EU H2020 PROJECT
GA 862848

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

EWA-BELT

D 3.5

Perception and Knowledge of Crops Pests and Diseases of 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:	

DISCLAIMER

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

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. EWA-BELT project is grateful to the EU Horizon 2020 for financing the study. 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.

Authors:
J. K. Bidzakin[1], Anil Graves[1*], Naresh Magan[1],
Giovanna Seddaiu[2], Quirico Migheli[2], Pier Paolo Roggero[2], Margherita Rizzu[2], Safa Oufensou[2]
Rachele Stentella[3],
Pierpaolo Saporito[4], Simone Merafina[4],
Joseph Adjebeng-Danquah[5], Prince Maxwell Etwire[5]
James Kombiok[6], Sheref Yakubu[6],
Deodatus Stanley Kiriba[7], Shadrack Mbapila[7]
Sheila Okoth[8], Beneath Mutsotso[8]
Joseph Tholley[9]
Kelvin Mtei[10], Josephine Mkunda[10]
Anthony Kimaro[11], Temu Emmanuel[11]
Alemayehu Chala[12]
Noel Nekesa Makete[13], Eunice Onyango[13]

Author Affiliation:

1. Cranfield University
2. Universita degli Studi di Sassari-Nucleo di Ricerca sulla Desertificazione
3. Fondazione ACRA
4. Osservatorio per la Comunicazione Culturale e Audiovisiva nel Mediterraneo e nel Mondo
5. Council for Scientific and Industrial Research Savanna Agricultural Research Institute
6. Kundok Development Consult
7. Tanzania Agricultural Research Institute
8. University of Nairobi
9. University of Makeni
10. The Nelson Mandela African Institute of Science and Technology
11. International Centre for Research in Agroforestry
12. Hawassa University
13. Kenya Agricultural and Livestock Research Organisation

***Correspondence:**
Cranfield University
Centre for Environmental & Agricultural Informatics
School of Water, Energy & Environment
MK43 0AL
Email: a.graves@cranfield.ac.uk

HISTORY OF CHANGES

Version	Date	Changes
REV 1	28th July 2022	In the executive summary, pag. 10, 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 17, pag. 39 has been corrected.
		The recommendation of investigating knowledge on pest and disease being held by same farmers will be considered in future research.
REV2	28th July 2022	Figure 18 shows the % of farmers who applied pesticides by themselves, page 40 and Figure 19 is introduced to show the rate of occurrence of symptoms after application of pesticides by those applying by themselves. D3.5 Page page 41
REV3	28th July 2022	This was restated as suggested ("*In Ghana, all farmers who stated knowing about traditional remedies (who are very few) indicated they frequently use them").* D3.5 page 43

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 nutritional insecurity. Most African countries are ill equipped to safeguard crops against existing and emerging pest and disease risks associated with climate change, increasing globalisation and human mobility. Major pest and disease outbreaks create shocks at local and larger scales and erode resilience of farming systems, perpetuating, and deepening poverty. A deep understanding of existing constraints in African farming systems, along with traditional knowledge and practices would provide new insights into the development of alternative strategies to improve pest and pathogen control by adding value to tacit knowledge of the local communities.

This study randomly sampled farmers from the five countries through the Country Farmer Field Research Units (FFRUs). A total of 531 farmers were randomly sampled and interviewed using semi-structured questionnaires aimed at generating baseline information on the status of pests/pathogens and their management in African agriculture. The main findings of this survey are summarised below, based on the study objectives of assessing farmers' perceptions and knowledge of pests and diseases in their crops in East and West Africa regions:

- The majority of farmers surveyed are over the age of 40 indicating a low participation of the youth in agriculture.
- Almost all the farmers had either limited primary school education or no eduction at all, which has implications for future agriculture.
- However, the farmers surveyed had considerable experience in farming.
- Most of farmers indicated that their farm sizes were too small and that they were willing to expand their farm surface area.
- In addition, the majority of farmers indicated that they were farming because they did not have other options of employment.
- It is clear that there is poor access to credit, and that the land tenure system is mainly family inherited land.
- Farmers mostly cultivated more than one crop.

- Rain fed irrigation systems were the main method used by farmers, implying that they have no control over how and when their crops are irrigated. This has significant implications for pest and disease control.
- The majority of farmers do not use certified seed as they depend on the seed saved on farm from the previous crop. This would represent an important source of pests and pathogens for subsequent crop damage.
- Crop rotation adaptation for improving pest and disease management was high in Burkina Faso, Kenya, and Ethiopia but low in Tanzania, Sierra Leone and Ghana.
- Seed treatment for pest and disease management was very low in all the surveyed countries except Burkina Faso.
- Many of the farmers acknowledged it would be very difficult to achieve the required yields without proper pest and disease management.
- Farmers indicated that they had very little knowledge of alternative IPM strategies, and this was similar across all the five countries surveyed.
- The majority of farmers had no awareness that pesticides could be harmful to humans and almost all the farmers surveyed had no knowledge of the World Health Organizations' guide on the safe use and application of pesticides.
- Of the six countries surveyed the farmers' knowledge of traditional practices used in controlling pests and diseases was relatively low except Tanzania.
- The traditional remedies identified included wood ash, plant extracts (crushed neem leaves, powdered pepper, tobacco leaves) and cattle dung/urine.
- Almost all the farmers from Tanzania, Ghana and Ethiopia indicated that it was not possible to grow botanicals while the majority of those from Burkina Faso and Kenya indicated that it was possible to grow botanical plants for use in crop protection.

We recommend that the EWA-BELT project include these key findings from the survey carried out in the six counties to inform the design and implementation of intervention strategies which can be effectively utilised for imporving the management of pests and diseases in the major cropping systems of both East and West Africa. This would lead to imporvements in farm productivity, food security and food safety and thus rural farm household livelihoods. The detailed results are presented in 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 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).

Since the beginning of agriculture, farmers have had to compete with harmful organisms in their agricultural production activities. These include pests, bacterial and fungal pathogens, viruses and weeds. The pests include mites, aphids, nematodes, rodents, birds, thrips, slugs and snails whereas plant pathogens include fungi, bacteria, and viruses. Weeds have also affected agricultural production by competing for soil nutrients with crops. These biotic stresses of crops have a significant impact on yield and nutritional quality for food and feed use (Narla, 2014). Insect pests are a major cause of crop yield losses around the world (Oerke, 2006) and can provide entry points for fungal pathogens including mycotoxigenic moulds resulting in food insecurity, especially post-harvest, in developing countries (Zakari et al., 2014).

Most African countries are ill equipped to safeguard crops against existing and emerging pest and disease risks associated with climate change, increasing globalisation and human mobility (Danielsen et al., 2014). Major pest and disease outbreaks create shocks at a local and larger regional scale and erode the resilience of farming systems, perpetuating, and deepening poverty (Kroschel et al., 2014). This predisposition is predicted to become more acute under scenarios of climate change, increased trade, human movement due to intensification of agriculture to meet the growing demand for food and feed from an increasing population. It has been predicted that because of climate change abiotic factors, pests and diseases are moving towards te poles at the rate of a few kms per annum and that the diversity of these is also changing impacting on minimisation and control strategies (Bebber et al., 2013; Bebber et al., 2014).

Thus, an in depth understanding of Indigenous Traditional Knowledge (ITK) and practices would provide new keys to perceive local resources which could be utilised to provide more

effective and alternative strategies to achieve pest and pathogens control 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 light of these that the EWA-BELT project is carrying out this study to establish the baseline with respect to perceptions and knowledge of pests and pathogens in the agriculture systems of East and West Africa regions.

1.2 Objectives of the study

The overall aim of this study was to assess farmers' perceptions and knowledge of crop pests and diseases in six countries in both the East and West African regions.
The specific objectives were;

- To assess farmer and farm characteristics.
- To understand the incidence of pests/pathogens, production constraints and sources of propagative materials.
- To assess the perceptions of farmers knowledge of pests and disease in existing cropping systems
- To assess farmers current knowledge on the management of pests/pathogens and use of pesticides.
- To identify the existing traditional knowledge and its application in managing pests and diseases in existing cropping systems.
- To assess the effect of pest and disease control on farm outputs.

CHAPTER 2: MATERIALS AND METHODS

2.1. Description of Study Sites

This survey 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 study countries were Burkina Faso, Ghana, Sierra Leone, Ethiopia, Tanzania and Kenya. A brief description of each Country is presented with its Map, See Figure 1.

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.

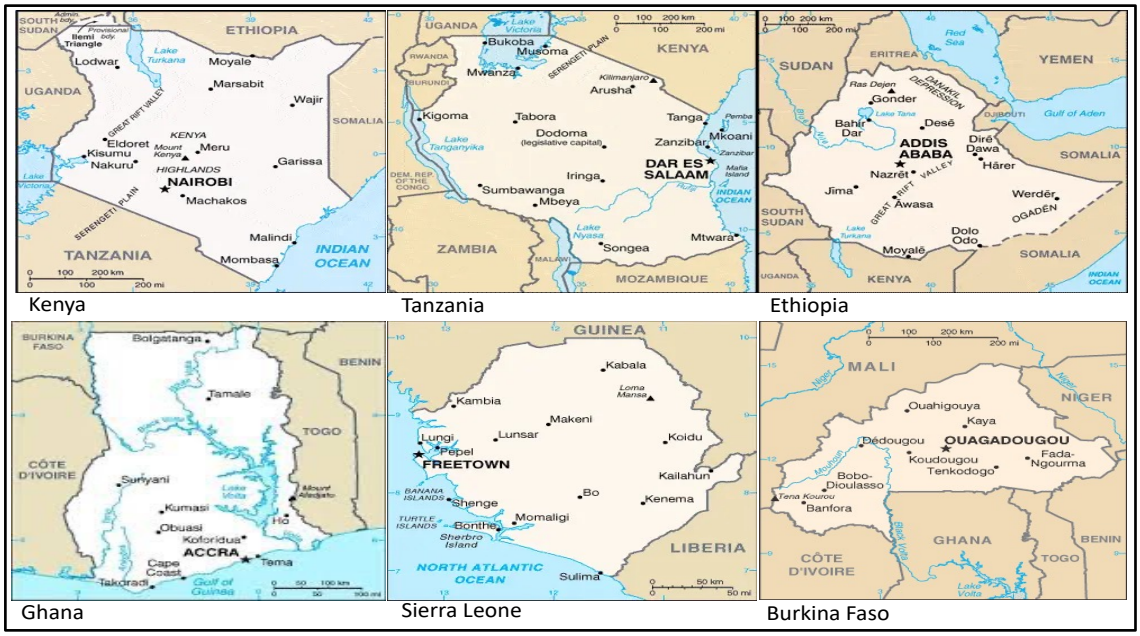

Figure 1: Google Map of the six study countries where the survey was carried out.

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 which comprised of 21 Females and 20 Males. In Ethiopia 65 farmers were sampled comprised of 3 Females and 62 Males. In Ghana, out of a total of 60 farmers sampled, 41 were males and 19 females. Kenya provided the largest sample size of 185 farmers made up of 122 females and 63 males. Tanzania was the second largest farmer group sample consisting 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 in the six countries

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

2.2.2 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 the 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' perceptions and knowledge of the impact of pests and pathogens on their crops.

2.3 Data analysis

The study employed descriptive analyses to analyse the survey data. Frequencies and percentages were used to generate summaries, Tables, and Figures at a country and global scale to summarise the views of the 531 farmers sampled. The analyses covered general characteristics of farmers and their farms and the incidence of pests and diseases in their cropping systems.

