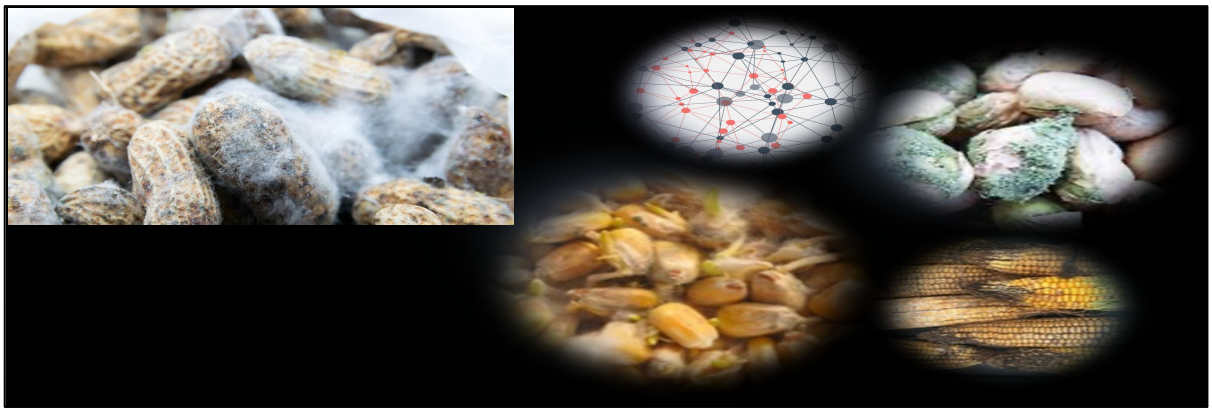
EU H2020 PROJECT
GA 862848

Linking East and West African farming systems experience into a BELT of sustainable intensification

EWA-BELT



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Incidence and Severity of Mould Spoilage and Grain Mycotoxin Contamination in East and West Africa

Grant Agreement:	862848
Project Title:	Linking East and West African farming systems experience into a BELT of Sustainable Intensification
Project Acronym:	EWA-BELT
Project Start Date:	1st October 2020
Related work package:	WP3
Lead Beneficiary:	CRAN
Submission date:	5th March 2022
Nature:	Survey Report
Dissemination Level:	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862848

DISCLAIMER

ACKNOWLEDGEMENT

This document is a deliverable of the EWA-BELT project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement Number 862848.

We thank all the collaborators of this project, particularly UNISS, CRAN, OCCAM, NM-AIST, ACRA, ICRA, CSIR-SARI, KDC, UoN, TARI, HU, KALRO and UNIMAK. The team wants to acknowledge the support of the six countries local experts who facilitated our meetings with their farmers and granting us interviews and providing us all relevant support on the field. We also appreciate the supervisors and enumerators who helped us in collecting the primary data on the field. Finally, we are thankful to all the respondents who participated in the survey.

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HISTORY OF CHANGES

Version	Date	Changes
REV 1	28th July 2022	In the executive summary, pag. 9, a note has been inserted in the Executive Summary to highlight the similarity of the two reports Deliverable 3.5 and Deliverable 3.6: *Note: The results for Deliverable 3.5 and Deliverable 3.6 were generated from a combined survey undertaken during 2021 in Kenya, Tanzania, Ethiopia, Ghana, Burkina Faso and Sierra Leone. The same sample of farmers were therefore interviewed for both deliverables. For this reason, the Introduction (Chapter 1), Materials and Methods (Chapter 2), and the General Characteristics (Chapter 3, Section 3.1) are identical for both Deliverables. This allows both reports to be read as separate standalone reports".*
		Figure 11, pag. 29 has been corrected.

TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

ACRA	Fondazione ACRA
CRAN	Cranfield University
CSIR-SARI	Council for Scientific and Industrial Research - Savanna Agricultural Research Institute
EWA-BELT	Linking East and West African Farming Systems Experience into a Belt of Sustainable Intensification
FAO	Food And Agriculture Organization
FFRUs	Farmer Field Research Units
GDP	Gross Domestic Product
ICRA	International Centre for Research in Agroforestry
IPM	Integrated Pest Management
ITK	Indigenous Traditional Knowledge
KDC	Kundok Development Consult
OCCAM	Osservatorio per la Comunicazione Culturale e Audiovisiva nel Mediterraneo e nel Mondo
TARI	Tanzania Agricultural Research Institute
UNIMAK	University of Makeni
UNISS	Universita degli Studi di Sassari-Nucleo di Ricerca sulla Desertificazione
UoN	University of Nairobi
WHO	World Health Organization

EXECUTIVE SUMMARY

Note: The results for Deliverable 3.5 and Deliverable 3.6 were generated from a combined survey undertaken during 2021 in Kenya, Tanzania, Ethipia, Ghana, Burkina Faso and Sierra Leone. The same sample of farmers were therefore interviewed for both deliverables. For this reason, the Introduction (Chapter 1), Materials and Methods (Chapter 2), and the General Characteristics (Chapter 3, Section 3.1) are identical for both Deliverables. This allows both reports to be read as separate standalone reports.

Linking East and West African Farming Systems Experience into a BELT of Sustainable Intensification (EWA-BELT) was formulated recognizing that African countries suffer from high levels of food and nutrition insecurity. In Africa, mycotoxin contamination is a major problem with implications that affect human and animal health and economic development. An in-depth understanding of traditional knowledge and practices would provide new insights into developing alternative strategies to managing mycotoxin contamination by adding value to traditional knowledge of local communities.

A total of 531 farmers were randomly sampled from the six countries through the Country Farmer Field Research Units (FFRUs) and interviewed using questionnaires aimed at generating baseline information on the incidence and severity of mould spoilage and mycotoxin contamination management in African agriculture. The main findings of this survey are summarized as follows, based on the objective of the study to assess the perception and knowledge of pre- and post-harvest management strategies to control mould spoilage and mycotoxin contamination in stored food and feed in East and West Africa regions:

- The majority of farmers surveyed are over the age of 40 indicating low participation of the youth in agriculture
- The majority of the farmers either have no education or just primary school which has implications for future agriculture.
- The farmers surveyed had considerable experience in farming.
- Farmers indicated their farm sizes are too small and they were willing to expand their farms.
- The majority of farmers indicated that they are farming because they do not have other options of employment.
- There is poor access to credit, and the land tenure system is mainly family inherited land.
- Farmers mostly cultivate more than one crop.
- The majority of farmers indicated that they lost their cereals to mycotoxin contamination. The losses ranged from 0-20%.
- The majority of farmers across all the six countries indicated that they knew about aflatoxins, however they did not know about the harmfulness of aflatoxins when consumed.
- Across all six countries, cereals are stored at the homestead and usually done predominantly using polypropylene sacs and PICS bags.

- Most farmers do not know the right target moisture content to dry their grains to, before storage.
- Globally, the majority of farmers indicated that their current storage techniques being used are effective.
- The majority of the farmers also indicated that they have some knowledge on how to prevent mould spoilage and possible mycotoxin contamination.

We recommend to EWA-BELT to take into consideration these key observations while designing and implementing intervention strategies to manage mycotoxin contamination in East and West Africa crop storage systems to reduce waste due to poor storage and improve farm household livelihoods. The detailed results are presented in the subsequent sections of this report.

CHAPTER 1: INTRODUCTION

1.1 Background to the assignment

Linking East and West African Farming Systems Experience into a BELT of Sustainable Intensification (EWA-BELT) was formulated recognizing that African countries suffer from high levels of food and nutrition insecurity exacerbated by the increasing impacts of climate change on agricultural production (FAO, 2018). The Sustainable Intensification (SI) approach offers practical ways to increase agricultural yields (NRC, 2010; Foresight, 2011; NEA, 2011) while preserving natural resources (water, soil, biodiversity, and land) and the flow of ecosystem services (Montpellier Panel, 2013; Pretty et al 2011).

Mycotoxins are toxic fungal secondary metabolites that contaminate various food raw commodities and feedstuff. The contamination of food by mycotoxins can occur during pre-harvest agronomy, harvesting/drying, during subsequent storage, processing, transportation, or marketing of the food products. Elevated temperatures and unsafe drying/storage moisture contents of commodities (e.g. >14.5-15% for maize/wheat; >7.5% peanuts) are amongst the critical predisposing factors that facilitate the growth of mycotoxigenic moulds and contamination of such commodities with mycotoxins (Bhat, et al.,1991; Magan et al., 2020). In Africa, mycotoxin contamination is a major problem with implications for human and animal health and economic development. Aflatoxin-related hepatic diseases are reported in many African countries (Darwish et al., 2014). The food-borne mycotoxins are of great importance in Africa and other parts of the world. The impact of such toxins on human health, animal production and economy has attracted worldwide attention (Wagacha et al., 2008). Across Africa, staple crops notably maize and groundnuts as well as sorghum and millet are often significantly contaminated with multiple mycotoxins produced by diverse fungi (Raj et al., 2022). This degree of contamination occurs due to agronomic, sociological, climatic, and institutional challenges (IARC 2015)

An in-depth understanding of Indigenous Traditional Knowledge (ITK) and practices would provide new keys to perceive local resources and alternative strategies to minimise mycotoxin contamination of grain during production and storage by adding value to the ecological knowledge of local communities. Discovering and validating such knowledge is particularly useful to open new research avenues, develop alternative messages for effective communication, planning of campaign strategies and create the basis for a constructive collaboration between researchers and farmers (Sileshi et al 2009; Van Mele et al 2001). It is in this context that the EWA-BELT project is carrying out this study to establish the baseline with respect to perceptions and knowledge of mycotoxins contamination in staple grains under storage in both East and West Africa regions.

1.2 Objectives of the study

The main objective of the study was to assess the perception and knowledge of pre- and post-harvest management strategies to control mould spoilage and mycotoxin contamination in stored food and feed in East and West Africa regions.
The specific objectives were:

- To assess farmer and farm characteristics
- To examine the incidence of mycotoxins and risk awareness/perceptions
- To understand the perceptions of farmers on moulds and mycotoxins in stored grains
- To assess farmers' awareness of the risks associated with mycotoxins contamination
- To identify the existing traditional knowledge and its application in managing mycotoxins contamination
- To assess losses of staple grains due to mycotoxins contamination

CHAPTER 2: MATERIALS AND METHODS

2.1. Description of Study Sites

The Study was implemented across the six project countries of East and West Africa, in line with the aim of the EWA BELT project which is "*linking East and west African farming systems into a belt of sustainable intensification*". The countries are Burkina Faso, Ghana, Sierra Leone , Ethiopia, Tanzania and Kenya. A brief description of each Country is presented with its Map.

