the first planting of this crop? (for each field)		Did the household find any insects, pests or diseases in the field? 1=Yes 2=No (skip to G14)	How did the household control the observed insects, pests or disease? 1=Did nothing 2=Pesticides 3=Traditional methods (spraying with chili, tephrosia etc) 4=Other (specify)	How did the household control weeds in the groundnut field? 1=Did nothing (skip to G18) 2=Manual weeding 3=Herbicide 4=Both Manual and herbicide	How many complete weedings (manual or with herbicide) did the household do in this field? (Enter 0 if no complete weeding of the whole field was done)	What did the household plant in the previous 2019/2020 agricultural season? (see codes below)
			Amount	Quantity (See codes below)	Distance	Unit 1=minutes 2= hours 3= meters 4=kilometers		Amount	Quantity 1=Kilograms			Amount	Unit 2=50kg bag 3=25kg bag 4=10kg bag 5=20 ltr tin 12=Meda 20=kg 21=5kg 22=litre 23=Militer		Amount	Unit 2=50kg bag 3=25kg bag 4=10kg bag 5=20 ltr tin 12=Meda 20=kg 21=5kg 22=litre 23=Militer	Month	Week	Month (see codes below)					
FIELD	G03	G04	G05a	G05b	G06a	G06b	G08	G09a	G09b	G10	G11a	G11b	G12c	G12	G12a	G12b	G13	G13a	G13b	G14	G15	G16	G17	G18

Seed Variety (G03)		Seed quantity (G05b)	Source of Seed (G04)	Crops planted (G07b)		Month (G13)	Crops planted in the previous season (G18)	
1=Local groundnuts 2=Hybrid groundnuts 3=Recycled hybrid 4=OPV groundnuts 5=Chipego 6=MGV 4 7=Chalimbana 8=Flamingo 9=Nyanda 10=Chishango 11=ICGVSM-99-568 12=MGV5 13=Natal Common 14=Kanjute 15=Makuru Red 16=SC Mwenje 17=SC Orion	18=ZamG 14 19=Muvuni 99=Other (Specify) 20= MGV6 21= MGV7 22= MGV8 23= MGV9	2=50kg bag 3=25kg bag 4=10kg bag 5=20lt tin 11=5lt gallon 12=MEDA 20=kilogram	1=Private retailer/agro-dealer near boma 2=Private seed company 3=Government Food Security Pack 4=Another farmer 5=Own harvest 6- Out-grower/input credit 7= Private retailer/agro-dealer outside boma 8= Local seed producer 9= Cooperative/farmer group Lima credit or others 10= Friends or relatives 12= Govt Farmer Input Support Program 11= Other (specify)	1=Maize 2=Sorghum 3=Rice 4=Millet 5=Sunflower 6=Groundnuts 7=Soya beans 8=Seed Cotton 9=Irish Potato 10=Virginia tobacco 11=Burley tobacco 12=Mixed beans 13=Bambara nuts 14=Cowpeas 15=Velvet beans 16=Coffee 17=Sweet potato-White or yellow 18=Orange fleshed Sweet potato	19=Cassava 20=Kenaf 21=Cashew nut 22=Paprika 23=Popcorn 24=Sugar cane 25=Pigeon peas 26=Sesame seed 27=Other (specify)	1=January 2=February 3=March 4=April 5=May 6=June 7=July 8=August 9=September 10=October 11=November 12=December	1= Maize 2 = Sorghum 3 = Rice 4 = Millet 5 = Sunflower 6 = Groundnuts 7 = Soya beans 8 = Seed cotton 9 = Irish potato 10 = Virginia tobacco 11 = Burley tobacco 12 = Mixed beans 13=Bambara nuts 14=Cowpeas 15=Velvet beans 16=Coffee 17=Sweet potato-white or yellow-fleshed 57=Sweet potato-orange fleshed 18=Cassava 9=Kenaf 20=Cashew nut 21=Other crop (specify)	22=Paprika 23=Garden 24=Natural fallow 25=Improved fallow 26=Rented/borrowed out 27=Orchard 28=Virgin 50=New field 51=Don't know/Not available 52=Did not borrow/rent in/use field 53=Woodlot 60=Popcorn 61=Sugarcane 64=Pigeon peas 66=Sesame seed