CHAPTER 3: RESULTS

3.1 General characteristics

3.1.1 Gender, Age, Education Distribution

The majority of the respondents were males (54%) and the rest females (46%). There were more male farmers sampled across three countries (Ethiopia, Ghana and Tanzania) and more females in three countries (Burkina Faso, Kenya and Sierra Leone; Table 2). The majority of farmers surveyed were found to be within the age range of 41-50 years (31%) followed by the age range of 31- 40 years which constituted about 28% of the total number of farmers sampled (Table 3). The oldest age bracket was 70+ years old, which accounted for only 3% of the respondents.

Table 2: Gender distribution in the six countires surveyed.

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: The age distribution of the survey respondents in each of the countries surveyed.

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%

Out of the total number of farmers sampled, 44% of them indicated that they had gone to primary school and 25% indicated that they have secondary school education. Only 4.5% indicated that they had university degrees across the six study countries. About 27% of the respondents had never attended school at all. Literacy levels in Kenya and Tanzania were 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 rates stood at about 86% in 2015. According to UNESCO Institute for Statistics (UIS, 2013) only 60% of the population of Sub-Saharan Africa is literate. The literacy rate of Ghana, Burkina Faso and Sierra Leone appeared to be less than the regional average.

Table 4: Education of farmers surveyed in the six countries 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, about 20% of the farmers' experience was in the range of 11-15 years followed by 16-20 years with 18%. About 39% and 33% of farmers in Burkina Faso and Ethiopia respectively had 30+ years of farming experience. Most Ghanaians and Kenyans sampled had 10-15 years of farming experience while the majority of Tanzanian farmers had about 5 years experience. About 32% of Sierra Leonean farmers sampled had 16-20 years experience (see 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. About 34% of Burkina Faso farmers sampled have 3+ acres size of farm. In Ethiopia the farms were predominantly small, in the range of 0.6- 1 acre. For Ghana, the majority of the farmers sampled have about 1.6-2.0 acres, Kenyan famers generaly had very small farm sizes of just 0.1-0.5 acres. About 26% of the Tanzanian farmers also indicated 0.6-1 acre of farmland and in Sierra Leone 22% of farmers farms were 0.1-0.5 acres. Overall, with the exception of Burkino faso and Ghana, all the other countries surved had <10% of farmers having farms >3.0 acres in size.

Table 6: Relative size of the farms of the farmers surveyed in the five 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 land area satisfaction, globally, the majority of the farmers (61%) indicated their farm size was too small. However, 39% indicated they were satisfied with their farm size. This trend is the same across the study countries except for Burkina Faso and Sierra Leone who indicated that the majority of them were satisfied with their current farm sizes (Figure 2).

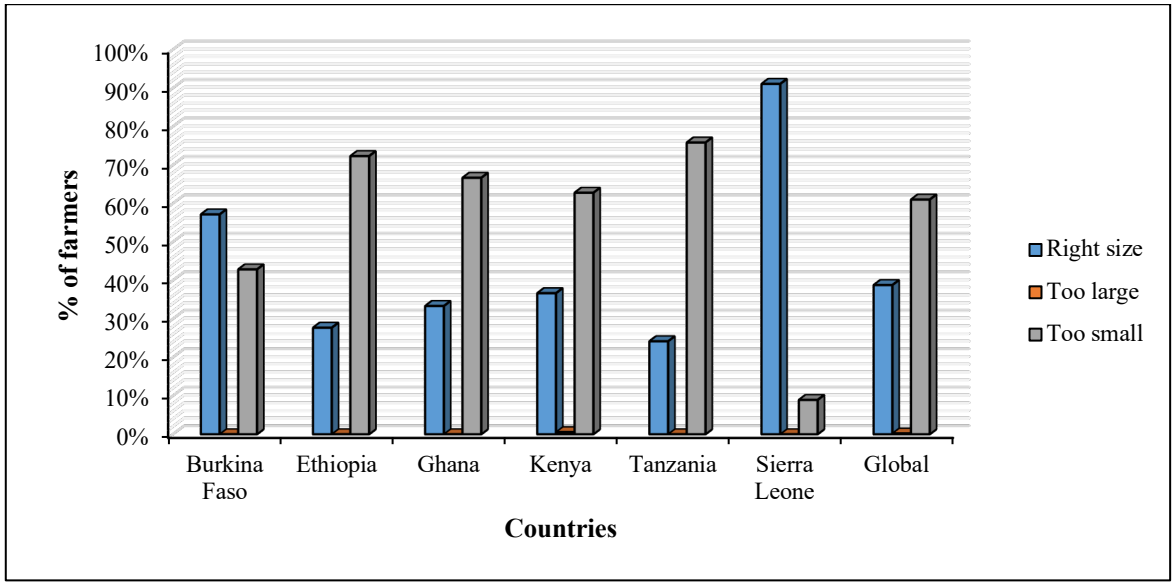

Figure 2: Farmer's satisfaction of their farm size in the six ountries surveyed.

Farmers had different reasons why they were involved in agriculture. In this study, the primary reason was because of the lack of other jobs, followed by it been the main source of their livelihood, thirdly a good source of income, fourthly it being a good job and lastly because of the group activity. The trend was similar for Burkina Faso, Ethiopia, Ghana and Sierra Leone for the first three top reasons as shown in Figure 3.

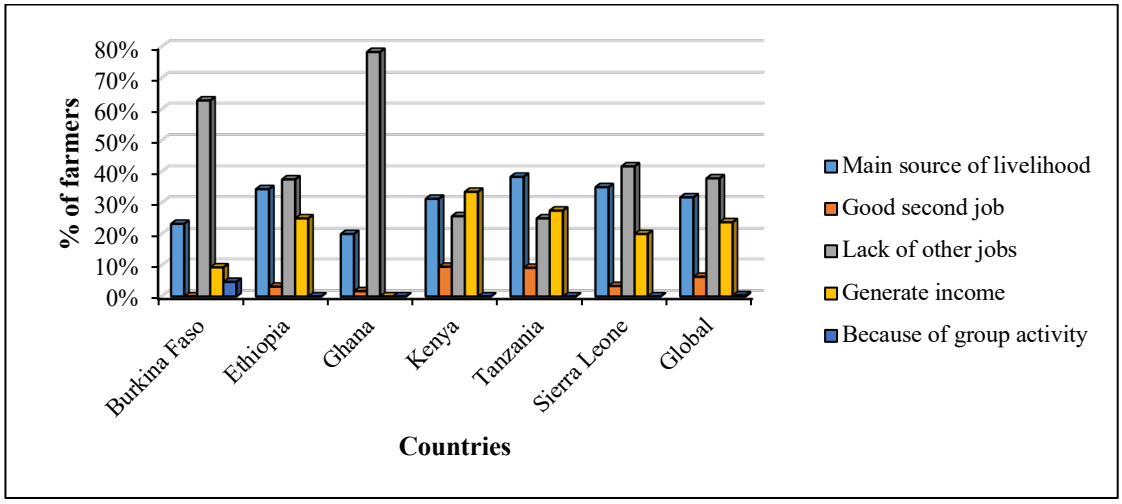

Figure 3: Key reasons for farmers to remain engaged in farming.

3.1.3 Farmers source of labour and its availability

The main source of farm labour across the six countries was mostly family labour only, followed by family labour and hired labour, except for Burkina Faso and Sierra Leone. The third was the use of mostly hired labour alone except for Burkina Faso, with the fourth being cooperative. The trend was similar across the six countries. Family labour thus is a very important factor in African agriculture (Figure 4).

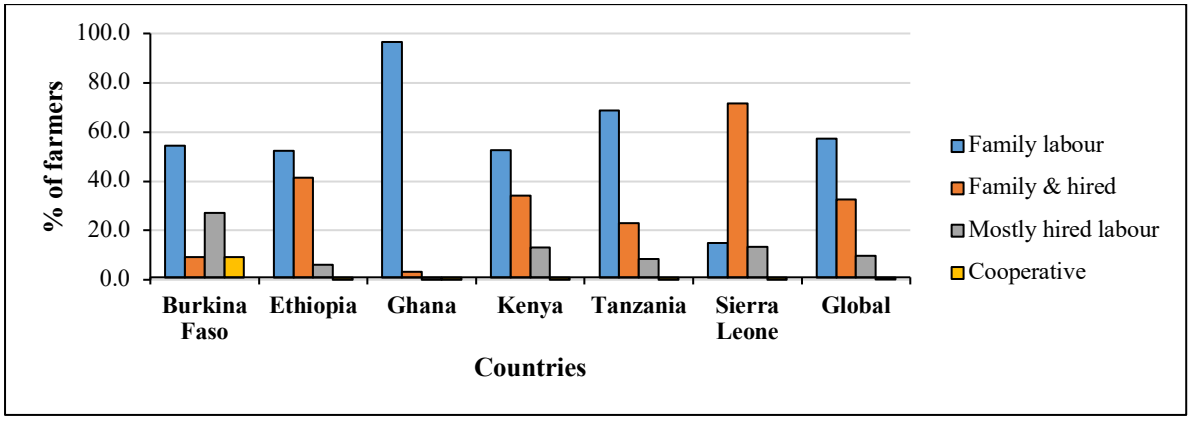

Figure 4: The main sources of farm labour used across the six countries

The majority of farmers (70%) indicated that labour costs were their main problem, and 25% of indicating that it was easy to access farm labour. Globally, about 5% indicated that it was difficult to access farm labour. The trend was similar in Burkina Faso, Ethiopia, Tanzania and

Ghana. In Kenya and Sierra Leone they indicated that labour was not readily available (Figure 5).

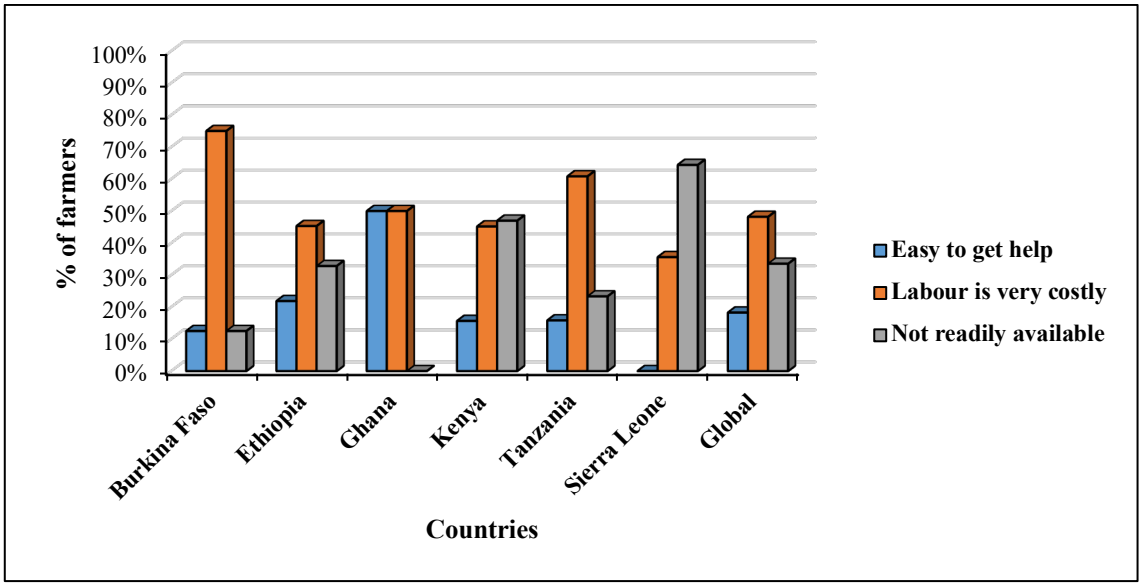

Figure 5: Labour availability across the six countries

Globally most respondents in all the countries indicated they would be able to do more work (80%) and 15% also indicated that they could even hire extra labour to do more work on their farm. Whereas, a small percentage (7%) indicated that they would not be able to do extra work on their farms. This trend was similar across all the six study countries (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% of the respondents indicated that they would not be able to borrow money anywhere, whilst 23% and 18% of farmers indicated that they could borrow money from banks and friends, respectively. About 8% said they would borrow from a money lender as shown in Table 8. The trend iwas generally the same across the five of the study countries except Sierra Leone where the majority of them indicated they would 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 also difficult to obtain farm capital as indicated by the respondents across the six countries. They also indicated that farm money is very expensive to borrow. A few indicated that it was easy to do so and cheap to obtain. About 67% of respondents indicated that it was difficult to access farm loans. Ghana's situation is similar for all (100%) of the respondents. Ethiopia, Kenya and Tanzania also recorded 49%, 55% and 69%, respectively (Figure 6).