2.1.1 Burkina Faso

Burkina Faso is a landlocked country in West Africa that covers an area of around 274,200 square kilometres (105,900 sq mi) and is bordered by Mali to the northwest, Niger to the northeast, Benin to the southeast, Togo and Ghana to the south, and the Ivory Coast to the southwest. The July 2019 population estimated by the United Nations was 20,321,378 (BF population 2021). Burkina Faso has a primarily tropical climate with two very distinct seasons. In the rainy season, the country receives between 600 and 900 mm (23.6 and 35.4 in) of rainfall; in the dry season, the harmattan (a hot dry wind from the Sahara) blows. The rainy season lasts approximately four months, May/June to September, and is shorter in the north of the country. Three climatic zones can be defined: the Sahel, the Sudan-Sahel, and the Sudan-Guinea. The Sahel in the north typically receives less than 600 mm (23.6 in) of rainfall per year and has high temperatures (5-47 °C).

Agriculture represents 32% of its gross domestic product and occupies 80% of the working population. It consists mostly of rearing livestock. Especially in the south and southwest, the people grow crops of sorghum, pearl millet, maize (corn), peanuts, rice, and cotton, with surpluses to be sold. Burkina Faso's climate also renders its crops vulnerable to insect attacks, including attacks from locusts and crickets, which destroy crops and further inhibit food production (Groten, 1993). Most of the population of Burkina Faso dependent on agriculture as a source of income, but they also rely on the agricultural sector for food that will directly feed the household (Thomas et al., 1988). Due to the vulnerability of agriculture, more and more families are having to look for other sources of non-farm income, (Roncoli et al., 2001) and often have to travel outside of their regional zone to find work (Thomas et al., 1988).

2.1.2 Ghana

Ghana, officially the Republic of Ghana, spans the Gulf of Guinea and the Atlantic Ocean to the south, sharing borders with the Ivory Coast in the west, Burkina Faso in the north, and Togo in the east. Ghana covers an area of 238,535 km^2 (92,099 sq mi), spanning a diverse geography and ecology that ranges from coastal savannas to tropical rainforests. With over 31 million people, Ghana is the second-most populous country in West Africa, after Nigeria (Jackson, 2001). Grasslands mixed with south coastal shrublands, and forests dominate the country, with forest extending northward from the south-west coast on the Gulf of Guinea in the Atlantic

Ocean 320 kilometres (200 miles) and eastward for a maximum of about 270 kilometres (170 miles). Ghana is home to five terrestrial ecoregions: Eastern Guinean forests, Guinean forest-savanna mosaic, West Sudanian savanna, Central African mangroves, and Guinean mangroves. It had a 2018 Forest Landscape Integrity Index mean score of 4.53/10, ranking it 112nd globally out of 172 countries. The climate of Ghana is tropical, and there are two main seasons: the wet season and the dry season (UNDP Ghana, 2013).

2.1.3 Sierra Leone

Sierra Leone is bordered by Liberia to the southeast and Guinea surrounds the northern half of the nation. Sierra Leone has a tropical climate with a diverse environment ranging from savanna to rainforests, a total area of 71,740 km2 (27,699 sq mi) and a population of 7,092,113 as of the 2015 census. Sierra Leone is home to four terrestrial ecoregions: Guinean montane forests, Western Guinean lowland forests, Guinean forest-savanna mosaic, and Guinean mangroves. Two-thirds of the population of Sierra Leone are directly involved in subsistence agriculture. Agriculture accounts for 58 per cent of gross domestic product (GDP) as at 2007. Human activities claimed to be responsible or contributing to land degradation in Sierra Leone include unsustainable agricultural land use, poor soil and water management practices, deforestation, removal of natural vegetation, fuelwood consumption and to a lesser extent overgrazing and urbanisation. Agriculture is the largest employer with 80 per cent of the population working in the sector. Rice is the most important staple crop in Sierra Leone with 85 per cent of farmers cultivating rice during the rainy season and an per capita consumption of 76 kg.

2.1.4 Ethiopia

Ethiopia, officially the Federal Democratic Republic of Ethiopia, is a landlocked country in the Horn of Africa. It shares borders with Eritrea and Djibouti to the north, Somaliland to the northeast, Somalia to the east, Kenya to the south, South Sudan to the west, and Sudan to the northwest. Ethiopia has a total area of 1,100,000 square kilometres (420,000 sq mi). It is home to 117 million inhabitants and is the 12th most populous country in the world and the 2nd-most populous in Africa after Nigeria. The predominant climate type is tropical monsoon, with wide topographic-induced variation. The Ethiopian Highlands cover most of the country and have a climate which is generally considerably cooler than other regions at similar proximity to the Equator.

Agriculture constitutes around 85% of the labour force. However, the service sector represents the largest portion of the GDP. Many other economic activities depend on agriculture, including marketing, processing and export of agricultural products. Production is overwhelmingly by small-scale farmers and enterprises, and a large part of commodity exports are provided by the small agricultural cash-crop sector. Principal crops include coffee, legumes, oilseeds, cereals, potatoes, sugarcane, and vegetables. Ethiopia is also a Vavilov centre of diversity for domesticated crops, including enset (Wilkin et al., 2019) coffee and teff. Exports are almost entirely agricultural commodities (with the exception of Gold exports), and coffee is the largest foreign exchange earner. Ethiopia is Africa's second biggest maize producer.

2.1.5 Tanzania

Tanzania, officially the United Republic of Tanzania, is a country in East Africa within the African Great Lakes region. It borders Uganda to the north; Kenya to the northeast; Comoro Islands and the Indian Ocean to the east; Mozambique and Malawi to the south; Zambia to the southwest; and Rwanda, Burundi, and the Democratic Republic of the Congo to the west. Mount Kilimanjaro, Africa's highest mountain, is in north eastern Tanzania. Climate varies greatly within Tanzania. In the highlands, temperatures range between 10 and 20 °C (50 and 68 °F) during cold and hot seasons respectively. The rest of the country has temperatures rarely falling lower than 20 °C (68 °F). The hottest period extends between November and February (25-31 °C or 77.0-87.8 °F) while the coldest period occurs between May and August (15-20 °C or 59-68 °F). Annual temperature is 20 °C (68.0 °F). The climate is cool in high mountainous regions.

Tanzania has two major rainfall periods: one is uni-modal (October-April) and the other is bi-modal (October-December and March-May). The former is experienced in southern, central, and western parts of the country, and the latter is found in the north from Lake Victoria extending east to the coast. The bi-modal rainfall is caused by the seasonal migration of the Intertropical Convergence Zone. The Tanzanian economy is heavily based on agriculture, but climate change has impacted its farming. Maize was the largest food crop on the Tanzania mainland in 2013 (5.17 million tonnes), followed by cassava (1.94 million tonnes), sweet potatoes (1.88 million tonnes), beans (1.64 million tonnes), bananas (1.31 million tonnes), rice (1.31 million tonnes), and millet (1.04 million tonnes).

2.1.6 Kenya

Kenya, officially the Republic of Kenya, spans over 580,367 square kilometres (224,081 sq mi), and is the world's 48th largest country by area. With a population of more than 47.6 million in the 2019 Kenya Population and Housing Census is the 29th most populous country. Kenya's capital and largest city is Nairobi. As of 2020, Kenya is the third-largest economy in sub-Saharan Africa after Nigeria and South Africa. Kenya is bordered by South Sudan to the northwest, Ethiopia to the north, Somalia to the east, Uganda to the west, Tanzania to the south, and the Indian Ocean to the southeast. Kenya's climate varies from tropical along the coast to temperate inland to arid in the north and northeast parts of the country. The area receives a great deal of sunshine every month. It is usually cool at night and early in the morning inland at higher elevations.

The "long rains" season occurs from March/April to May/June. The "short rains" season occurs from October to November/December. The rainfall is sometimes heavy and often falls in the afternoons and evenings. Climate change is altering the natural pattern of the rainfall period, causing an extension of the short rains, which has begat floods, and reducing the drought cycle from every ten years to annual events, producing strong droughts such as the 2008-09 Kenya Drought (Peck et al., 2015). The temperature remains high throughout these months of tropical rain. The hottest period is February and March, leading into the season of the long rains, and the coldest is in July, until mid-August. Agriculture is the second largest contributor to Kenya's

gross domestic product (GDP) after the service sector. The principal cash crops are tea, horticultural produce, and coffee. Horticultural produce and tea are the main growth sectors and the two most valuable of all of Kenya's exports. The production of major food staples such as corn is subject to sharp weather-related fluctuations.

Figure 1: Map of the six study countries where the survey was carried out.

2.2 Data collection

2.2.1 Household sampling strategy and sample size

Farmers were randomly sampled from the six countries through the Country Farmer Field Research Units (FFRUs). A total of 531 farmers were randomly sampled and interviewed comprising of 244 Females and 287 Males. The detailed sample size is shown in Table 1. A total of 41 farmers were sampled from Burkina Faso comprising 21 Females and 20 Males. In Ethiopia 65 farmers were sampled comprising 3 Females and 62 Males. In Ghana, out of a total of 60 sampled, 41 were males and 19 females. Kenya recorded the largest sample size of 185 farmers made up of 122 females and 63 males. Tanzania has the second largest farmer sample of 72 males and 48 females. In Sierra Leone , 60 farmers were sampled, 31 Females and 29 Males.

Table 1: Sample size and gender of farmers surveyed

Country	Gender		Total
	Female	Male	
Burkina Faso	21	20	41
Ethiopia	3	62	65
Ghana	19	41	60
Kenya	122	63	185
Tanzania	48	72	120
Sierra Leone	31	29	60
Global	244	287	531

2.2.3 Survey instrument

A questionnaire was developed in consultation with all stakeholders with the aim of generating baseline information on the status of pests/pathogens and mycotoxins in African agriculture. The tool was designed to capture information on households' social and demographic characteristics, such as age, education, farming experience, farm characteristics, land tenure systems, crops grown and gender of household head. It also captures information on farm characteristics, incidence of pests/pathogens, control means and exposure to pesticides, traditional knowledge, as well as detailed information on pest management options.

2.2.3 Farmer interviews

Using questionnaire, farmers were randomly sampled and interviewed. Within each FFRU, farmers were randomly selected for individual interviews using the list of farmers obtained from the local authorities. The household heads were the targeted respondents, although any adult in the household who was familiar with the crop production situation of the household was interviewed if the head of the household was absent. The farmer's consent was obtained after explaining the purpose of the study and before the interview commenced. The study focused on farmers' perception and knowledge of the impact of insect pests and pathogens on their crops.