Table 3.4 Groundnut harvesting, storage and management

When did the household start harvesting groundnuts? **(see codes below)**	Where the groundnuts mostly harvested when fresh or dry? **1=Fresh (skip to Gh04) 2=Dry**	How did the household dry the groundnuts after harvest? **1=Unshelled 2=Shelled**	Did the household experience the groundnuts becoming wet or mouldy during the drying process? **1=Yes 2=No (skip to GH06) 3=Did not dry (skip to GH06)**	How did the household handle the wet groundnuts when this happened? **1=Did nothing 2=Laid it out in the sun 3=Threw away 4=Other (specify)**	Were there any broken discoloured or shrivelled groundnuts in the field at the time of harvest? **1=Yes 2=No**	Did the household sort any broken, discoloured or shrivelled groundnuts during harvest? **1=Yes 2=No**	On what surface did the household dry most of the groundnuts harvested from the 2020/21 agricultural season? **(see codes below)**	What was the TOTAL quantity of groundnuts harvested from all the groundnut fields in the 2020/2021 agricultural season (this should include both fresh and dry harvest)		Was the area harvested equal to the area planted? **1=Yes (skip to GH12) 2=No**	What was the main reason for not harvesting the whole area planted? **(see codes below)**	How did the household dispose of the crop residue after harvest? **1=Burning 2=Cleared and removed from the field 3=Left to rot in field 4=Other (specify)**
								Amount	**Quantity (see codes below)**			
GH01	**GH02**	**GH03**	**GH04**	**GH05**	**GH06**	**GH07**	**GH08**	**GH09a**	**GH09b**	**GH10**	**GH11**	**GH12**

Month (GH01)		Drying Surface (GH08)	Quantities (GH09b)		Reason for not harvesting total area planted (GH11)	
1=January 2=February 3=March		1=On a mat or tarpaulin2=Drying rack 8=On pallets 10=On a sack	1=90 kg bag 2=50kg bag 3=25kg bag	11=5lt gallon 12=MEDA 13=bunches	1 = water logging 2 = wilting due to drought 3 = animal/bird destruction	10=lack of fertilizer 11= lack management experience 12= received bad advice

4=April 5=May 6=June 7=July 8=August 9=September 10=October 11=November 12=December 13=Did not harvest (skip to GH12)	13=Directly on the ground 3=Concrete 4= Rooftop 5=In the field/on the ground 6=Used a Mandela Cock 7=On plastic//polyethylene bags 8=Did not dry 99=Other (specify)	4=10kg bag 5=20lt tin 6=90kg bag unshelled 7=50kg bag unshelled 8=25kg bag unshelled 9=10 kg bag unshelled 10=20lt tin unshelled	14=MUCHUMBU 15=ka B.P. 16=crates 17= tonnes 18=boxes 19=number/cuttings/ seedlings 20=kilogram 21=cup 22=meda unshelled 23=ka B.P. unshelled	4 = field not weeded, weeded late 5 = pests and diseases 6 = fire 7 = theft 8 = floods, heavy rain 9 = soils generally bad	13= not enough labour 14= failed germination due to drought 15= failed germination due to bad seed 16=due to bad seed 17= planted late 18= eaten fresh 19 = witch weed / striga 20 = do not know 21= other (specify)

F. STORAGE PRACTICES

***Enumerator: Please tell the household you are now going to ask about the produce storage practices. (Ask if* F03=1 or F03B=1)**

Table 1: 2019/2020 Agricultural Season

Did the household store any maize from its own production in the 2019/2020 agricultural season?	1=Yes	2=No (skip to SG01)	SM01	
In what form did the household mainly store the maize?	1=Shelled	2=Unshelled (skip to SM03)	SM02a	
If shelled, what method of shelling did the household use? 1=Hand shelling 2=Beating 3=Maize Sheller 4=Other (specify)			SM02b	
How did the household treat the maize before storage? 1=Did not treat 2=Used chemicals 3=Used traditional Methods (e.g. Ash, chili, tephrosia) 99=Other (specify)			SM03	
What material did the household use to store the maize? 1=Jute bags 2=Polypropylene bags 3=Hermetic bags 4=Did not use any bags 5=Other (specify)			SM04	
For long-term storage, in what kind of structure did the household store most of the maize from the 2019/2020 agricultural season for future home consumption or sale? 1=In an open crib, loose ..... 7=In a brick structure, loose 2=In an open crib in sacks ..... 8=In a brick structure in sacks 3=In a closed mud structure, loose 9=In the house loose 4= In a closed mud structure in sacks 10=In the house, in sacks			SM05	