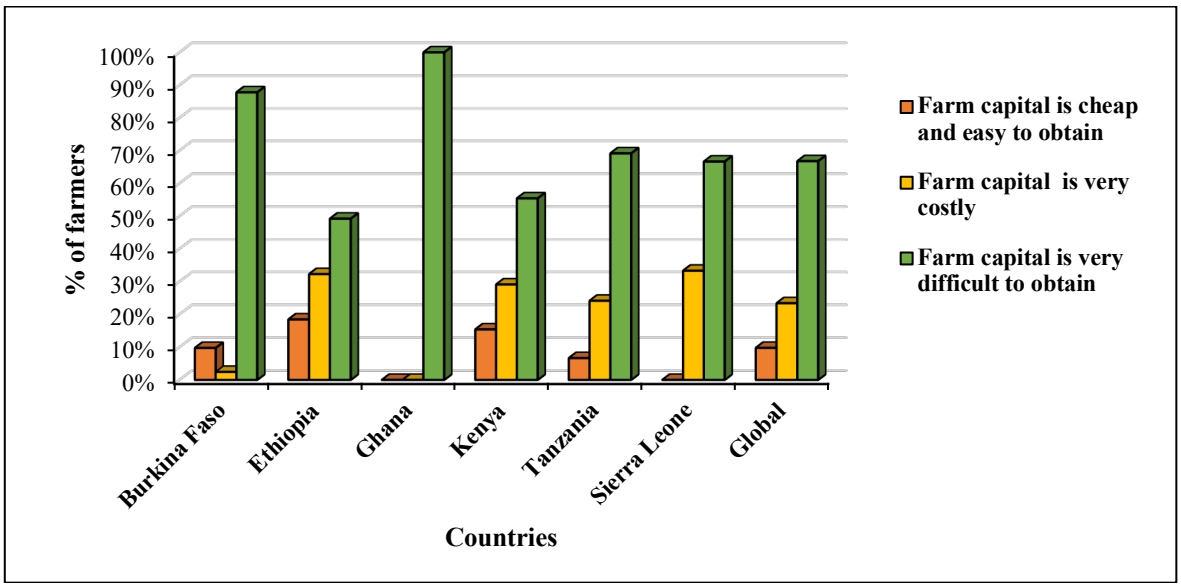

Figure 6: Relative cost of farm capital for the farmers sampled.

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 was similar in Sierra Leone. The third was agroforestry farming and the fourth livestock systems and lastly tree systems. In Tanzania, the two dominant systems are mixed farming and arable systems followed by agroforestry. Kenya has mixed farming as the dominant system followed by arable system. The dominant system in Ghana is the arable system followed by the mixed system. Ethiopia has mixed systems as their dominant one followed by the agroforestry system. Burkina Faso has arable system as their dominant system followed by the agroforestry one (Figure 7).

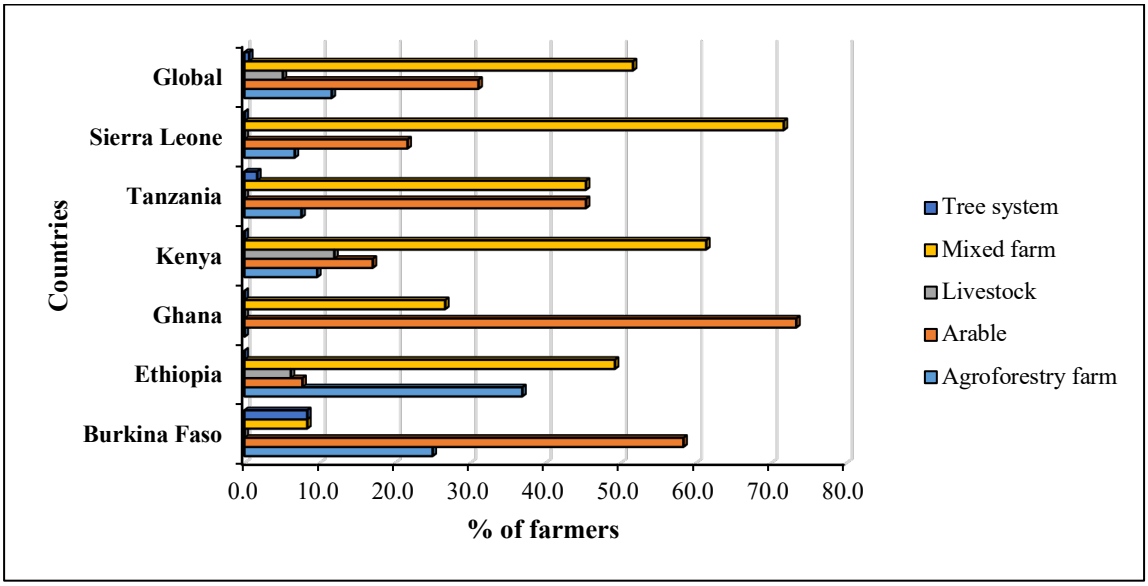

Figure 7: Relative percentage (%) of farmers using different cropping systems.

3.1.6 Land tenure system practised by farmers

There were several land tenure systems in the study areas and the trend was similar across the countries surveyed (Figure 8). The dominant land tenure system across the six countries was 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.

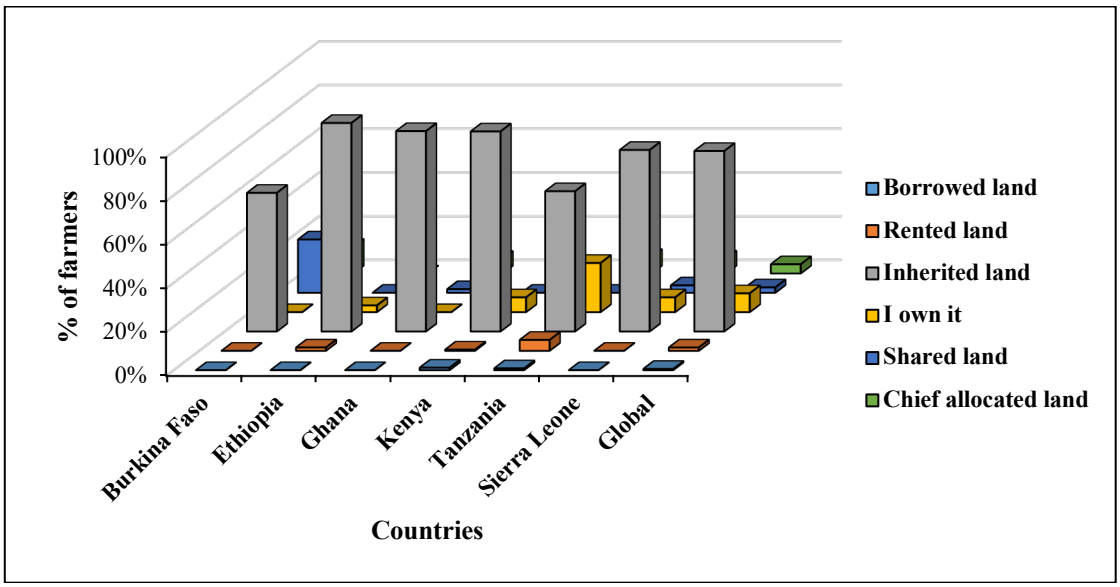

Figure 8: Land tenure system practised by farmers.

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 had a 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 was owning of the land through outright purchase as shown in Figure 9.

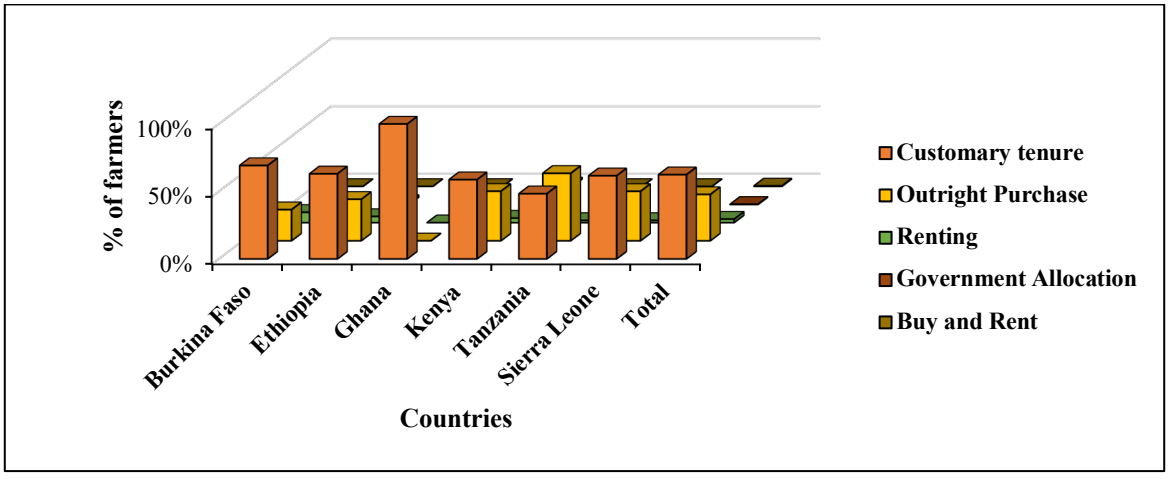

Figure 9: The preference of the farmers for different land tenure systems across the six countries surveyed.

3.1.8 Household farm enterprises and their importance

The results indicated that the majority of farmers cultivate more than one crop. This shows crop diversification is highly adopted across the study countries as a risk minimising technique. Very few farmers engaged in mono cropping systems (Figure 10).

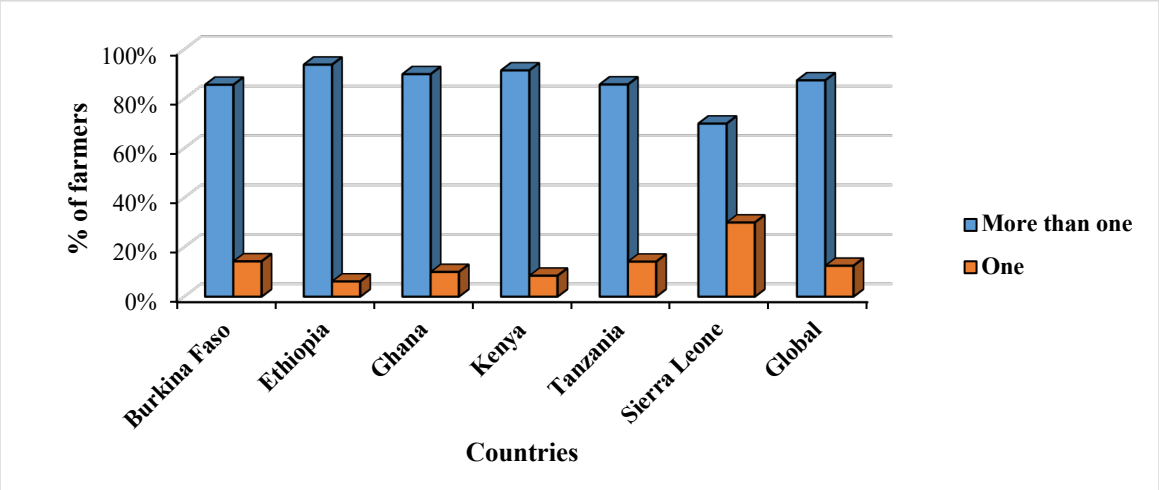

Figure 10: Relative percentage of farmers growing one or more crops in their farm.