2.3 Data analysis

The study employed descriptive analyses to analyse the survey data. Frequencies and percentages were generated and used to generate summaries, tables, and figures at country and global scales to summarise and describe the 531 farmers sampled. The analyses covered general characteristics of farmers and their farms and incidence of pest and diseases in their cropping systems.

CHAPTER 3: RESULTS

3.1 General characteristics

3.1.1 Gender, age and education

The majority of farmers surveyed were found within the age range of 41-50 years (31%) followed by age range of 31- 40 years constituting about 28% of the total sampled (See Table 3). The oldest age bracket was 70 and above years which accounted for only 3% of the respondents. The majority of the respondents were males (54%) and females 46%. There were more male farmers sampled across three countries (Ethiopia, Ghana and Tanzania) and more Females were also sampled across three countries (Burkina Faso, Kenya and Sierra Leone), see Table 2.

Table 2: Gender distribution of farmers across the six countries

Gender	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Female Freq	21	3	19	122	48	31	244
Female %	51.2	4.6	31.7	65.9	40.0	51.7	46.0
Male Freq	20	62	41	63	72	29	287
Male %	48.8	95.4	68.3	34.1	60.0	48.3	54.0

Table 3: Age of farmers across the six countries

Age	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
<21	0%	0%	0%	0%	3%	0%	1%
21-30	7%	3%	5%	9%	22%	5%	10%
31-40	32%	23%	40%	25%	17%	48%	28%
41-50	22%	49%	42%	22%	30%	35%	31%
51-60	27%	14%	12%	22%	22%	12%	19%
61-70	12%	8%	2%	18%	4%	0%	9%
>70	0%	3%	0%	4%	3%	0%	3%

About 27% of the respondents have never been to school at all. The majority of farmers sampled (44%) indicated they had gone to primary school and 25% indicated they have had

secondary education while just about 4.5% indicated they have university degrees across the six study countries. Literacy levels in Kenya and Tanzania obviously are high compared to Ghana, Burkina Faso and Sierra Leone which recorded 50%, 61% and 78% illiteracy rates, respectively. Educational levels of the respondents are presented in Table 4. Global adult literacy rate stands at 86.2% in 2015, and only 59.76% of the population of Sub-Saharan Africa is literate according to the 2013 UNESCO Institute for Statistics (UIS). The literacy rate in Ghana and Burkina Faso are even more than the regional average.

Table 4: Education of farmers surveyed

Education	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
BSc	0.0%	1.5%	6.7%	3.2%	10.8%	0.0%	4.5%
None	61.0%	24.6%	50.0%	9.2%	5.0%	78.3%	26.6%
Primary	24.4%	49.2%	33.3%	55.1%	53.3%	10.0%	44.1%
Secondary	14.6%	24.6%	10.0%	32.4%	30.8%	11.7%	24.9%

3.1.2 Farming experience, farm size and reasons for farming

From the global sample, the majority of the farmers' experience is in the range of 11-15 years followed by 16-20 year. Majority of farmers in Burkina Faso and Ethiopia are 30 years and above. Most Ghanaians and Kenyans sampled have have 10-15 years of farming experience and majority of Tanzanian farmers have about 5 years farming experience. The majority of Sierra Leone an farmers sampled have 16-20 years experience, Table 5.

Table 5: Comparison of the relative experience of farmers surveyed from the six countries

Years of farming Experience	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
≤5 (%)	0.0	3.1	1.7	11.9	22.5	1.7	10.0
6-10 (%)	2.4	10.8	13.3	20.0	15.8	13.3	15.1
11-15 (%)	7.3	7.7	38.3	24.3	15.0	21.7	20.2
16-20 (%)	17.1	15.4	21.7	14.6	17.5	31.7	18.3
21-25 (%)	22.0	7.7	15.0	7.0	6.7	18.3	10.4
26-30 (%)	12.2	21.5	3.3	9.2	11.7	10.0	10.9
31≤ (%)	39.0	33.8	6.7	13.0	10.8	3.3	15.3

According to Table 6, about 25% of the farmers sampled have about 0.6-1 acre of farmland. 34% of Burkina Faso farmers sampled have 3 and more acres of farm size. Majority of farms in Ethiopia are within 0.6- 1 acre. For Ghana, the majority of the sample have about 1.6-2.0 acres of farmland and Kenya famers sampled indicated that the majority of them have about 0.1-0.5 acre of land. Majority of Tanzanians sampled indicated they have 0.6-1 acre of farmland and in Sierra Leone majority of farmers farm size is (0.1-0.5) and (1.1-1.5) both categories have a bout 21.7% of farmers respectively.

Table 6: Relative size of the farms of the farmers surveyed in the six countries

Farm Size (Ha)	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
<0.1	0.0%	0.0%	1.7%	10.9%	11.7%	1.7%	6.8%
0.1-0.5	0.0%	7.7%	0.0%	29.0%	25.0%	21.7%	19.1%
0.6-1	17.1%	40.0%	23.3%	23.5%	25.8%	20.0%	25.1%
1.1-1.5	24.4%	9.2%	15.0%	15.3%	13.3%	21.7%	15.5%
1.6-2.0	24.4%	16.9%	25.0%	11.5%	9.2%	13.3%	14.4%
2.1-2.5	0.0%	6.2%	15.0%	3.8%	4.2%	11.7%	6.0%
2.6-3.0	0.0%	10.8%	8.3%	3.8%	4.2%	1.7%	4.7%
>3.0	34.1%	9.2%	11.7%	2.2%	6.7%	8.3%	8.3%

Responding to relative satisfaction with the farm areas they had, globally, the majority of the farmers indicated that their farm size was too small 61% and 39% indicated that they were satisfied with their farm size. This trend was the same across the study countries, except for Burkina Faso and Sierra Leone , where the majority were satisfied with their current farm sizes, see Figure 2.

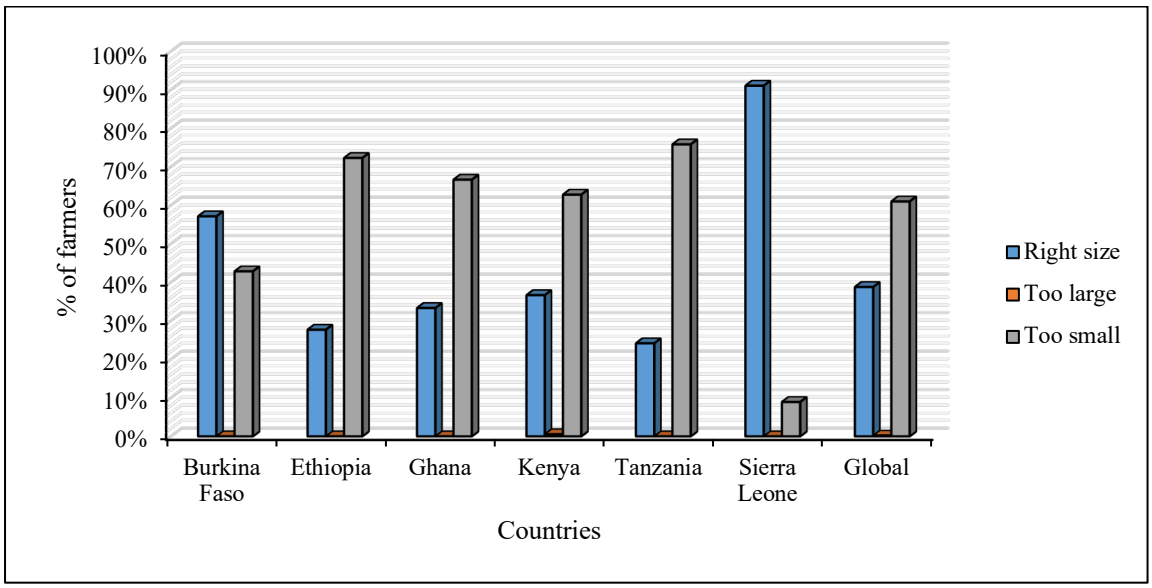

Figure 2: Farmers' satisfaction of their farm size

Farmers had different reasons as to why they were involved in agriculture and from this study, the most important reason was because of a lack of alternative jobs, followed by farming being the main source of livelihood, thirdly it was a good source of income, fourth, considered to be a good job and lastly because of group activity. The trend is similar for Burkina Faso, Ethiopia, Ghana and Sierra Leone for the first three top reasons as shown in Figure 3.

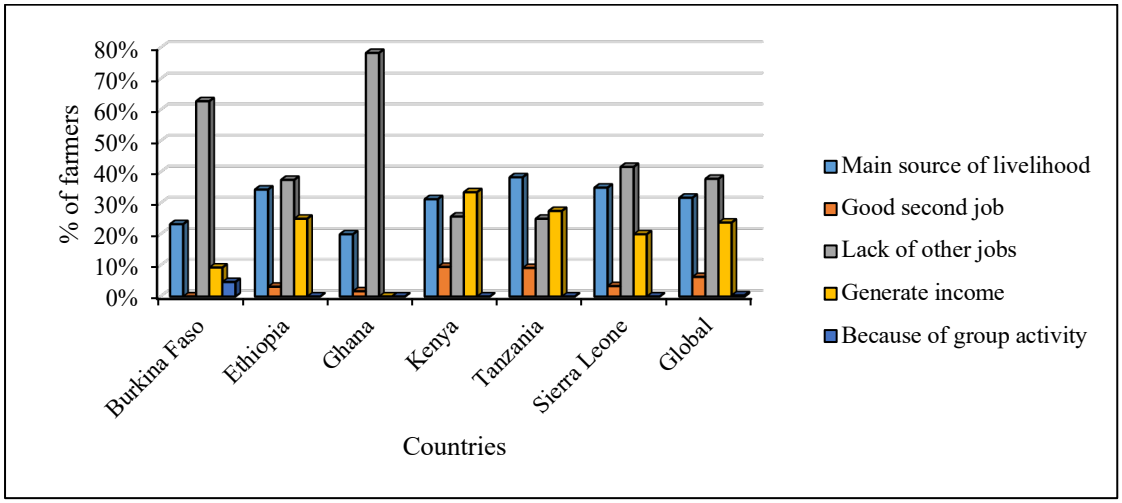

Figure 3: Key reasons for farmers to remain engaged in farming.

3.1.3 Farmers source of labour and its availability

The main source of farm labour across the six countries is mostly family labour only, followed by family labour and hired labour, except for Burkina Faso and Sierra Leone . The third is

mostly hired labour alone except for Burkina Faso, with the fourth being cooperative. The trend is similar across the six countries. Family labour is thus very important in African agriculture. See Figure 4.