5=In a cement plastered structure loose 11=Household did not store maize 6=In a cement plastered structure in sacks 12=On a rack 13=Tied to tree branches					
How did the household clean the storage structure before storage of the harvest? 1=Did not clean 2=Cleaned with chemicals 3=Cleaned with water 4=Used traditional Methods (e.g. Ash, chili, tephrosia) 5=Swept room 99=Other (specify)				SM06	
When did the household treat the maize after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know -98 Does not treat	Unit **1=Week** **2=Month** **3=Year**		SM07	
How often did the household check on the maize after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know -98 Does not check	Unitt **1=Week** **2=Month** **3=Year**		SM08	
Did the household observe any sign of moulding of the stored grain?	1=Yes		2=No (skip to SM10)	SM09a	
If yes, what action did the household mainly take? 1=Did nothing 2=Threw away the moulded grain 3=Aerated/cleaned out the storage area 4=Laid out in the sun 5=Used traditional Methods (e.g. Ash, chili, tephrosia) 6=Fed to livestock 99=Other (specify)				SM09b	
Are these your usual storage practices? **1=Yes** (skip to section 5) **2=No**				**SM10**	

***Enumerator: Please tell the household you are now going to ask about the produce storage practices. (Ask if* F03=6 or F03B=6)**

Table 1.1: 2019/2020 Agricultural Season

Did the household store any groundnuts after harvesting in the 2019/2020 Agricultural season?	1=Yes	2=No (skip to SG201)	SG01	
In what form did the household store the groundnuts?	1=Shelled	2=Unshelled (skip to SG03)	SG02a	
If shelled, what method of shelling did the household use? 1=Hand shelling (added water)			SG02b	

2= Hand shelling (did not add water) 3=Groundnut Sheller 4=Hand shelling (both with and without adding water) 5=Other (specify)		
Did the household treat the groundnuts before storage? 1=Did not treat 2=Used chemicals 3=Used traditional Methods (e.g. Ash, chili, tephrosia) 4=Other (specify)	SG03	
What material did the household use to store the groundnuts? 1=Jute bags 2=Polypropylene bags 3=Hermetic bags 4=Did not use any bags 5=Open bucket 6=Closed bucket 99=Other (specify)	SG04	
Did the household sprinkle any water on the groundnuts during the shelling process 1=Yes 2=No		
Did the household clean the storage structure before storage of the harvest? 1=Did not clean 2=Cleaned with chemicals 3=Cleaned with water 4=Used traditional Methods (e.g. Ash, chili, tephrosia) 5=Swept room 99=Other (specify)	SG05	
For long-term storage, in what kind of structure did the household store most of the groundnuts from the 2019/2020 agricultural season for future home consumption or sale? 1=In an open crib,loose..... 7=In a brick structure, loose 2=In an open crib in sacks ..... 8=In a brick structure in sacks 3=In a closed mud structure, loose 9=In the house loose 4= In a closed mud structure in sacks 10=In the house, in sacks 5=In a cement plastered structure loose 11=Household did not store maize 6=In a cement plastered structure in sacks 12=On a rack 13=Tied to tree branches	SG06	

Did the household treat the groundnuts after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know	Unit **1=Week**		SG07	

	-98 Does not treat	**2=Month 3=Year**				
How often did the household check on the groundnuts after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know -98 Does not check	Unit **1=Week 2=Month 3=Year**			SG08	
Did the household observe any sign of moulding of the stored grain?			1=Yes	2=No(skip to SG10)	SG09a	
If yes, what action did the household mainly take? 1=Did nothing 2=Threw away the moulded groundnut 3=Aerated/cleaned out the storage area 4=Used traditional Methods (e.g. Ash, chili, tephrosia) 6=Fed to livestock 99=Other (specify)					SG09b	
Are these your usual storage practices?			1=Yes (skip to section 5)	2=No	SG10	

***Enumerator: Please tell the household you are now going to ask about the produce storage practices. (Ask if* F03=1 or F03B=1)**

Table 2: Storage for ***2020/2021 Agricultural Season***

Did (will) the household store any maize from its own production in the 2020/2021 agricultural season?	1=Yes	2=No (skip to SG201)	SM201	
In what form did (will) the household mainly store the maize?	1=Shelled	2=Unshelled (skip to SM03)	SM202a	
If shelled, what method of shelling did (will) the household use? 1=Hand shelling 2=Beating 3=Maize Sheller 4=Other (specify)			SM202b	
How did (will) the household treat the maize before storage? 1=Did not treat 2=Used chemicals 3=Used traditional Methods (e.g. Ash, chili, tephrosia) 99=Other (specify)			SM203	
What material did (will) the household use to store the maize? 1=Jute bags			SM204	