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 pests/pathogens

3.2.1 Irrigation systems and soil classification

The study tried to identify the irrigation system used by farmers and assess the types of soils being used for production. Clearly rainfed irrigation system are used across the six countries to irrigate their farms. This implies they have very little control over the irrigation of their farms. We tried to identify the different types of soil across all the project countries. Globally the most prevalent soil identified is loam soil constituting about 36% of all the 21 soils classified by the study. The second most prevalent is sand (17%) followed by silt and clay (10% and 9%, respectively). Burkina Faso's most prevalent soil is sand with 37% followed by sand clay with

34%. Ethiopia's most prevalent soil is loam and Ghana is sand with 45%. The prevalent soil for Kenya and Tanzania is loam with both around 44% (Table 9).

Table 9: Classification of soils of the five countries surveyed

Country	Soil Classification		
	1st	2nd	3rd
Burkina Faso	Sand (36.6%)	Sand Clay (34.1%)	Clay sand (26.8%)
Ethiopia	Loam (43.1%)	Clay (30.8%)	Clay loam (10.8%)
Ghana	Sand (45%)	Loam (13.3%)	Sand clay (8.3%)
Kenya	Loam (44%)	Sandy loam (17%)	Sandy loam (13.2%)
Tanzania	Loam (44.2%)	Sandy loam (23.3%)	Clay (15%)
Sierra Leone	Sand loam (22%)	Loam (20%)	Clay sand loam (19%)
Global	loam soil (36.3%)	Sand (17.3%)	Silt (9.6%)

3.2.2 Production constraints

We tried to identify production constraints of the farmers surveyed across the six countries. With respect to seed availability, 31% of farmers indicated that this represented a minor problem, 25% that it was not a problem, whereas 23% indicated that it was problematic. In Burkina Faso, the majority of farmers indicated no problems at all. In Ethiopia 35% of farmers indicated it was not a problem at all. About 63% of Ghanaian farmers indicated that it was a slight problem and Significant number of Kenyans and Sierra Leoneans (36%) and (28%) respectively indicated it was problematic. In Tanzania about 40% indicated that it was not a problem at all (Figure 11).

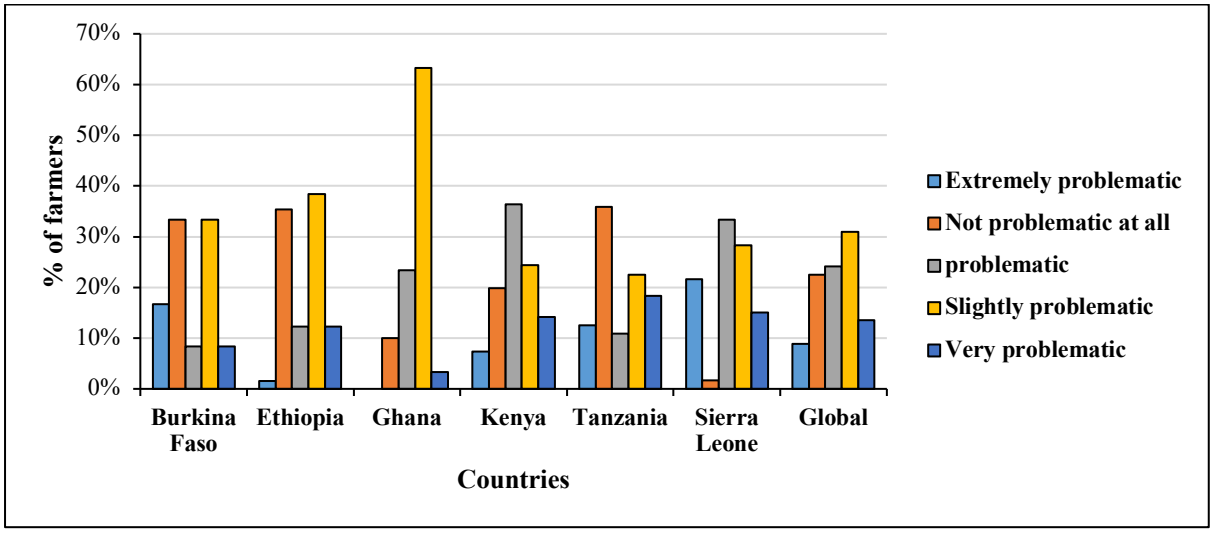

Figure 11: Ranking of propagative material problem by farmers surveyed

3.2.3 Source of propagative materials of farmers

This question aimed at identifying the main source of propagative material per country. The two main sources of propagative material across the six study countries are represented by buying from the market followed by self-production. In Burkina Faso the main source is self-production (91%) followed by buying from the market (9%). In Ethiopia, the main source is buying from the market (60%) followed by self-production (40%). This same trend is also adopted in Kenya and Tanzania. In Ghana and Sierra Leone however, self-production is the main source followed by buying from the market (Figure 12).

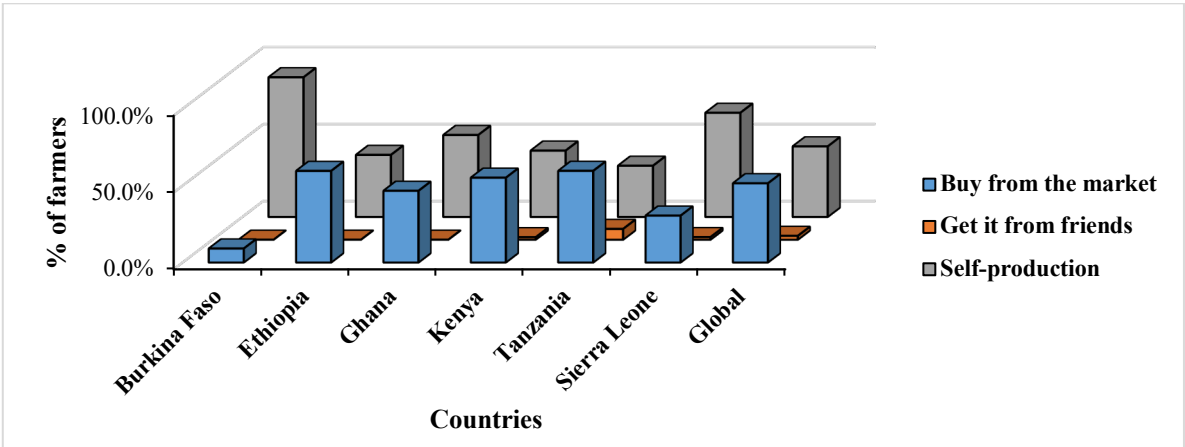

Figure 12: Source of propagative material to farmers surveyed

3.2.4 Knowledge of different effects of pests, pathogens and environmental factors

We tried to gauge the knowledge level of farmers on the differences in the effects of pests, pathogens, and environmental effects. Globally 39% indicated that it was easy to identify their effects followed by 20% of them saying they could not really tell. About 18% said that they could tell with some hesitation. A low number (10%) indicated they would not be able to tell the difference. In Burkina Faso, 50% and in Ethiopia 42% indicated that it would be easy to differentiate the effects. The trend was similar for Ghana and Kenya with 42% and 57% respectively as shown in Table 10.

Table 10: Knowledge of different pest; pathogens and environmental effects on the crops of farmers surveyed

Knowledge	Countries						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Not at all	0.0%	1.5%	0.0%	1.7%	32.5%	0.0%	8.5%
Not really	30.0%	10.8%	16.7%	18.3%	23.9%	26.7%	19.7%
Sometimes	20.0%	12.3%	15.0%	5.0%	12.8%	53.3%	15.2%
Easily	50.0%	41.5%	41.7%	57.2%	17.1%	16.7%	38.6%
With some hesitation	0.0%	33.8%	26.7%	17.8%	13.7%	3.3%	17.9%

3.3.5 Pests/Pathogens Identified

In Ethiopia the major pest problem identified were “rust”, followed by “worms” and “insects”. In Burkina Faso insects attack was the main problem followed by striga weeds. The current major problem in Ghana is fall army worm. The major problems in Kenya and Tanzania are represented by “insects” and “worms’ attack”.

3.4 Knowledge on management of pests/pathogens and use of pesticides

3.4.1 Practice of crop rotation and seed treatment

The study also wanted to assess the adoption of crop rotation across the study area. A little over 51% of the farmers indicated they practiced crop rotation. In Tanzania and Sierra Leone just

about 15% and 12% of farmers, respectively indicated that they practiced crop rotation. The adoption of crop rotation was very high in Kenya (65%) and in Ghana about 45%. The adoption in Ethiopia and Burkina Faso was very high, at about 90% (Figure 13).

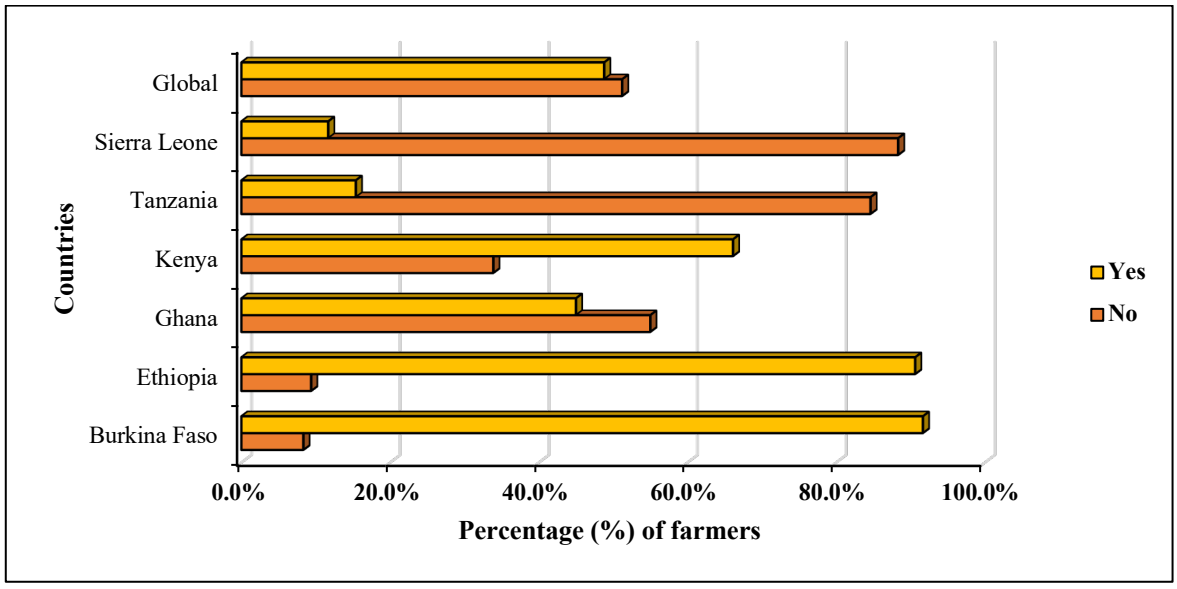

Figure 13: Adoption of crop rotation practice by farmers surveyed

3.4.2 Crop seed treatment

The study tried to assess if farmers treated their seeds before planting. The majority of them (91%) indicated that they did not treat their seeds before planting. This situation was similar in Ghana, Ethiopia, Kenya, Tanzania and Sierra Leone (Figure 14). It was only in Burkina Faso that the majority of farmers (80%) indicated that they did treat their seeds before planting.