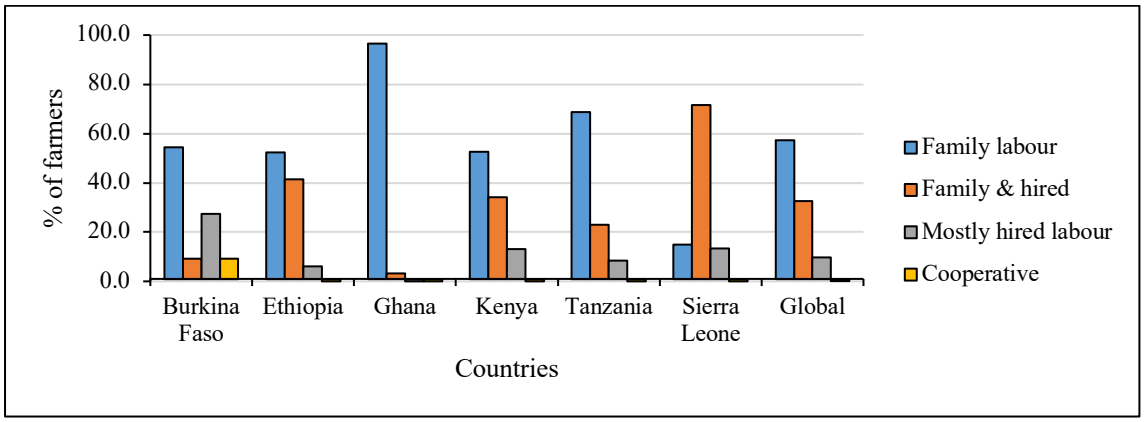

Figure 4: The main sources of farm labour used across the six countries

The majority of farmers (70%) indicated labour cost is their main problem and 25% of them indicated it is easy to access farm labour and about 5% of them indicated it is difficult to access farm labour globally. The trend is similar in Burkina Faso, Ethiopia, Tanzania and Ghana. In Kenya and Sierra Leone they indicated labour is not readily available, Figure 5.

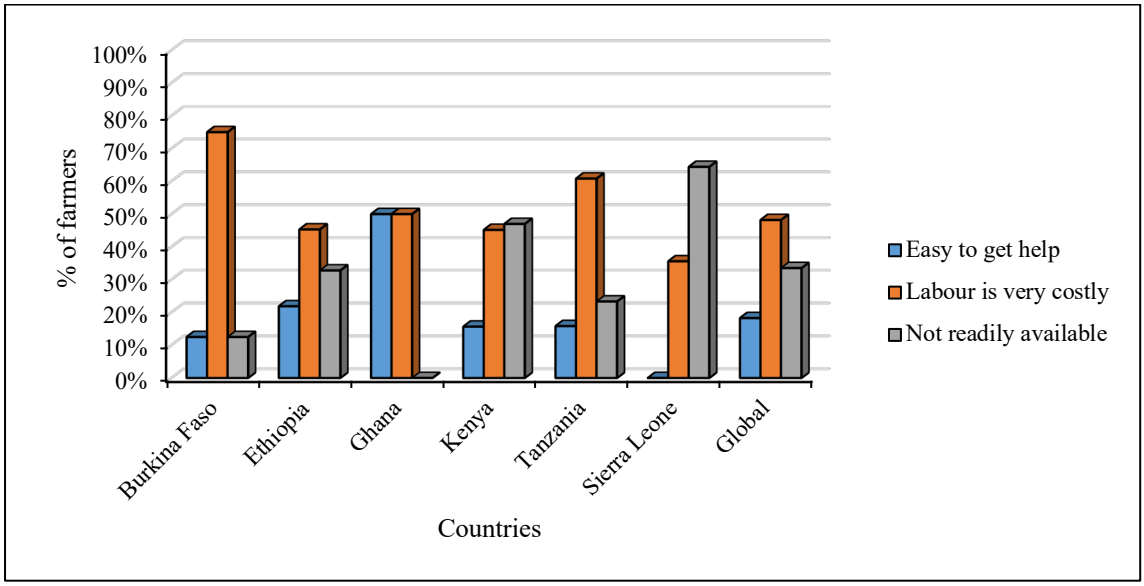

Figure 5: Labour availability across the six countries

Globally most respondents in all the countries indicated they would be able to do more work (79.5%) and 14.8% also indicated they could even hire extra labour to do more work on their

farm. Whereas, just about 6.5% of them indicated they would not be able to do extra work on their farms. The trend is similar across all the six study countries, See Table 7.

Table 7: Summary of farm household labour allowance across the six countries surveyed

Labour Allowance	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
I would be able to do more work (%)	78.0	87.7	90.0	79.5	82.5	55.0	79.5
I would be able to hire help (%)	22.0	3.1	1.7	11.9	15.8	41.7	14.8
I would not be able to do more work (%)	0.0	9.2	8.3	8.5	1.7	3.3	6.5

3.1.4 Access and cost of capital

Access to capital is a major problem in agriculture in general and particularly in African agriculture. Globally, 48.3% of the respondents indicated they will not be able to borrow money anywhere, while 23.3% and 17.6% of farmers indicated they can borrow money from banks and friends, respectively. About 8% said they will borrow from a money lender as shown in Table 8. The trend is generally the same across the five of the study countries except Sierra Leone where majority of them indicated they will borrow money from a bank.

Table 8: Farmers access to capital across the six countries surveyed

Access to apital	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
I cannot borrow money anywhere %	67.6	60.0	77.2	29.1	61.7	26.7	48.3
I will borrow money from a bank %	17.6	20.0	0.0	32.6	7.5	56.7	23.3
I will borrow money from a money lender %	2.9	1.5	0.0	12.6	12.5	3.3	8.0
I will borrow money from friends %	0.0	15.4	22.8	22.9	16.7	11.7	17.6
I don't need a loan %	11.8	3.1	0.0	2.9	0.8	1.7	2.5
I am afraid to borrow %	0.0	0.0	0.0	0.0	0.8	0.0	0.2

It was thus generally difficult to obtain farm money as indicated by respondents across the six countries. They also indicated that farm money is very expensive to borrow. Few of them indicated it is easy to and cheap to obtain. About 67% of respondents indicated it was difficult to access farm loans. Ghana's situation is similar for about 100% of respondents. Ethiopia, Kenya and Tanzania also recorded 49%, 55% and 69%, respectively for accessing such funds (Figure 6).

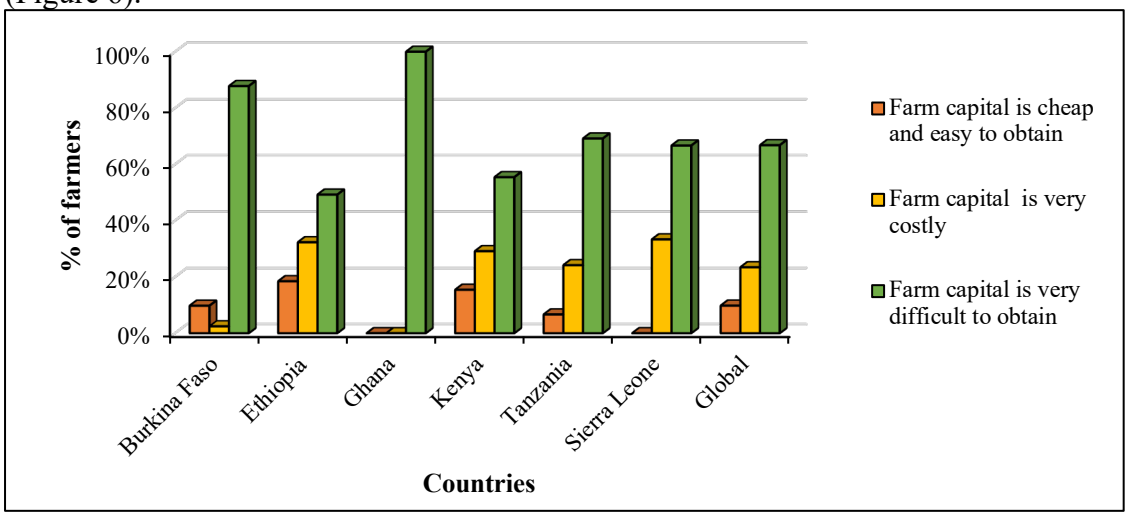

Figure 6: Relative cost of farm capital for the farmers sampled.

3.1.5 Farming and land tenure Systems

There are different farming systems across the study sites, and these may differ across different countries. On a global scale, mixed (arable and livestock) farming is the dominant farming system practiced by the farmers, followed by arable cropping system, this trend is the similar in Sierra Leone . The third is agroforestry farming and the fourth is livestock system and lastly tree system. In Tanzania, the two dominant systems are mixed farming and arable systems followed by agroforestry system. Kenya has mixed farming as the dominant system followed by arable system. The dominant system in Ghana is arable system followed by the mixed system. Ethiopia has mixed system as their dominant system followed by the agroforestry system. Burkina has arable system as their dominant system followed by the agroforestry system. See Figure 7 for more details.

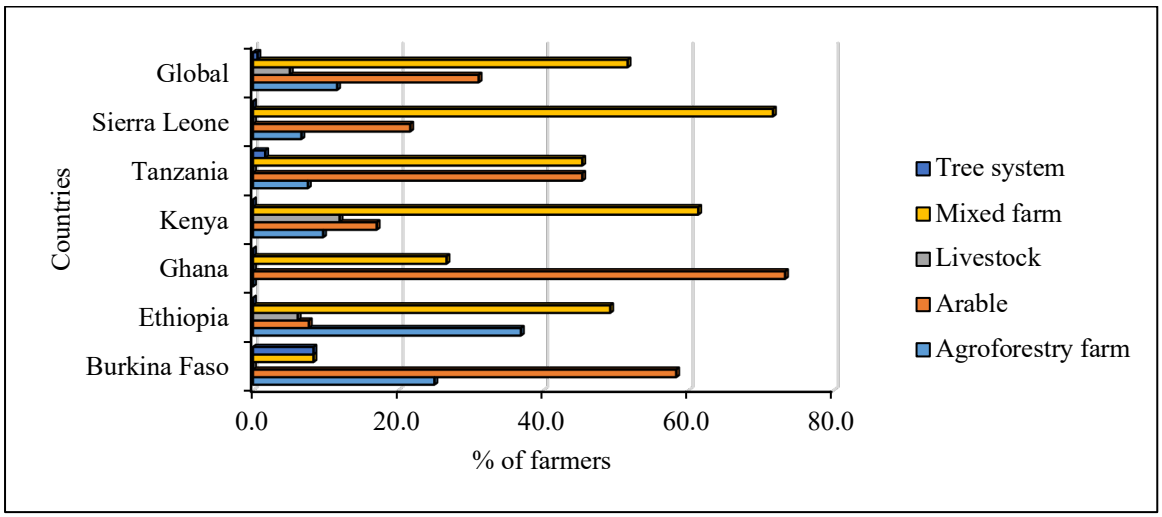

Figure 7: Relative percentage (%) of farmers using different cropping systems.