2=Polypropylene bags 3=Hermetic bags 4=Did not use any bags 5=Open bucket 6=Closed bucket 99=Other (specify)						
For long-term storage, in what kind of structure did (will) the household store most of the maize from the 2020/2021 agricultural season for future home consumption or sale? 1=In an open crib, loose ..... 7=In a brick structure, loose 2=In an open crib in sacks ..... 8=In a brick structure in sacks 3=In a closed mud structure, loose 9=In the house loose 4= In a closed mud structure in sacks 10=In the house, in sacks 5=In a cement plastered structure loose 11=Household did not store maize 6=In a cement plastered structure in sacks 12=On a rack 13=Tied to tree branches					SM205	
How did (will) the household clean the storage structure before storage of the harvest? 1=Did not clean 2=Cleaned with chemicals 3=Cleaned with water 4=Used traditional Methods (e.g. Ash, chili, tephrosia) 5=Swept room 99=Other (specify)					SM206	
When did (will) the household treat the maize after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know -98 Does not treat	Unit **1=Week** **2=Month** **3=Year**			SM207	
How often will the household check on the maize after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer -9=Do not know -98 Does not check	Unit **1=Week** **2=Month** **3=Year**			SM208	
Did the household observe any sign of moulding of the stored grain?			1=Yes	2=No (skip to SG201)	SM209a	
If yes, what action did the household mainly take? 1=Did nothing 2=Threw away the moulded grain 3=Aerated/cleaned out the storage area 4=Laid out in the sun 5=Used traditional Methods (e.g. Ash, chili, tephrosia)					SM209b	

6=Fed to livestock 99=Other (specify)				
Are these your usual storage practices?	1=Yes	2=No	SM210	If SM01=No

***Enumerator: Please tell the household you are now going to ask about the produce storage practices. (Ask if* F03=6 or F03B=6)**

Table 2.2: 2020/2021 Agricultural Season

Did (will) the household store any groundnuts after harvesting in the 2020/2021 Agricultural season?	1=Yes	2=No (skip to Section 5)	SG201	
In what form did (will) it store the groundnuts?	1=Shelled	2=Unshelled (skip to SG03)	SG202a	
If shelled, what method of shelling did (will) the household use? 1=Hand shelling (added water) 2= Hand shelling (did not add water) 3=Groundnut Sheller 4=Other (specify)			SG202b	
Did (will) the household treat the groundnuts before storage? 1=Did not treat 2=Used chemicals 3=Used traditional Methods (e.g. Ash, chili, tephrosia) 4=Other (specify)			SG203	
What material did (will) the household use to store the groundnuts? 1=Jute bags 2=Polypropylene bags 3=Hermetic bags 4=Did not use any bags 5=Open bucket 6=Closed bucket 99=Other (specify)			SG204	
Did (will) the household sprinkle any water on the groundnuts during the shelling process 1=Yes 2=No				
Did (will) the household clean the storage structure before storage of the harvest? 1=Did not clean 2=Cleaned with chemicals 3=Cleaned with water 4=Used traditional Methods (e.g. Ash, chili, tephrosia) 5=Swept room			SG205	

99=Other (specify)						
For long-term storage, in what kind of structure did (will) the household store most of the groundnuts from the 2020/2021 agricultural season for future home consumption or sale? 1=In an open crib,loose..... 7=In a brick structure, loose 2=In an open crib in sacks ..... 8=In a brick structure in sacks 3=In a closed mud structure, loose 9=In the house loose 4= In a closed mud structure in sacks 10=In the house, in sacks 5=In a cement plastered structure loose 11=Household did not store maize 6=In a cement plastered structure in sacks 12=On a rack 13=Tied to tree branches					SG206	
Did (will) the household treat the groundnuts after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer	Unit			SG207	
	-99=Do not know -98 Does not treat	**1=Week** **2=Month** **3=Year**				
How often will the household check on the groundnuts after storage *(Enumerator: Put -9 if do not know and -98 if does not treat)***?**	Integer	Unit			SG208	
	-99=Do not know -98 Does not check	**1=Week** **2=Month** **3=Year**				
Did the household observe any sign of moulding of the stored grain?			1=Yes	2=No(skip to section 5)	SG209a	
If yes, what action did the household mainly take? 1=Did nothing 2=Threw away the moulded groundnut 3=Aerated/cleaned out the storage area 4=Laid out in the sun 5=Used traditional Methods (e.g. Ash, chili, tephrosia) 6=Fed to livestock 9=Other (specify)					SG209b	
Are these your usual storage practices?			1=Yes	2=No	SM210	If SG01=No