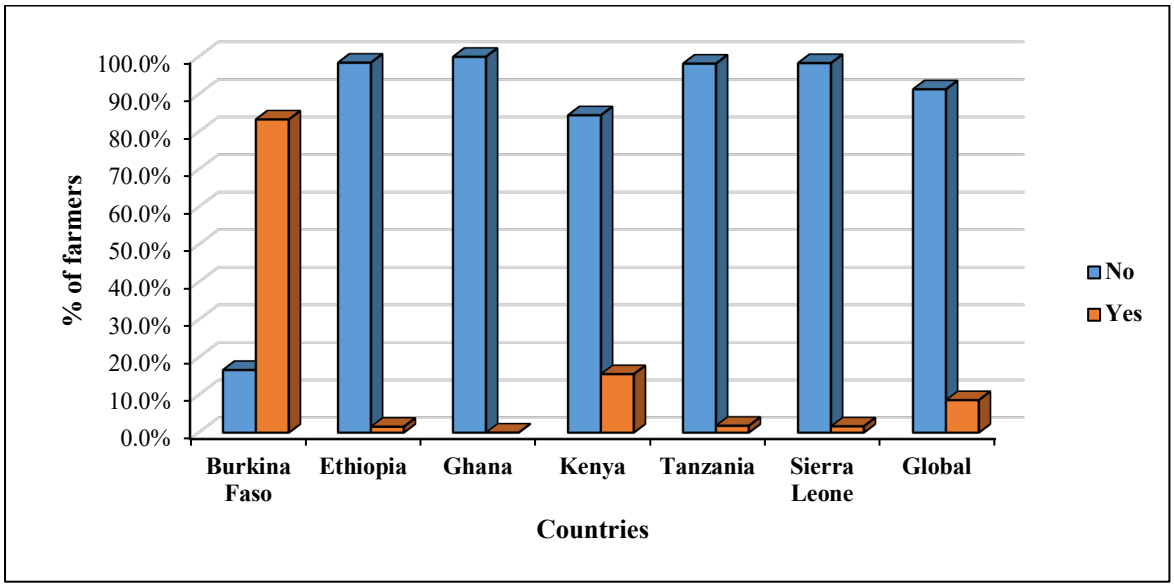

Figure 14: Adoption of crop seed treatment by farmers surveyed across the six countries

3.4.2 Farmers application of Pest/Pathogen control methods

The number of farmers who do not use any control methods were significantly higher than those using control methods as shown in Figure 15. Globally 87% of farmers indicated that they did not use any control methods with only 13% indicating that they did use control methods.

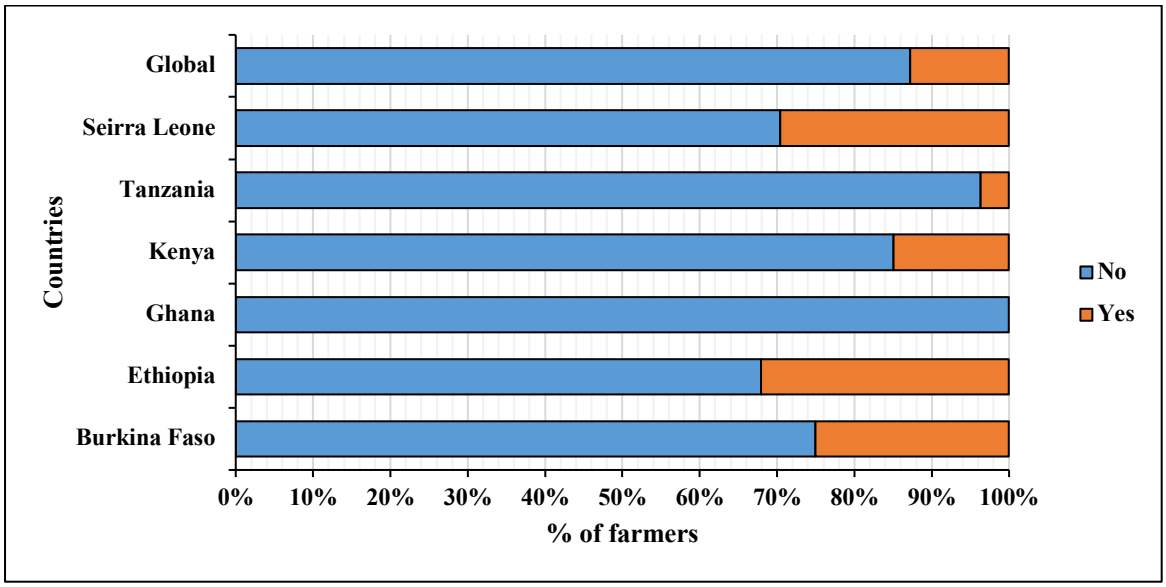

Figure 15: Adoption of Pest/pathogen control methods by farmers across the six countries

3.4.3 Farmers source of pesticides

The study tried to assess the source of the pesticides to farmers who are using them on their farms. The majority of the respondents purchased pesticides at the local market as summarized in Table 11. This situation was the same across the six countries ranging between 62%- 98%.

Table 11: Source of pesticide used by farmers surveyed across the six countries

Pesticide source	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Borrow from friends	0.0%	0.0%	0.0%	13.8%	2.4%	6.3%	5.5%
Buy at local market	90.0%	62.3%	93.3%	74.5%	97.6%	93.8%	81.9%
Prepared by myself	10.0%	0.0%	6.7%	0.0%	0.0%	0.0%	1.0%
Government	0.0%	37.7%	0.0%	11.7%	0.0%	0.0%	11.6%

3.4.4 Access to technical information on pesticides

The study also sought to assess the availability of technical information on pesticides to famers. About 79% of farmers said they did not have access to technical information on pesticides globally. The same situation was reported for Sierra Leone, Tanzania, Kenya and Ghana. This was however different in Burkina Faso and Ethiopia, where the majority of farmers answered that they had access to technical information on pesticides (Figure 16).

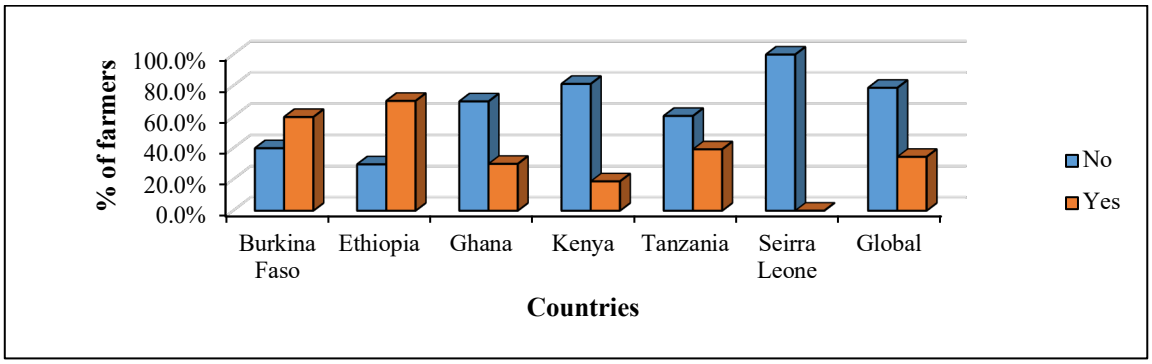

Figure 16: Availability of technical information on pesticides to farmers surveyed across the six countries surveyed

3.4.5 Knowledge on pest control and its contribution to farm output

The study tried to assess the contribution of pest control to farm output. About 47% of farmers said yes it contributes to their yield, 29.1% said it does not increase their yield and 24% indicated they don't know. This status is similar across four countries (Burkina Faso, Ethiopia, Kenya, and Tanzania). In Ghana and Sierra Leone the majority (52%) and (53%) of farmers respectively indicated they don't know and only 20% and 33% of them agreeing it contributes to their farm yield as shown in Table 12.

Table 12: Pest control and its contribution to crop yield across the six countries

Higher Harvest	Countries						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
I don't know	0.0%	3.2%	51.7%	10.5%	29.1%	53.3%	24.0%
No	18.2%	46.8%	28.3%	27.6%	31.6%	13.3%	29.1%
Yes	81.8%	50.0%	20.0%	61.9%	39.3%	33.3%	46.8%

3.4.6 Achieving satisfactory yield without applying pesticides

Globally, the majority of farmers (55%) indicated they would not be able to achieve satisfactory yields if pesticides were not applied to the farm. Only 26% indicated they can achieve satisfactory yields without applying pesticides. In Burkina Faso majority of farmers (55%) indicated they could achieve their yields without pesticides, this is however different in Ethiopia, Kenya and Tanzania, where the majority of them said they cannot achieve satisfactory yields without pesticides. A significant number of farmers from Ghana and Sierra Leone indicated they don't know if yields could be achieved without pesticides, Table 15.

Table 13: Framers ability to achieve yield without applying pesticides

Satisfactory yield Without Pesticides	Countries						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
I don't know	0.0%	3.2%	46.7%	9.9%	28.2%	45.0%	22.0%
No	45.5%	76.2%	13.3%	64.1%	52.1%	28.3%	51.9%
Yes	54.5%	20.6%	40.0%	26.0%	19.7%	26.7%	26.3%

3.4.7 Harmfulness of pesticides on humans and knowledge of World Health Organization toxicity levels

Respondents were asked to indicate whether pesticides may be harmful to farmers or consumers. The findings obviously were that it is harmful with about 49% of farmers agreeing globally. The same trend was reported in Tanzania, Kenya, Ethiopia and Burkina Faso. Still, in Ghana 57% of the respondents said pesticides are not harmful to them and consumers. In Sierra Leone the majority of farmers indicated they did not know if the pesticides are harmful or not (Table 14).

Table 14: Farmers knowledge on harmfulness of pesticides to themselves and consumers

Are Pesticides harmful to Humans	Countries						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
I don't know	0.0%	0.0%	33.3%	14.4%	31.2%	61.7%	24.2%
No	18.2%	36.5%	56.7%	26.5%	21.1%	0.0%	26.9%
Yes	81.8%	63.5%	10.0%	59.1%	47.7%	38.3%	49.0%

Clearly, the majority of the respondents could not mention the World Health Organization (WHO) toxicity level/grade. The situation is the same across the six countries under study. At least about only 18% of Burkina Faso farmers indicated they know about it, Figure 17.