3.1.6 Land tenure system practised by farmers

There are several land tenure systems in the study area and the trend is similar across the study area as shown in Figure 8. The dominant land tenure system across the six countries is inherited land ranging from 63%-95% depending on the country. Ethiopia has about 95% of inherited land tenure systems followed by Ghana and Kenya with 92% of inherited land and then Sierra Leone with 83%. In Burkina Faso and Tanzania, inherited land represents 63% and 64%, respectively. The second most practiced land tenure system for Tanzania, Kenya and Ethiopia is the self-owned land tenure system. The second most practiced land tenure system for Ghana is the chief allocated land tenure.

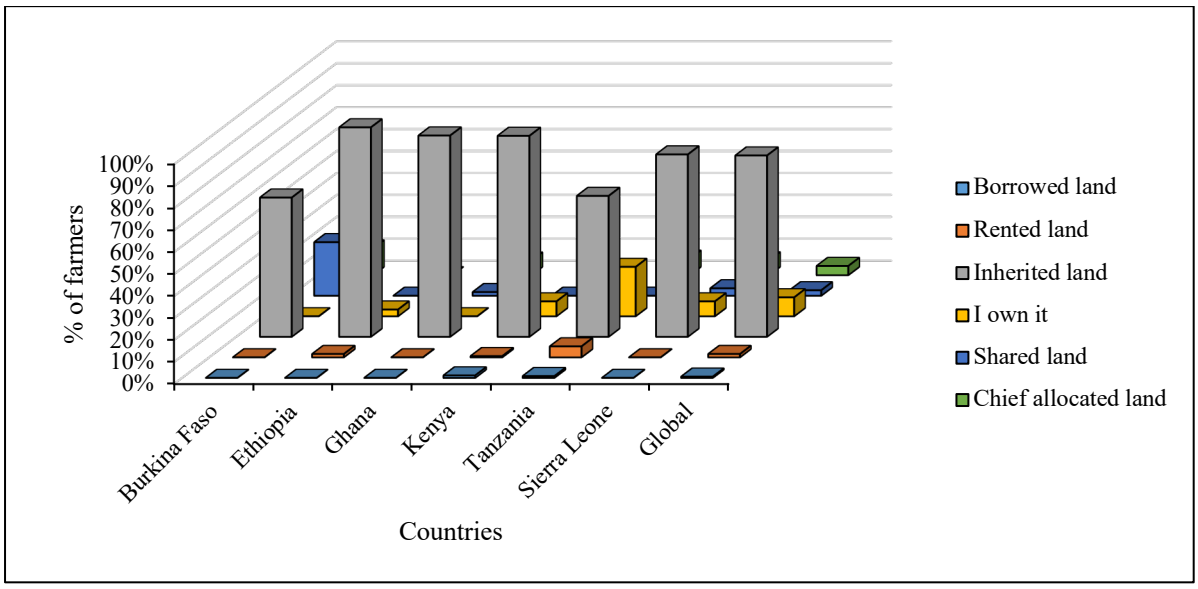

Figure 8: Land tenure system practised by farmers.

3.1.7 Preference of land tenure system

We tried to gauge farmers' preference of the land tenure systems and the results showed that farmers have strong preference for the customary land tenure system across the six countries except for Tanzania, where farmers indicated outright purchase as their most preferred system. The second most important tenure system preferred is owning of the land through outright purchase as shown in Figure 9.

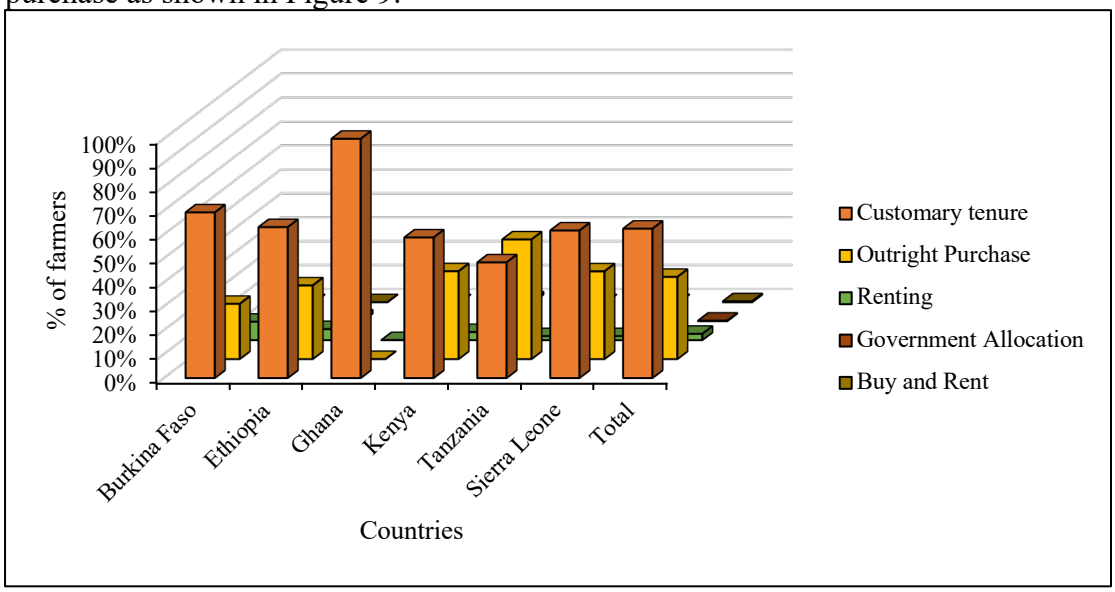

Figure 9: The preference of the farmers for different land tenure systems across the six countries surveyed.

3.1.8 Household farm enterprises and their importance

Table 16 indicates that the majority of farmers cultivated more than one crop. This shows crop diversification is a highly adopted process across the study countries as a risk minimisation technique. This is demonstrated in Figure 10. Very few farmers engaged in mono-cropping systems.

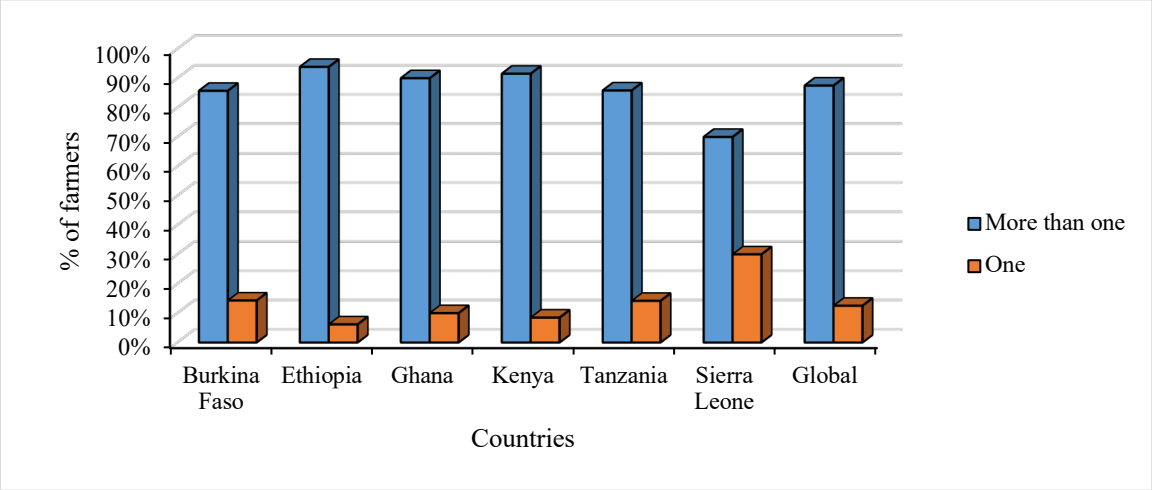

Figure 10: Relative percentage of farmers growing one or more crops in their farm.

The most essential crops grown across the study area was maize. Other important crops were beans for Kenya and Tanzania. Groundnuts for Ghana, teff for Ethiopia and rice for Burkina Faso and Sierra Leone .

3.2 Incidence of mycotoxins and risk awareness/perception

3.2.1 Prevalence of mouldy cereals amongst farmers

The study sought to assess perceptions and the level of grain storage losses due to mould spoilage and mycotoxin contamination, Approx. half of the farmers (51%) indicated that they lost their cereals because of mould spoilage or mycotoxin contamination, with the other half indicating that they did not lose their cereals because of these problems. On a country basis, the majority of farmers surveyed in Ethiopia and Kenya indicated that they had experience of losses of cereals due to spoilage and mycotoxin contamination. However, this was different in Ghana and Tanzania (see Figure 11).

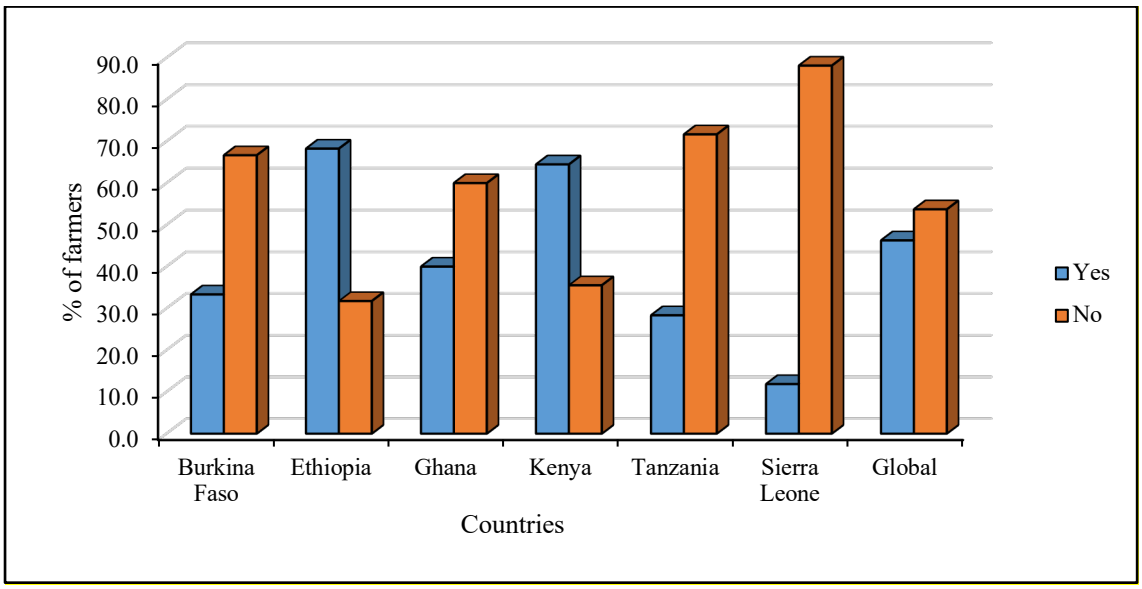

Figure 11: Prevalence of farmer's cereals becoming mouldy and probably contaminated with mycotoxins.