G. AFLATOXIN MANAGEMENT PRACTICES DURING FOOD PROCESSING FOR CONSUMPTION

Enumerator: Please tell the respondents you are now going to ask about their food processing practices

FP00 Does the household grow maize 1=Yes 2=No (if no skip to FP05)

Does the household mill the harvested maize into flour? **1=Yes 2=No (skip to FP03)**	**FP01**	

Is the maize mainly wet milled or dry Milled? **1=Wet milled 2=Dry milled**	**FP02**	
Does the household sort the maize to remove the rotten/discoloured/shrivelled grains before milling or consumption? **1=Yes 2=No**	**FP03**	
Does the household dehull the maize before milling or consumption? **1=Yes 2=No**	**FP04**	

FP00_1 Does the household grow groundnuts 1=Yes 2=No (if no skip to section 6)

Does the household mill the harvested groundnuts into flour? (If F03=6) **1=Yes 2=No (skip to FP07)**	**FP05**	
Does the household sort the groundnuts before making flour? **1=Yes 2=No**	**FP06**	
Does the household soak the groundnuts before cooking them? **1=Yes 2=No**	**FP07**	

H. KNOWLEDGE ON AFLATOXINS

Enumerator: Please tell the respondents you are now going to ask about their knowledge on aflatoxins

Do you know what aflatoxins are? 1=Yes 2=No (Skip to section 7)		AF01
What do you understand about what aflatoxins are and their consequences? (Multiple select) 1=Poison 2=Fungi 3=Infection in crops 4=Other (specify)		AF03
What do you think causes aflatoxins? (Multiple select) 1=Delayed harvesting after crops attained physiological maturity 2=Poor post-harvest storage 3=Poor post-harvest handling 4=Droughts and extreme temperature 5=Humidity -9=Do not know 99=Other (specify)		AF04
What are the health risks of aflatoxins **Diarrhoea** **Stomach pain** **-9=Don't know** **99=Specify (other)**		AF04B
How can you prevent aflatoxins? (Multiple select) 1=Timely harvest 2=Proper drying of seeds 3=Proper produce handling 4=Proper storage 5=Sorting ungraded-seeds (for planting) 6=Spray chemicals		AF05

-99=Do not know 99=Other (specify)			
Have you ever had an experience with aflatoxins in your crops?	1=Yes	2=No	AF06
How did you prevent it? (Multiple select) 1=Timely harvesting 2=Sorting ungraded seeds 3=Proper storage after harvest 4=Shelling before drying 5=Air drying without any contact with soil 6=Mandela cork (ventilated stalking) 7=Did nothing			AF07

I. SOURCES OF INFORMATION ON AFLATOXINS

Enumerator: Please tell the respondents you are now going to ask about their sources of information on Aflatoxins

Who is the most important supplier of support or information on agriculture? 1=Locally organized group..... 2=Fellow farmers 3=Cooperative/farmer group..... 4= MoA Extension..... 5=FRA cooperative..... 6=Non-governmental organizations/civil society organizations 7=Ministry of Health/health officer/facility /National Food & Nutrition Commission 8=Private output traders..... 9= Private input suppliers/ stockists/ agro-dealers/ agents 10=Church based groups 11=UN Agencies 12=Parents/Relatives 99= Other (specify)			**SIG01**
Through what medium did the household receive this information? 1=Informal conversation 2=Radio program 3=Pamphlet/newspaper 4=Workshop 5=Field Day 6 =Demonstration plot 7=Visit 8=Meeting 9=Training program			**SIG02**
Have you received any information about the problems associated with aflatoxins in maize and/or groundnuts?	1=Yes	2=No (skip to	**SI01**