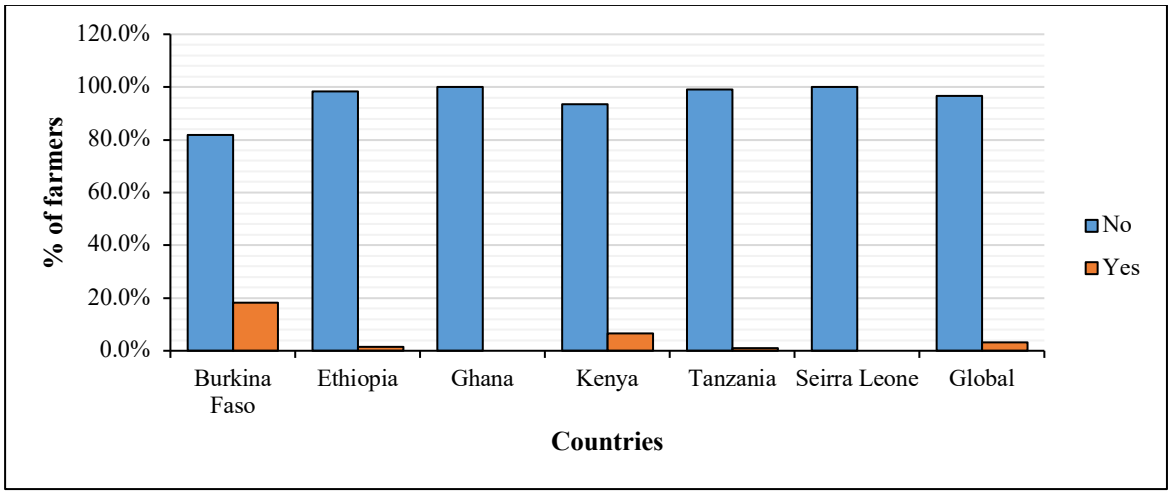

Figure 17: Farmers knowledge of WHO acceptable toxicity levels across the six countries

As shown in Figure 18, Farmers who indicated they do not apply pesticides by themselves (55%) are slightly more than those who said they apply them themselves (45%) globally, which is almost the same situation in Tanzania and Sierra Leone. However, Kenya and Ethiopia have more farmers applying the pesticides by themselves. In Ghana, all the farmers indicated that they do not apply pesticides by themselves, whereas in Burkina Faso all the respondents declared that they apply pesticide treatments by themselves.

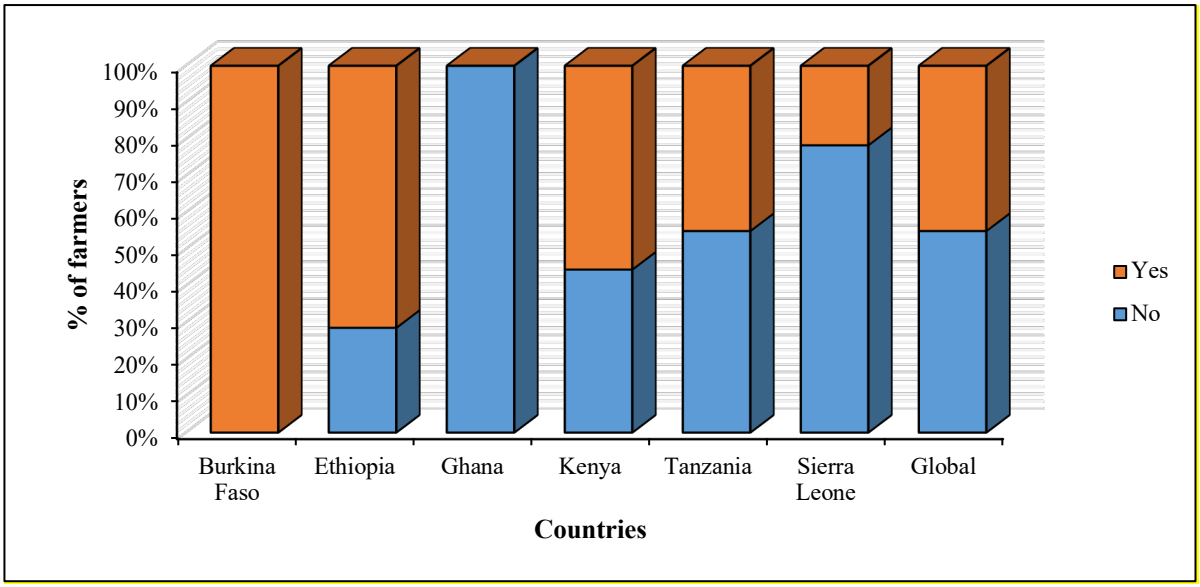

Figure 18: Application of pesticides to crops by farmers themselves

Out of the farmers who indicated they apply pesticides to their crops by themselves were asked to indicate if they experience any symptoms after application. The majority of them indicated they experience symptoms with rates of occurance ranging from 51% -100%. Sierra Leone scored the highest rate of occurance (100%) and Kenya recorded the lowest rate (51%), Figure 19.

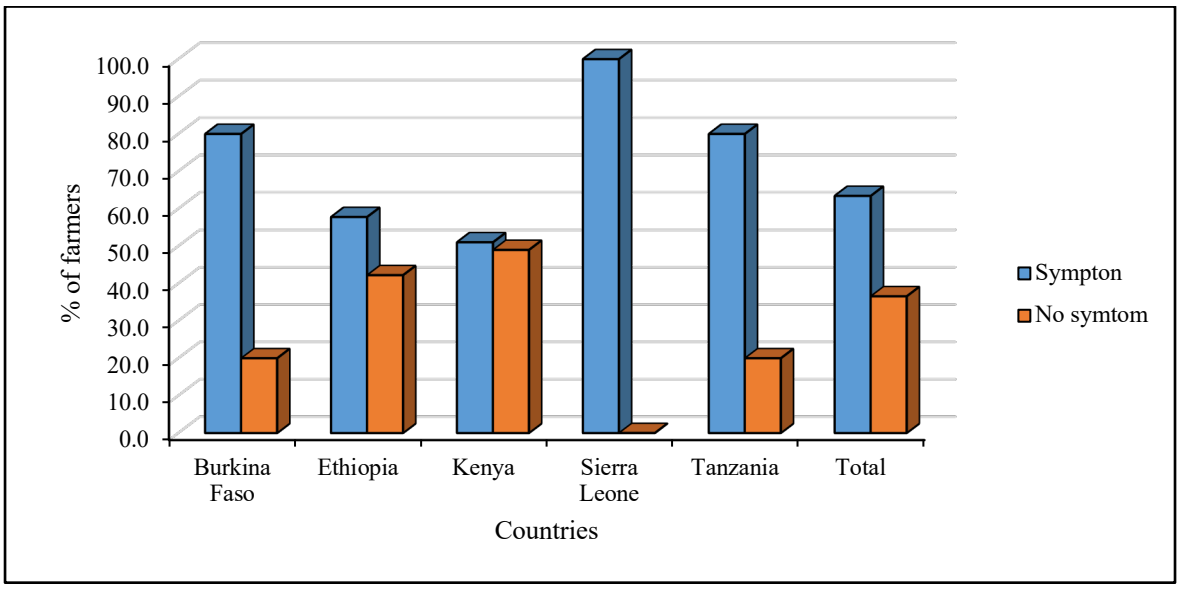

Figure 19: Prevalence of symptoms after chemical application

The study tried to identify possible symptoms observed by farmers after the application of pesticides. Globally, the majority of them indicated they do not see any symptom. About 26% of them indicated they experienced itching, and 7% experienced headache. From Table 15, this status is similar across the six countries. The no symptoms status is particularly high in Ghana and Kenya. In Sierra Leone itching is the main symptom reported.

Table 15: Symptoms experienced by farmers after the application of pesticides.

Symptoms	Countries					Global
	Burkina Faso	Ethiopia	Kenya	Tanzania	Sierra Leone	
Vomit	0.0%	3.2%	1.5%	1.2%	0.0%	1.5%
Nausea	0.0%	3.2%	2.9%	8.6%	0.0%	3.8%
Itching	27.3%	25.4%	18.2%	35.8%	77.8%	25.7%
Headache	27.3%	11.1%	4.4%	7.4%	11.1%	7.1%
Diziness	9.1%	9.5%	4.4%	6.2%	11.1%	5.9%
No symptom	36.4%	47.6%	68.6%	40.7%	0.0%	55.9%

3.4.8 Knowledge of Integrated Pest Management (IPM) strategies

The study also tried to measure the level of farmers' awareness of alternative IPMs, and the results show that the majority of famers (90%) indicated they did not know of any alternative IPMs. This status runs across the six countries. In Ethiopia and Burkina Faso, about 32% and 25%, respectively, of farmers had knowledge of some alternative IPMs, whereas amongst respondents from Tanzania, Sierra Leone and Ghana the possibility of alternative IPM approaches appear to be virtually unknown (Figure 20).

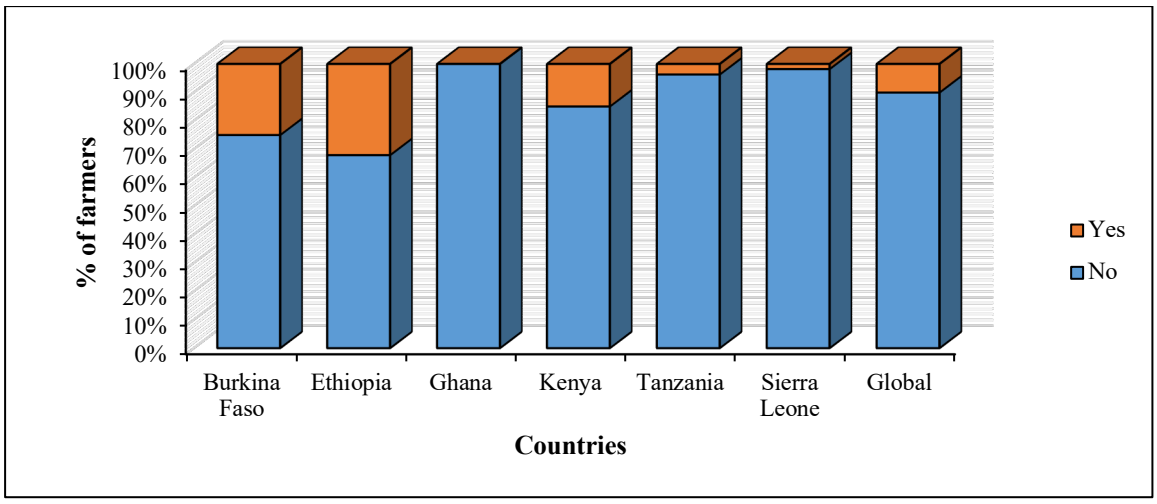

Figure 20: Farmer's awareness of the existence of alternative IPMs.

3.4.9 Traditional knowledge on plant protection and Level of usage of traditional remedies

Over a half (52%) of the african farmers interviewed affirmed they have no knowledge of any traditional approach to plant protection. However, this proportion varied greatly across the countries, ranging from 84-93% in Tanzania and Ghana, respectively, to 54-67% in Burkina Faso and Ethiopia respectively. In contrast, the majority of farmers in Kenya and Sierra Leone indicated they had some knowledge of traditional practices (Figure 21).