3.2.2 Magnitude of cereals lost to moulds

Figure 12 shows that across the six counties the majority of farmers (44%) indicated that they had experienced losses of cereals due to mould contamination ranging from (0-10%), with about 33% also indicating losses ranging from 11-20%. Farmers experiencing losses in the range of 21-40% and >41-60% constituted 16%, 6% and 1% of farmers respectively. The majority of farmers in Ethiopia, Kenya, and Tanzania had all experienced losses due to mould spoilage ranging from 0 to 10%. Most of the farmers in Burkina Faso and Ghana also indicated higher losses of 11-20% due to visible mould spoilage of their commodities.

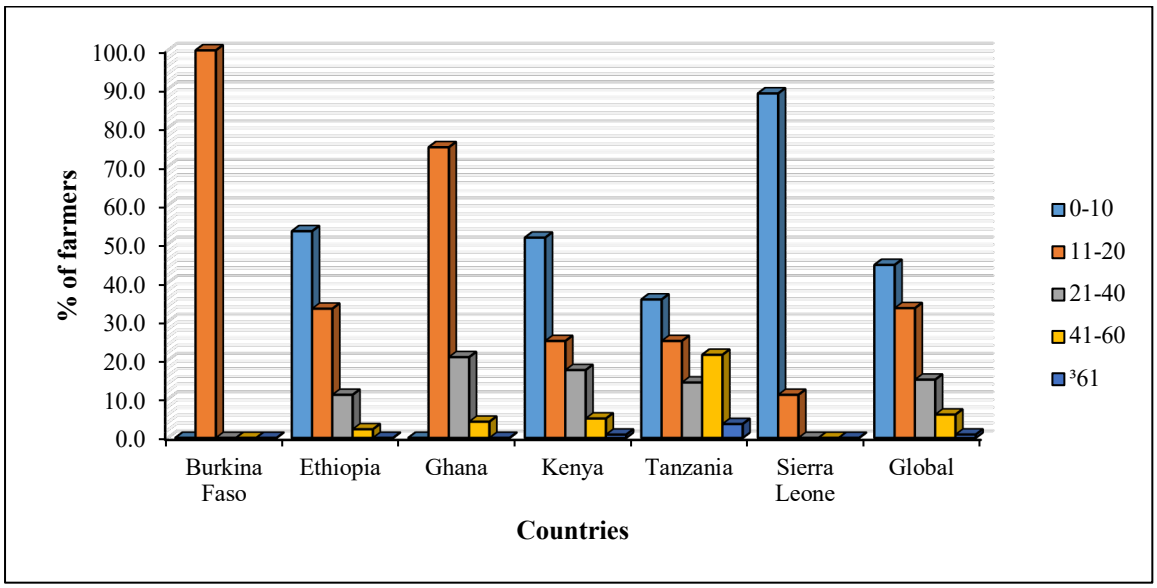

Figure 12: The percentage of cereals lost to moulds in each of the five counties surveyed.

3.2.3 Prevalence of consumption of mouldy cereals

There was a clear indication that the majority (83-100%) of farmers did not consume the visibly mouldy grains. Only a few farmers indicated that they consumed mouldy grains, representing 4-15% of those sampled. The trend was the same as indicated in all the countries (see Figure 13).

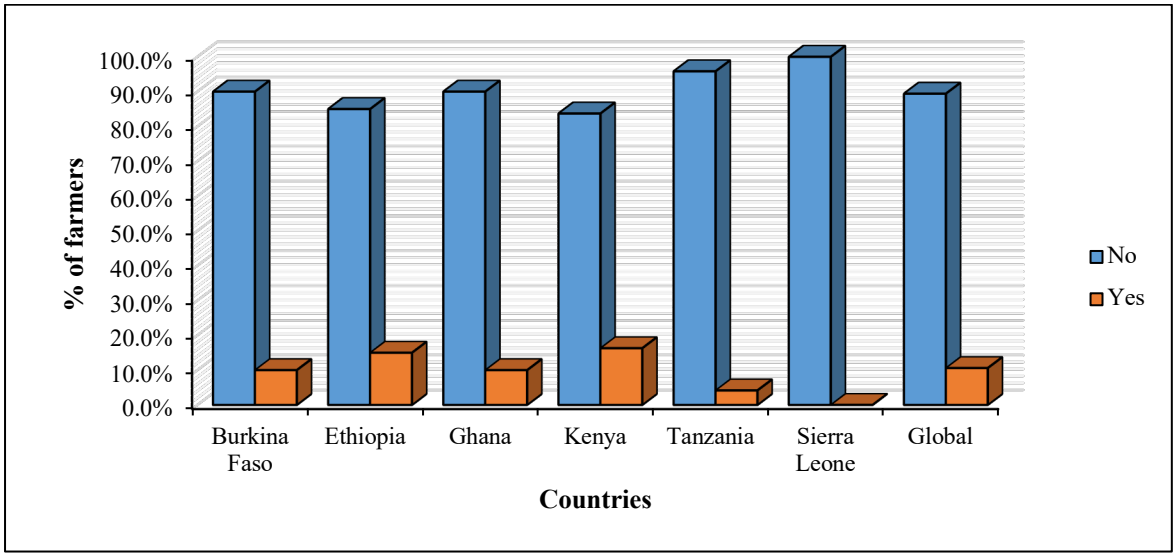

Figure 13: Incidence of eating of visibly mouldy cereals in each of the five counties surveyed.

3.3 Knowledge of mycotoxins and risk awareness/perception

3.3.1 Knowledge of mycotoxins

The majority of farmers across all six countries indicated that they knew little about mycotoxins. However, almost half of farmers surveyed in Kenya indicated that they did know about mycotoxins with the other half indicating that they did not know (see Figure 14).

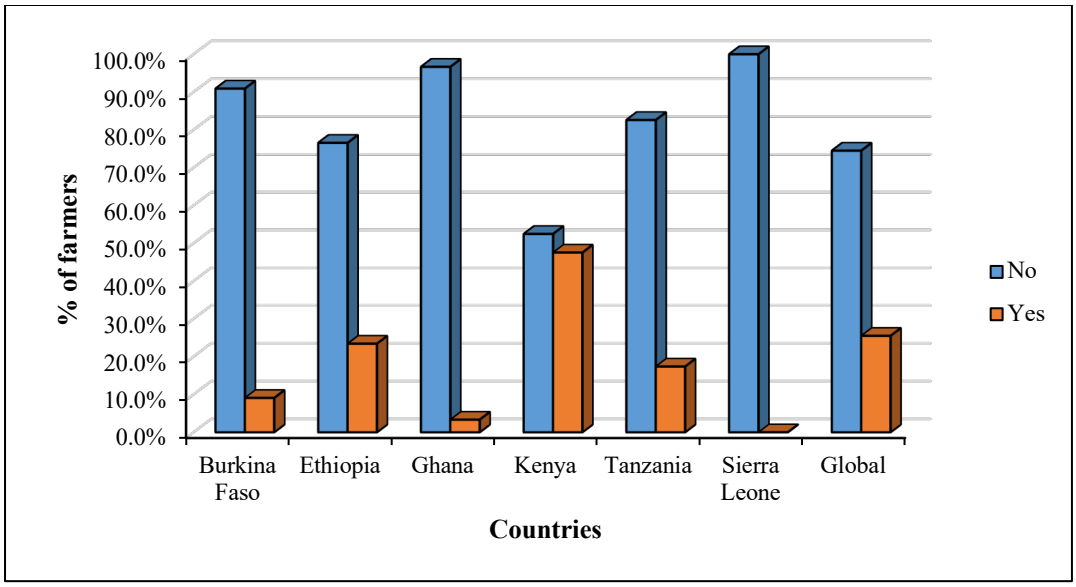

Figure 14: Farmer knowledge of mycotoxins across the six surveyed counties.

3.3.2 Harmfulness of moulds to humans

This study also sought to assess farmers knowledge on the risk of consuming mouldy grains. The majority of farmers surveyed in Burkina Faso, Tanzania Ghana and Kenya agreed that mouldy grain consumption was not harmful to the human body. It was only in Sierra Leone that the majority of farmers (71%) indicated that they don't know if mouldy grains were harmful to humans. A significant number of farmers indicated they did not know if it was harmful or not (Table 9).

Table 9: Knowledge of whether moulds are harmful to humans

Are moulds harmful	Country					Global
	Burkina Faso	Sierra Leone	Ghana	Kenya	Tanzania	
Harmful	83.3%	23.8%	53.3%	89.8%	64.9%	73.8%
Not harmful	16.7%	4.8%	33.3%	4.5%	1.4%	9.3%
Dont know	0.0%	71.4%	13.3%	5.7%	33.8%	16.9%

3.3.3 Consumption of mouldy foods

Most of the farmers surveyed across all the six countries indicated that their family members had not fallen ill after the consumption of mouldy grains. A significant number of farmers from Ghana said that they were unaware of such a problem. About 5% and 10% of Sierra Leone and Ethiopian farmers, respectively, indicated that they knew some people who had become sick after the consumption of mouldy food (Figure 15).