			section 8)	
When last did you receive this information	Year			
How often do you receive this information?	Integer	Unit 1=Month 2=Year		
Who was the most important supplier of this information 1=Locally organized group..... 2=Fellow farmers ..... 3=Cooperative/farmer group..... 4= MoA Extension..... 5=FRA cooperative..... 6=Non-governmental organizations/civil society organizations 7=Ministry of Health/health officer/facility /National Food & Nutrition Commission 8=Private output traders..... 9= Private input suppliers/ stockists/ agro-dealers/ agents 10=Church based groups 11=UN Agencies 12=Parents/Relatives 99= Other (specify)				**SI02**
Through what medium did the household receive this information? 1=Informal conversation 2=Radio program 3=Pamphlet/newspaper 4=Workshop 5=Field Day 6 =Demonstration plot 7=Visit 8=Meeting 9=Training program				**SI03**
What information or advice did you receive? (Multiple select) 1=Moisture Monitoring (in storage) 2=Temperature Monitoring (in storage) 3=Proper drying methods 4=Proper produce Handling 5=Stock rotation 6=Aflatoxin prevention and control 7=Visual inspection of produce 8=Storage structure cleaning and maintenance 9=Types of structure to prevent moulding 10=Leakage proofing storage structures 10=Where to test for aflatoxins				**SI04**

99=Others (specify)			
Did you apply this information received?	1=Yes	2=No (skip to SI07)	**SI05**
On a scale of 1 to 5 how, how high would you rate your ability to apply the information? 1=Very High 2=Above Average 3=Average 4=Below Average 5=Very Low			**SI06**
What challenges do you have in applying the information? 1=None 2=Did not understand the information 3=Lack of technical guidance 4=Lack of resources for implementation 5=Labor intensive 99=Other (specify)			**SI07**

J. OBSERVATIONS

O00: Which crop are you observing? (1= Maize 6=Groundnuts)

Enumerator: This section requires that you physically observe for the following sections at site. This can be at the field or the homestead. Please ensure you obtain consent for this process and inform the farmer this will be useful for future interventions and generation of advice.

What form is the produce in?	**O01**	1=In field (Not harvested) 2=Harvested but still at the field 3=Being dried 4=In short term storage 5= In long-term storage 6=Part in field, Part harvested 99=Other specify	
If the produce is being dried, on what surface is it being dried?	**O02** **If O01=3**	1=On a mat or tarpaulin ..... 2=Drying rack..... 3=Concrete..... 4= Rooftop..... 5=In the field/on the ground ..... 6=Used a Mandela Cock ..... 7=On plastic/polyethylene bags 8=On pallets 9=On sacks 10=On a Rack	

		11=In field (Skip to O05) 99=Other (specify)	
Is the storage structure as well as any grain handling equipment is free of leftover grain.	**O03a (If O01= 4 and 5)**	1=Yes 2=No	
Does the structure have sealing cracks and/or holes in the structures?	**O03b (If O01= 4 and 5)**	1=Yes 2=No	
Is the area around the structure should is weed free?	**O03c (If O01= 4 and 5)**	1=Yes 2=No	
Does the structure have cracks or light coming in (No leaks)?	**O03d(If O01= 4 and 5)**	1=Yes 2=No	
Is there any debris and possible animal droppings?	**O03e(If O01= 4 and 5)**	1=Yes 2=No	
For long-term storage, in what kind of structure did the household store most of the produce?	**O04** **If O01=~~4 and~~ 5**	1=In an open crib, loose..... 2=In an open crib in sacks ..... 3=In a closed mud structure, loose 4= In a closed mud structure in sacks 5=In a cement plastered structure loose 6=In a cement plastered structure in sacks 7=In a brick structure, loose 8=In a brick structure in sacks 9=In the house loose 10=In the house, in sacks 11=Household did not store maize 12=On a rack 13=Tied to tree branches	
Is there any presence of insects on produce?	**O05**	1=Yes 2=No	
Is there any presence of mould on produce?	**O06**	1=Yes 2=No	
Does the produce feel wet to the touch?	**O07**	1=Yes 2=No	
Do you notice any damaged or shrivelled produce	**O08**	1=Yes 2=No	
In what form did the household store the produce?	**O09** **(If O01= 4 and 5)**	1=Shelled 2=Unshelled 3=Both shelled and unshelled	
What material has the household used to store the produce?		1=Jute bags 2=Polypropylene bags 3=Hermetic bags 4=Did not use any bags 5=Open bucket 6=Closed bucket 99=Other (specify)	
Is the produce treated? If O00=1	**O10**	1=Yes 2=No 3=Cannot tell	

END OF QUESTIONNAIRE