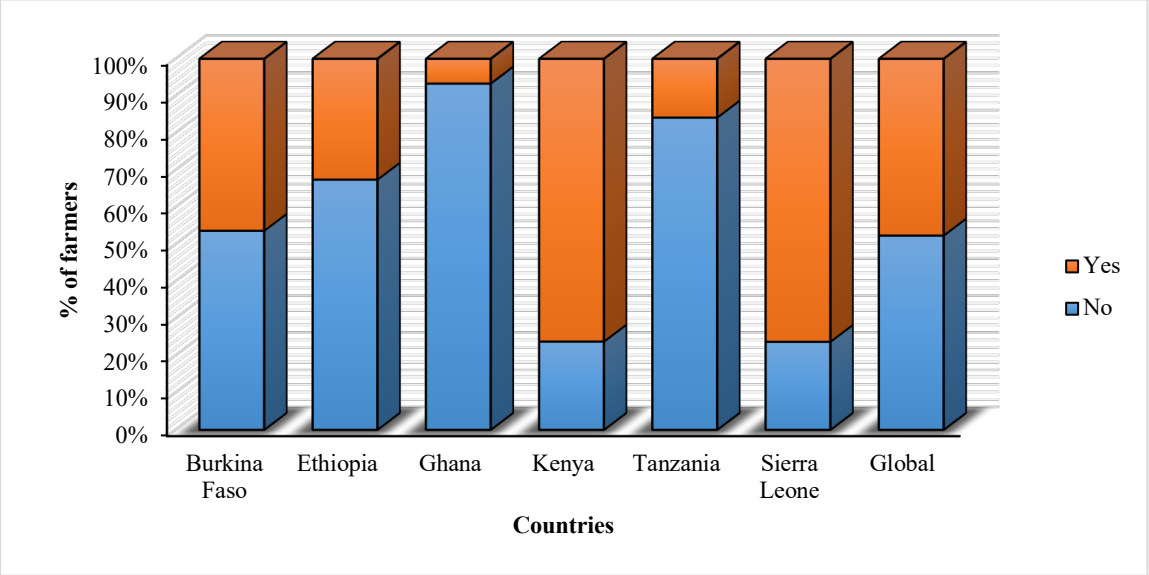

Figure 21: Knowledge of Traditional remedies of pest/pathogens in crop production

Out of the total number of farmers who indicated they had knowledge of some traditional remedies, 29% indicated that they seldom use them, 27% indicated that they rarely use them, 26% indicated that they used them routinely, while about 20% confirmed that they frequently used them. In Burkina Faso, Ethiopia and Tanzania the majority of respondents indicated that they rarely use their traditional knowledge to protect their crops. In Ghana, all farmers who stated knowing about traditional remedies (which are very few) incated they frequently use them and in Sierra Leone 73% said they seldom use this knowledge (Table 16).

Table 16: Use of traditional remedies for pest and disease control.

Likert Scale	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Frequently	21%	21%	100%	18%	11%	16%	19%
Rarely	58%	43%	0%	24%	68%	2%	27%
Routinely	11%	36%	0%	37%	0%	9%	26%
Seldom	11%	0%	0%	21%	21%	73%	29%

The majority of farmers in Burkina Faso, Tanzania and Kenya indicated that they acquired their knowledge from their mothers. The majority of Ethiopian farmers acquired their

knowledge from their chiefs. In Ghana all the respondents indicated that they obtained their knowledge from their fathers and the majority from Kenya indicated via their mothers (Table 17).

Table 17: Source of traditional knowledge.

Likert Scale	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Chief (%)	0.0	37.5	0.0	1.5	5.0	2.3	4.4
Extension Service (%)	0.0	12.5	0.0	1.5	5.0	0.0	2.2
Father (%)	33.3	25.0	100.0	16.7	30.0	43.2	25.9
Friend (%)	0.0	6.3	0.0	12.1	40.0	6.8	12.3
Mother (%)	66.7	0.0	0.0	68.2	15.0	43.2	52.6
Traditional healer (%)	0.0	18.8	0.0	0.0	5.0	4.5	2.6

3.4.10 Status of botanical sources and their effectiveness as pesticides

The survey also tried to assess the presence of botanicals in the study areas and how they are used and what their effectiveness was. Globally, 81% of the sampled farmers indicated they did not have an abundance of such sources. This was a similar response in Ethiopia, Ghana, Tanzania, Sierra Leone and Kenya. In contrast, in Burkina Faso, 68% of the interviewed farmers stated that they have botanicals in abundance (Table 20).

With respect to the question about the possibility of growing botanical plants for use as biological pesticides, the majority of farmers from Tanzania (87%), Ghana (60%) and Ethiopia (84%) indicated that it would not be possible to do so. In contrast, the majority of famers from Burkina Faso (59%) and Kenya (62%) indicated that it was possible to grow such botanical plants. The survey also tried to assess whether these local biopesticides would really be effective. Except for Ghana, the majority of farmers from the five other countries confirmed that in their view traditional remedies were not effective. The majority of farmers across the six countries said that they had never thought about the approach of growing botanicals for income. They also did not make any connection between the use of such traditional botanicals as alternatives to chemical pesticides (Table 18).

Table 18: Status of botanicals and their effectiveness as pesticides

Botanicals	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Do you think that botanicals are abundant and common in your region?							
No (%)	32.5	98.4	93.3	68.9	94.2	95.5	80.8
Yes (%)	67.5	1.6	6.7	31.1	5.8	4.5	19.2
Is it possible to grow botanical plants for use as pesticides?							
No (%)	41.0	83.9	60.0	38.0	87.4	50.0	59.2
Yes (%)	59.0	16.1	40.0	62.0	12.6	50.0	40.8
Do you think that traditional remedies are as effective as chemical pesticides?							
No (%)	37.5	96.7	96.7	63.0	85.0	80.8	75.8
Yes (%)	62.5	3.3	3.3	37.0	15.0	19.2	24.2
Have you ever thought to grow medicinal plants as a source of income?							
No (%)	100.0	100.0	100.0	78.8	96.7	100.0	91.7
Yes (%)	0.0	0.0	0.0	21.2	3.3	0.0	8.3
Do you associate traditional remedies with chemical pesticides?							
No (%)	100.0	100.0	96.7	86.4	97.5	100.0	94.3
Yes (%)	0.0	0.0	3.3	13.6	2.5	0.0	5.7

Most of the traditional remedies identified included wood ash, plant extracts (crushed neem leaves, powdered pepper, tobacco leaves), and cattle dung/urine. Wood ash was the most prevalent globally with 70%, followed by plant extracts with 21% and then cow dung/urine. Plant extracts were predominant in Burkina Faso and Wood ash in Ghana, Tanzania, Sierra Leone and Ethiopia (Table 19).

Table 19: Traditional pest control remedies practiced by farmers surveyed

Remedy	Country						Global
	Burkina Faso	Ethiopia	Ghana	Kenya	Tanzania	Sierra Leone	
Cow dung (%)	10.0	0.0	0.0	10.1	23.5	0.0	8.4
Plant extract (%)	50.0	21.4	100.0	22.5	17.6	0.0	21.4
Wood ash (%)	40.0	78.6	0.0	67.4	58.8	100.0	70.2

CHAPTER 4: Discussion

4.1 General characteristics

4.1.1Gender, 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. The majority of farmers surveyed were 40+ years old indicating a low participation of the youth in agriculture. The survey revealed that the youth said working in agriculture was a last resort and that agriculture is not profitable. They thus were turning away from it and opting for waged employment (Filmer & Fox 2014; Irungu et al. 2015; Kadzamira & Kazembe 2015; Thika, 2012). There is thus certainly 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 risks (Kirui, 2019). The majority of the farmers either had no education or just at primary school level, which has implications for future agricultural development and the rate of implementation/adoption of new technologies.

4.1.2 Farming experience, farm size and reasons for farming

The mian reasons for engaging in farming in the survey was because there was no alternative jobs and sources of livelihood and income for farmers. Over 70% of the farmers had farming experience ranging from a minimum of 10 years to over 30 years. The surveyed farmers had considerable experience in farming and also indicated that their current farm sizes were too small. They were keen to expand them. The main source of labour was and is family-based, with very few using hired labour. The main problem with hired labour was the high cost implications. This will have a significant impact on the adoption of new technologies that are more labour intensive.

4.1.3 Access and cost of capital

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

4.1.4 Farming, land tenure Systems and crop enterprises

Different farming systems emerged across the survey sites and the most dominant approaches were mixed farming and arable farming. In East Africa mixed farming was the main approach, followed by arable farming system. In West Africa arable farming systems were dominant with the next most common being mixed farming. The dominant land tenure system appears to be inherited family land across the two regions. Farmers have a lot of control of their land and can manage it in the way they want. This land tenure system is the most preferred one by most farmers across the two regions.

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

4.2 Incidence of pests/pathogens

Integrated pest management (IPM) was introduced in the late 1950s (Stern, 1973) but more widely practiced between 1970-1990 (Van Lenteren, 1995, 2000; Van Lenteren and Woets, 1988; Flint, 1987). IPM promotes the use of several measures such as insecticide applications, crop rotation, biological control, harvest and post-harvest management, and the use of pest-resistant varieties of crops to reduce pest populations below economic levels.

4.2.1 Irrigation systems and soil classification

Adequate, timely irrigation is one of the key requirements of a sustainable IPM system since it is linked to overall plant health (Ayanava, 2021). This survey assessed the type of irrigation systems used by farmers. It was clearly established that the rain-fed system was the main irrigation system for all the farmers across the six countries. This implies that the farmers have no control on how and when their farms can be irrigated. The decline in soil health is a serious worldwide problem that impacts on the soil nutritional quality and structure and the stability of agricultural ecosystems. Poor management makes them more prone to outbreaks of herbivorous insect pests (Alyokhin et al., 2020). The most dominant soil globally was loam-based which is relatively high in nutrients. Loam-based soils were predominant in Ethiopia, Kenya, and Tanzania. Ghana and Burkina Faso had more sandy soils which have less organic matter and hold less soil nutrients and hence result in plant stress encouraging more insect pest issues as compared to those in East Africa countries.

4.2.2 Crops production constrains

The susceptibility of cultivated crops to pests and diseases also depends on the vigour of the plant stand which is highly related to the kind of propagative material used. Depending on the

source of the planting material, may be a major pathway for entry of pathogens and pests into the farm. The majority of the interviewed farmers did not use certified seed as they depend on the farm seed saved from previous harvests. This increases the possibility of systemic pathogens and pest transmission through the seed resulting in a carryover to the next generation of crops impacting on yield and quality. The survey also evaluated farmers' ability to identify and distinguish the different biotic and abiotic pathogens affecting their crops. Knowledge on the main pests and pathogens can greatly help farmers to adopt the most effecive control methods. Across all countries, the majority of respondents indicated that they could differentiate them, although the exact level of awareness remains questionable.

4.2.3 Knowledge on the effects of pest, pathogens, and environmental factors

Crop rotation is an important pest and disease management technique (Sauerborn et al., 2000; Rusinamhodzi, 2020; Kuyah, et al., 2021). The survey tried to assess the level of adoption of this approach amongst the farmers. This showed that this approach was effectively use in Burkina Faso, Kenya, and Ethiopia. However, this was low in Tanzania and Ghana. EWA-BELT will need to address how this approach can be effectively adopted in Ghana and Tanzania.

Seed treatment/coatings are sometimes the only delivery route for the control of certain seed-borne pathogens. Seed treatment can also deliver high levels of efficacy for the control of early season pests and diseases at a much-reduced usage rate compared to many foliar or soil applied alternatives (ISF, 2007). Seed treatment is also yet another important technique in managing pest/pathogens and diseases. Except for Burkina Faso, where the majority of farmers indicated seed was treated before planting, in the other five countries, farmers indicated that they did not use seed treatments prior to planting. Globally, about 90% of the interviewed farmers did not treat their seed, making them very vulnerable to pests/pathogens and has significant implications for yield, quality and food security.

Farmers indicated that they had no awareness of alternative IPMs. This situation was the same across all the six countries. In only a few countries did farmers indicate that they knew about the IPM alternatives. A significant number of farmers indicated that pesticides were harmful to humans. However, there was less knowledge of their toxicity and health implications if not following the instructions for their safe use (World Health Organization to guide to the use and application of pesticides). The majority of these chemicals are applied by the farmers themselves hence there is a need to educate them on the harmful side effects of pesticide exposure.