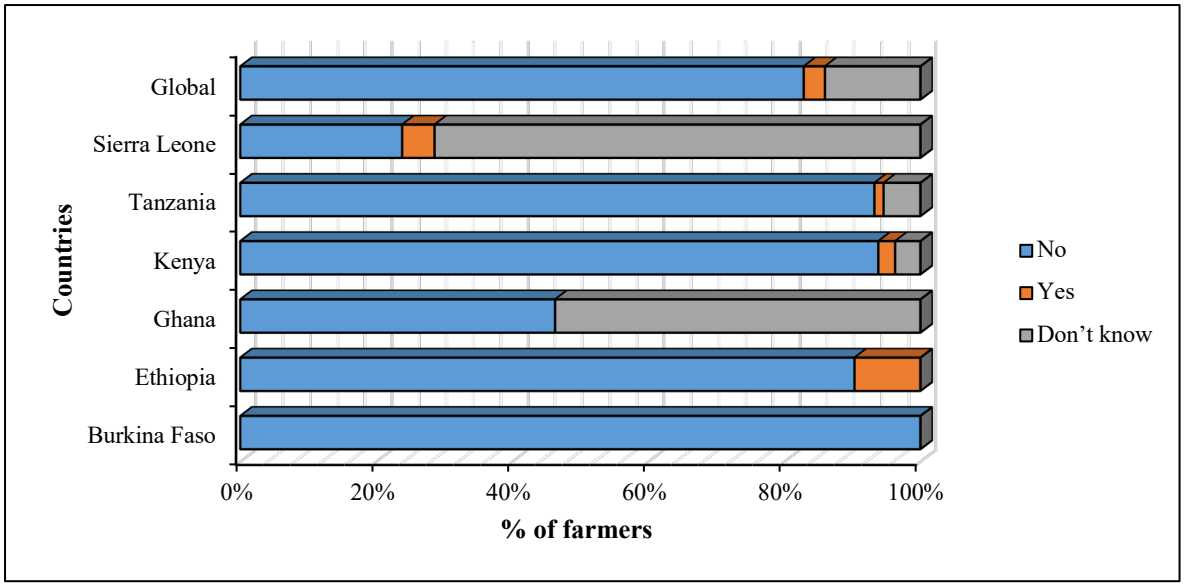

Figure 15: The percentage of family members who had become ill from the consumption of mouldy food in the six countries surveyed.

3.3.4 Safety of milk from animals fed with mouldy feed

Most of the farmers across all six countries indicated that milk from animals fed with mouldy feed was not safe for human consumption. Almost all farmers surveyed from Ghana and 81% of farmers from Sierra Leone indicated that they were unaware of whether this would be harmful or not. About 32% of Ethiopia farmers and 36% of Kenyan farmers indicated that milk from these animals was safe to consume (see Table 10).

Table 10: Relative knowledge of whether milk consumed from animals fed with mouldy feed safe or not in each of the six countries surveyed.

Is Milk safe	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
No %	0.0	58.5	96.3	59.4	49.2	18.8	59.5
Yes %	0.0	32.3	0.0	35.8	15.3	0.0	24.1
Don't know %	100.0	9.2	14.8	4.8	35.6	81.3	16.5

3.3.5 Place where farmers store their cereals

Almost all the farmers (95%) indicated that they stored their produce in their houses and just 2% of them indicated that they stored them on-farm. The situation was the same across all the study countries (Figure 16).

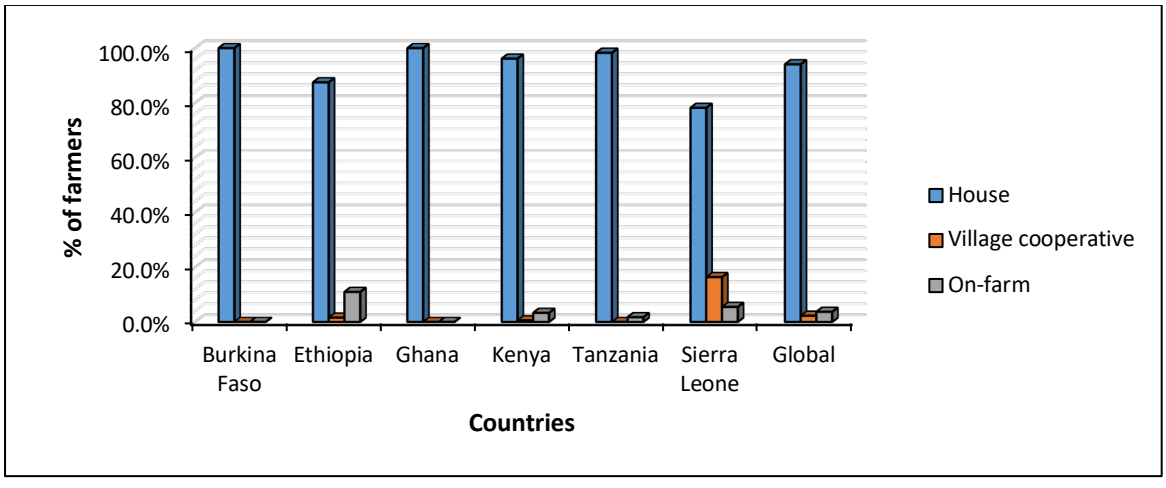

Figure 16: Place of storage of farm produce by farmers in each of the six countries surveyed.

3.3.6 Grain storage techniques adopted by farmers

This study tried to assess the adoption of storage techniques amongst farmers across the six countries (Table 11). The most prevalent storage techniques were the PICS and Hessian bags with both being used by approx. 35% and 30% of the farmers respectively. Polypropylene bags were also quite prevalent (28%). The most prevalent storage technique in Burkina Faso was the use of polypropylene bags (80%). In Ethiopia the most prevalent storage technique was the use of the PICS bags (50%) followed by Hessian/polypropylene ones at 16% each. In Ghana hessian bags (87%) was most prevalently used, followed by small farm silos (13%). Polypropylene was the most prevalent storage bags used in Kenya and Tanzania.

Table 11: Adoption of different storage techniques.

Storage Technique	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Hessian bags %	10.0	16.1	86.7	30.3	6.1	38.6	30.4
PICS bags %	0.0	50.0	0.0	33.2	37.7	59.7	35.1
Pits %	0.0	6.5	0.0	0	0.0	0.0	0.8
Polypropylene Bags %	80.0	16.1	0.0	35.4	47.4	0.0	28.1
Small farm silos %	10.0	11.3	13.3	0	8.8	1.8	5.6
Plastic Tank%	0.0	0.0	0.0	1.1	0.0	0.0	0.0

3.3.7 Effectiveness of cereal storage techniques

A Likert scale was constructed to assess the effectiveness of the existing storage techniques. Farmers were asked to rate their effectiveness using a five-level scale of effective, slightly effective, very effective, extremely effective, and not effective at all. Generally, across the six counties, 35% of farmers indicated that it was effective, followed by 25% of them saying the storage methods are very effective. In BF 33% of famers said the storage methods were effective and another third saying it was extremely effective. Similar trends were observed in in Ethiopia (Figure 17).

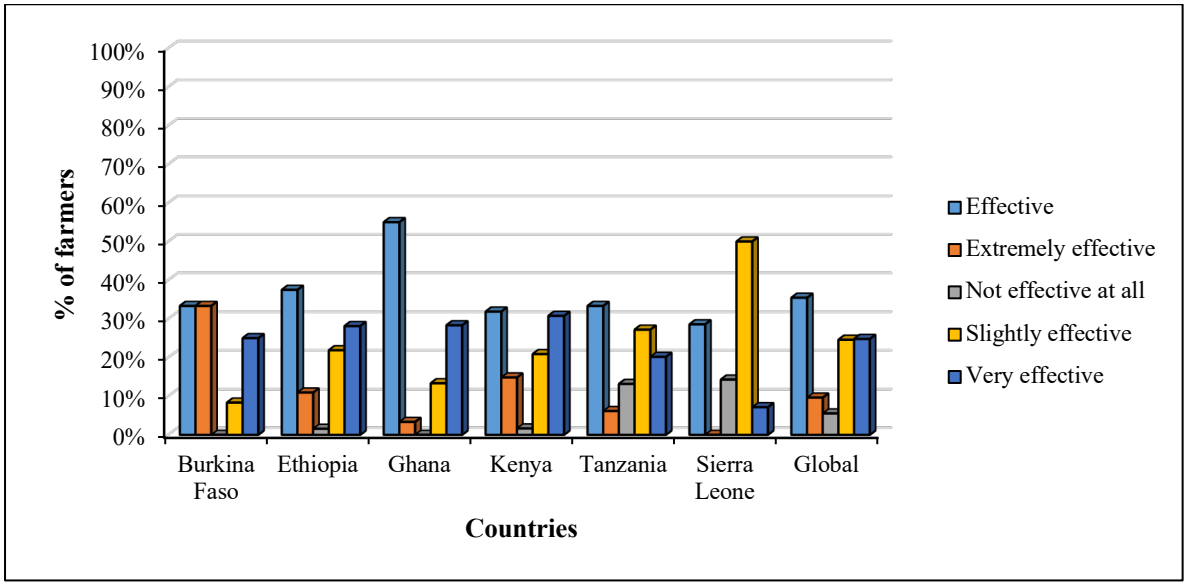

Figure 17: The farmers' perceptions of how effective the storage methods they are using are in each of the six countries.

3.3.8 Importance of drying cereals

All the farmers surveyed across the six countries indicated it was important to dry their cereals. They indicated the main reasons being to prevent the commodities from getting mouldy and to increase the shelf life. Farmers indicated that cereals could be stored for different periods of time. In Burkina Faso they indicated that cereals could be stored for between 6 months to 1 year depending on the crop. Ethiopian farmers indicated that they could store them for 7 months to 2 years. Ghananian farmers indicated 5 months to 1 year. Kenyan and Tanzanian farmers surveyed both indicated 6 months to 2 years (Table 12).

Table 12: The farmers' perceptions of the safe post-harvest cereal storage periods for cereals.

Country	Period of storage Years
Burkina Faso	0.5-1
Ethiopia	0.6-2
Ghana	0.4-1
Kenya	0.5-2

Tanzania	0.5-2
Sierra Leone	0.5-1

3.3.10 Farmer's knowledge of safe moisture content

We were also interested in assessing the knowledge level of farmers on the right storage moisture level for cereals. Generally, most farmers did not know the right safe moisture levels for storage. Only about 8% indicated they had knowledge of the right moisture levels. The situation was the same across all six countries as shown in Table 13. They however indicated that the causes of mycotoxin contamination was as a result of high moisture content of grains.

Table 13: Knowledge of safe moisture contents before storage of cereals

Knowledge of safe moisture content	Country						Global
	Burkina Faso	Ghana	Kenya	Tanzania	Ethiopia	Sierra Leone	
Yes %	0.0	3.3	14.3	5.4	18.3		8.3
No %	91.7	96.7	85.7	94.6	71.7	96.0	88.0
I am not sure %	8.3	0.0	0.0	0.0	10.0	4.0	3.7

3.4. Prevalence of mycotoxins preventive techniques

Majority of farmers surveyed in Ghana (97%) and Burkina Faso (91%) had no knowledge of mycotoxins prevention strategies. Also, farmers in Tanzania and Ethiopia indicated that they have no knowledge of preventive methods for minimising mycotoxins. However, in Kenya (32%) of farmers indicated that they had knowledge of preventive methods for mycotoxins. Accross all the countries about 83% of farmers indicated they did not have knowledge on prevention strategies for mycotoxin contamination of cereals. About a 1/4 of farmers did indicate that they knew how to prevent mycotoxin contamination (Figure 18).

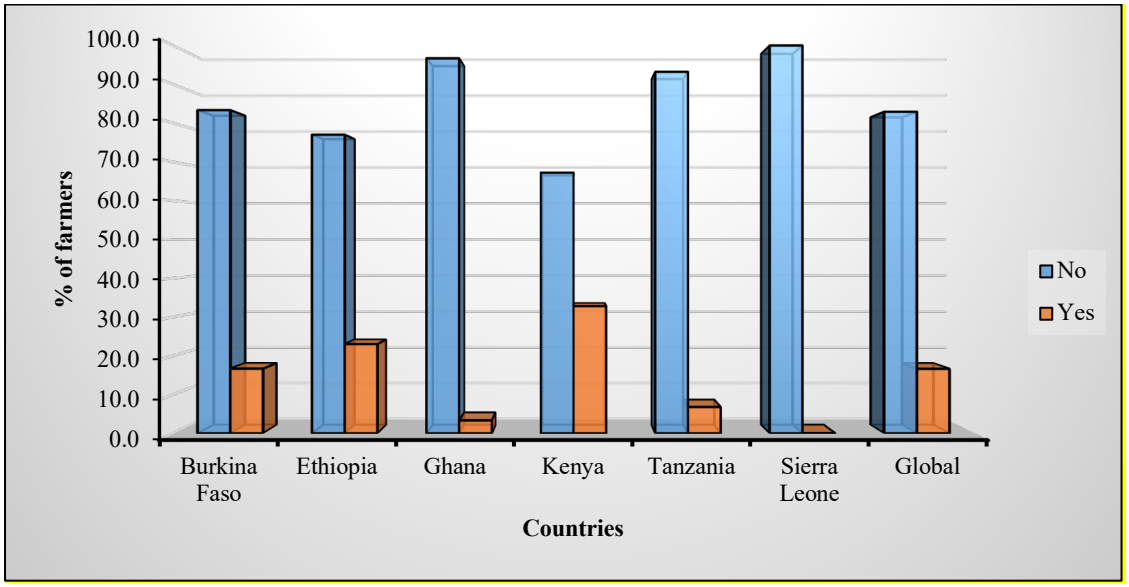

Figure 18: Knowledge of mycotoxin prevention/minimisation strategies in the different countries surveyed.

CHAPTER 4: Discussion

4.1 General characteristics

4.1.1 Gender, Age, Education Distribution

More males were sampled than females and gender inequality is dominant in African agriculture (Ogunlela et al., 2009). Agriculture production and productivity can be enhanced with many more females getting involved in agriculture. Majority of farmers surveyed are over the age of 40 indicating a low participation of the youth in agriculture. Studies indicates that the youth view agriculture as a last resort and not profitable hence turning away from it and opting for wage employment (Filmer & Fox 2014; Irungu et al. 2015; Kadzamira & Kazembe 2015; Thika, 2012). There is a negative impact of aging on technology adoption (Huang et al., 2020; Yang et al., 2018; Li and Zhao, 2009). The youth have high propensity to adopt new agriculture innovations because of their education and willingness to take risk (Kirui, 2019). The majority of the farmers either have no education or just primary school, which has implications for future agriculture.

4.1.2 Farming experience, farm size and reasons for farming

The reasons for engaging in farming was mainly because there were no alternative jobs as a source of livelihood and income for farmers. The majority of farmers had farming experience ranging from a minimum of 10 years to over 30 years. The farmers surveyed had considerable experience in farming, they also indicated their current farm sizes are too small and they would benefit from expanding them.

4.1.3 Labour source and allowance

The main source of labour was extended family, with very few of the farmers able to use hired labour. The main problem with hired labour was the high cost implications. This has further impacted as it affects the adoption of new technologies that are perhaps more labour intensive.

4.1.4 Access and cost of capital

Most new technologies are also associated with increased cost of production. Most of the farmers surveyed indicated that they would not be able to access additional capital because of lack of access to agriculture financing from financial institutions. This would thus make it very difficult to expand production or adopt new technologies associated with the associated increased cost of operations.

4.1.4 Farm enterprises and land tenure Systems

There are different farming systems across the study sites and the most dominant ones were mixed farming and arable farming. The dominant systems for East African was mixed farming followed by arable farming. For West Africa this was arable farming followed by mixed

farming. The dominant land tenure system was inherited family land across the two regions. Farmers had a lot of control of their land and could manage it in the way they wanted to. This land tenure system was the most preferred by the majority of the farmers across the two regions.

Close to 90% of all farmers interviewed indicated that they grew more than one crop. This was a climate risk management strategy and has implications for the management of pests and diseases. Maize was mentioned as the most important crop across all the six countries.

4.2 Incidence of mould spoilage, mycotoxins and risk awareness/perception

4.2.1 Prevalence of mouldy cereals among farmers and their knowledge levels

In Africa, mycotoxin contamination is a major problem with implications for human and animal health and the economy (Darwish t al., 2014). This study sought to assess the level of grain storage losses associated with spoilage moulds and mycotoxin contamination. About 44% of farmers indicated that they lost their cereals to mould spoilage and mycotoxin contamination. The losses were in the range 0-10% and a significant number of them also experienced higher losses of 11-20%. These losses are significant and constitute a significant economic loss to the farmer and possess a serious health risk when consumed, because mycotoxins are heat stable and remains present after processing.

Almost all the farmers across all the six countries indicated that they knew about aflatoxins. However, they did not know how dangerous they were when consumed. They indicated their families had previously fallen ill as a result of consuming aflatoxin contaminated grains. This lack of knowledge could have dire consequences/impacts on the health of rural farming families and communities. They also indicated that it was unsafe to consume milk from animals fed with contaminated grains. Education on the health implications of aflatoxins (Class1a carcinogen) and other mycotoxins is therefore very important and should be considered by the project.

4.2.2 Length of safe storage time and moisture content

Across all six countries, cereals were stored at the homestead and usually done using polypropylene bags in Burkina Faso, Kenya and Tanzania. PICS bag adoption is high in Ethiopia. In Ghana, the hessian bags are most commonly used for grain storage. They indicated that these storage techniques were effective. However, aflatoxin contamination is still very high, especially in Sub-Saharan Africa. The question then is why? Most of these farmers emphasised the importance of drying grains but had no knowledge of the target safe moisture content to dry their grains to, prior to storage. This could be the major reason for the high aflatoxin contamination. To ensure low grain losses, crops must be dried to the safe storage moisture content within the safe storage time (Ekechukwu, 1999; Magan et al., 2020).

4.2.3 Grain storage techniques identified

Traditional methods of storage ranged from storing on the floor to storing in cribs and more modern methods from small drums and bags to complex silos (USDA, 2011). This study tried to assess the adoption of storage techniques amongst farmers across the six countries. The most prevalent storage techniques globally are PICS and hessian bags with each having a use prevalence score of 35% and 30% respectively. Polypropylene bags were also commonly used in 28% cases. The most prevalent storage technique in Burkina Faso was polypropylene sacs with a score of 80%. In Ethiopia the most prevalent storage technique was the PICS bags (50%) followed by Hessian and polypropylene ones with 16% each. In Ghana, the most prevalent was hessian bags (87%) followed by small farm silos (13%). Polypropylene was the most prevalent bags used in Kenya and Tanzania.

4.2.4 Effectiveness of Cereal Storage Techniques

Food security and safe storage at the farmer level go together. As well as providing food security for times of scarcity, effective grain storage is an inflation-proof savings bank (Thamaga-Chitja et al., 2004). A Likert scale was constructed to assess the effectiveness of the existing storage techniques. Farmers were asked to rate the effectiveness using a five level scale of effective, slightly effective, very effective, extremely effective, and not effective at all. Overall, most of the farmers (35%) indicated it was effective followed by 25% of them saying the storage methods are very effective. In Burkina Faso, 1/3rd of famers said the storage methods were effective, another 1/3rd extremely effective. Similar trends in Ethiopia were observed across the other countries.

4.2.5 Prevalence of mycotoxins Preventive techniques

Majority of the farmers also indicated they have knowledge on how to prevent mycotoxin contamination, yet mycotoxin contamination levels are still very high in Africa. It appears that they may be confusing visible mould spoilage with mycotoxin contamination, as the latter is not visible but caused by the moulds. They either are unaware of this difference or are failing to apply their knowledge. It will be important to engage more with farmers to educate them properly and encourage them to apply their knowledge to minimise mycotoxin contamination, especially in cereals and groundnuts.

CHAPTER 5: CONCLUSIONS

The results of this survey have established the status of farmers' perceptions and knowledge on the incidence and severity of mould spoilage and mycotoxin contamination in both East and West Africa. These results will be used to guide the development of new strategies to reduce mould spoilage and mycotoxin contamination of grains in these two regions of Africa. These results may also open up new research avenues, develop alternative messages for effective communication, planning of campaign strategies and create the basis for a constructive collaboration between researchers and farmers. The results show:

- Most of the farmers surveyed were over 40 years of age indicating low participation of the youth in agriculture
- The majority of the farmers either had no education or just primary school level which has implications for future agricultural strategies.
- The farmers surveyed had considerable experience in farming.
- Farmers indicated that their farm sizes were too small and that they were willing to expand their farms.
- The majority of farmers indicated that they were farming because they did not have other options of employment.
- There was also poor access to credit and land tenure systems. The land was usually inherited by the family.
- Farmers mostly cultivated more than one crop.
- Most of the farmers indicated that they lost their cereals due to mould spoilage and/or mycotoxin contamination. The losses ranged from 0-20%.
- The majority of farmers across all the six countries indicated that they knew about aflatoxins. However, they did not know about the heat stability and that after cooking the toxins remained dangerous when consumed in food.
- Across all six countries, cereals are stored at the homestead and usually done using polypropylene and PICS bags.
- Most farmers did not know the right moisture content to dry their grains to, before storage.
- Overall, most of the farmers perceived that their current storage techniques being used were effective.
- Most of the farmers also indicated that they had knowledge on how to prevent mould spoilage and mycotoxin contamination.

We recommend to EWA-BELT to take into consideration these key observations while designing and implementing interventions to manage mycotoxin contamination, especially by aflatoxins, in both East and West Africa to minimise the exposure of rural populations to this class 1a carcinogen.

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