4.2.4 Farmers application of Pest/Pathogen control methods

Overall, there is very low adoption of IPM approaches although this is considered an effective way to reduce the losses caused by pests and diseases in developing counties in Low Middle Income Countries (LMICs; Parsa et al., 2014). The survey also assessed the level of application of pathogen and disease control methods in the farm operations. This showed that in most cases the majority of the interviewed farmers do not utilise these methods. The trend was the same across all countries, similar to what was found previously (Parsa et al., 2014). This will require effective extension work to provide information on the importance of applying these techniques on their farms to increase farm productivity and reduce crop losses.

Pesticide application represents the standard approach for the control of pests and diseases. The survey outlined that the majority of farmers used synthetic pesticides purchased from the market. Only a minority of farmers from Burkina Faso and Ghana indicated that they prepared pesticides themselves. In contrast to what we expected, there was a negligible adoption of traditional knowledge in the management of pests and diseases. There was also generally poor knowledge on the potential toxicity of pesticides, with the exception of Burkina Faso and Ethiopia. It is very important to develop effective methods for educating farmers on the safe usage of these chemicals to ensure their effectiveness as well as their safe application to avoid families being exposed to toxic chemicals.

4.2.5 Knowledge on Pest control and its contribution to farm outputs

Globally, yield losses due to arthropods, diseases and weeds are estimated to account for about 35% in major crops. Losses may exceed 50% in developing regions where pest control options are limited (Oerke, 2006). The knowledge of the benefits one can obtain from adopting technologies such as IPM needs to be clearly transferred for improving the potential for effective adoption. The survey tried to assess what farmers thought were the benefits of controlling pests and diseases on their farms. Most of the interviewed farmers from Burkina Faso, Ethiopia, Kenya and Tanzania agreed that pest control has a positive impact on crop yields and acknowledged that it would be very difficult to achieve adequate yields without proper pest and disease management. However, many farmers were not aware of the importance of recommended methods for pesticide applications and their timely application.

4.2.6 Traditional knowledge on plant protection

Generally, farmer knowledge of traditional practices used for controlling pests and diseases was low. The majority of them indicated very little knowledge of traditional techniques in

controlling pests and diseases. It was only in Tanzania that the majority indicated knowledge of traditional practices that are used in controlling pests and diseases which are used routinely. The application of these techniques was however not regular or consistent. Most of this knowledge was acquired from their parents or from the community chiefs and traditionalists. Most of the traditional remedies identified included wood ash, plant extracts (crushed neem leaves, powdered pepper, tobacco leaves) and cattle dung/urine. Plant extracts were the dominant traditional remedy in Burkina Faso and wood ash was dominant in Ghana, Tanzania and Ethiopia. Theses approaches need to be evaluated and if effective should be more widely disseminated to farmers across both regions.

4.2.9 Status of botanicals sources and their effectiveness as pesticides

When chemicals are extracted from plants, these are often referred to as "botanicals". The use of botanical compounds, often essential oil extracts, are now emerging as effective means for the protection of crops as alternatives to chemical pesticides because of the latters environmental implications. Botanicals often degrade more rapidly than most synthetic pesticides in soil, and are, therefore, considered relatively environmently friendly and less likely to kill beneficial pests than synthetic pesticides (Guleria & Tiku, 2009). Globally, farmers surveyed indicated that they do not have knowledge or use botanicals products. This was the case for farmers in Ethiopia, Ghana, Tanzania and Kenya. However, in Burkina Faso the majority of the farmers indicated that botanicals were available in abundance. The majority of farmers from Tanzania, Ghana and Ethiopia indicated that it was not possible to grow botanicals while the majority of those from Burkina Faso and Kenya indicated it is possible to grow botanical plants. Except for Ghana, the majority of farmers from the five other countries said that traditional remedies were not effective.

CHAPTER 5: CONCLUSIONS

The results of this survey have established the status of farmers perception and knowledge of crop pests and diseases in the six African partner countries involved in the EWA-BELT consortium. These results should help to guide the development of new strategies to achieve pest and pathogen control in both East and West Africa farming systems. This forms the baseline for the development and application of more effective extenson strategies including communication, educational campaigns and knowledge transfer between East and West Africa that will be beneficial for farmers in all the target countries.

The results shows:

- Rain fed system was the main irrigation system practised by farmers implying that they have no control on how and when their farms are irrigated, which has significant implications for pest and disease control.
- The majority of farmers did not use certified propagative materials as they depend on saved seed from previous crops which may provide good sources of pest and pathogen inoculum for more disease impacts and crop damage from pests.
- Crop rotation as a pest and disease management technique adoption was high in Burkina Faso, Kenya, and Ethiopia but low in Tanzania, Sierra Leone and Ghana.
- Seed treatment as a pest and disease management technique adoption was very low in all the countries except Burkina Faso.
- Most farmers acknowledged that it would be very difficult to achieve the required yields without proper pest and disease management.
- Farmers indicated that they did not have much knowledge of alternative IPM approaches across all six countries.
- Most farmers did not have any awareness that pesticides could be harmful to humans and almost were unaware of the World Health Organizations' guide on the the use and application of pesticides.
- Knowledge of traditional practices used for controlling pests and diseases was low in four of the surveyed countries but high in Kenya and Sierra Leone.
- The traditional remedies identified included wood ash, plant extracts (crushed neem leaves, powdered pepper, tobacco leaves) and use of cattle dung/urine.
- The majority of farmers from Tanzania, Ghana and Ethiopia indicated that it was not possible to grow botanical plants while most famers in Burkina Faso and Kenya indicated that it was possible to grow botanical plants for the development of alternatives to chemical pesticides.

We recommend that EWA-BELT take into account these key findings and use them for designing and implementing interventions to manage pests and diseases in both East and West Africa cropping systems. This would result in the transfer of knowledge between these countries as well as utilise the intervention strategies which will increase farm productivity and improve farmer household livelihoods.

REFERENCES

1. Alyokhin, A., Nault, B., & Brown, B. (2020). Soil conservation practices for insect pest management in highly disturbed agroecosystems–a review. Entomologia Experimentalis et Applicata, 168(1), 7-27.
2. Ayanava Majumdar (2021, May 18). Irrigation and Water Management for Sustainable IPM Systems, Alabama Cooperative Extension System. Retrieved from (https://www.aces.edu)
3. Bebber, D.P., Holmes, T., Gurr, S.J., 2014. The global spread of crop pests and pathogens. Global Ecol. Biogeo. 23, 1398–1407.
4. Bebber, D.P., Ramotowski, M.A.T., Gurr, S.J., 2013. Crop pests and pathogens move poleward in a warming world. Nature Climate Change 3, 985-988.
5. Burkina Faso Population 2021 (Demographics, Maps, Graphs)". worldpopulationreview.com.
6. Filmer, D. & Fox, L., 2014, Youth employment in sub-Saharan Africa, The World Bank, Washington, DC.
7. Flint, M.L., ed.: Integrated Pest Management for Walnuts, University of California Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources, Second Edition, University of California, Oakland, CA, publication 3270, 1987, pp. 3641
8. Groten, S. M. E. (1993). crop monitoring and early yield assessment of Burkina Faso. International Journal of Remote Sensing. 14 (8): 1495–1515. Bibcode:1993IJRS...14.1495G. doi:10.1080/01431169308953983.
9. Guleria S., Tiku A. (2009) Botanicals in Pest Management: Current Status and Future Perspectives. In: Peshin R., Dhawan A.K. (eds) Integrated Pest Management: Innovation-Development Process. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8992-3_12
10. Huang, X., Lu, Q., Wang, L., Cui, M., & Yang, F. (2020). Does aging and off-farm employment hinder farmers' adoption behavior of soil and water conservation technology in the Loess Plateau?. International Journal of Climate Change Strategies and Management.
11. Irungu, K., Mbugua, D. & Muia, J., 2015, 'Information and communication technologies (ICTs) attract youth into profitable agriculture in Kenya', East African Agricultural and Forestry Journal 81(1), 24–33. https://doi.org/10.1080/00128325.2015.1040645
12. Jackson, John G. (2001) Introduction to African Civilizations, Citadel Press, p. 201, ISBN 0-8065-2189-9.
13. Kadzamira, M.A. & Kazembe, C., 2015, 'Youth engagement in agricultural policy processes in Malawi', Development Southern Africa 32(6), 801–814. https://doi.org/10.1080/0376835X.2015.1063984
14. Kenya Population and Housing Census Results". Kenya National Bureau of Statistics. 4 November 2019. Archived from the original on 5 November 2019. Retrieved 15 November 2019.
15. Kirui, O. (2019). The complementarity of education and use of productive inputs among smallholder farmers in Africa. ZEF-Discussion Papers on Development Policy, (277).

16. Kuyah, S., Sileshi, G. W., Nkurunziza, L., Chirinda, N., Ndayisaba, P. C., Dimobe, K., & Öborn, I. (2021). Innovative agronomic practices for sustainable intensification in sub-Saharan Africa. A review. Agronomy for Sustainable Development, 41(2), 1-21.
17. Li, M. and Zhao, L. (2009), "The phenomenon of aging of agricultural labor force and its impact on agricultural production – based on the empirical analysis of Liaoning province", Issues in Agricultural Economy, Vol. 30 No. 10, pp. 12-18.
18. MKUKUTA Annual Implementation Report 2012/13" (PDF). Tanzania Ministry of Finance. November 2013. p. 11. Archived from the original (PDF) on 1 November 2014. Retrieved 1 November 2014.
19. Narla, R. (2014). Importance of insect pests, diseases, weeds and disorders in seed production.
20. National Accounts Estimates of Main Aggregates". The United Nations Statistics Division. Retrieved 12 November 2013.
21. Oerke, E. C., Dehne, H. W., Schönbeck, F., & Weber, A. (2012). Crop production and crop protection: estimated losses in major food and cash crops. Elsevier.
22. Parsa, S., Morse, S., Bonifacio, A., Chancellor, T. C., Condori, B., Crespo-Pérez, V., & Dangles, O. (2014). Obstacles to integrated pest management adoption in developing countries. Proceedings of the National Academy of Sciences, 111(10), 3889-3894.
23. Peck, Dannele E.; Peterson, Jeffrey M. (2015). Climate Variability and Water Dependent Sectors: Impacts and Potential Adaptations. Routledge. ISBN 978-1-317-61427-2.
24. Population Projections for Ethiopia 2007–2037". www.csa.gov.et. Archived from the original on 3 August 2020. Retrieved 25 September 2020.
25. Reardon, Thomas; Matlon, Peter; Delgado, Christopher (September 1988). "Coping with household-level food insecurity in drought-affected areas of Burkina Faso" (PDF). World Development. 16 (9): 1065–1074. doi:10.1016/0305-750X(88)90109-X.
26. Roncoli, Ingram, and Kirshen (2001). "The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso". Climate Research. 19: 119–132. Bibcode:2001ClRes. 19..119R. doi:10.3354/cr019119.
27. Rusinamhodzi, L. (2020). Managing Crop Rotations in No-till Farming Systems. In No-till Farming Systems for Sustainable Agriculture (pp. 21-31). Springer, Cham.
28. Salih, Mohamed (2012). Local Climate Change and Society. Routledge. p. 119. ISBN 9780415627153.
29. Sauerborn, J., Sprich, H., & Mercer-Quarshie, H. (2000). Crop rotation to improve agricultural production in sub-Saharan Africa. Journal of Agronomy and Crop Science, 184(1), 67-72.
30. Seed Treatment and Environment Committee of the International Seed Federation (ISF) (2007). Seed-Treatment A Tool for Sustainable Agriculture. CropLife International Retrieved from https://croplife.org/wp-content)
31. Stern, V.M.: Economic Thresholds. Ann. Rev. Entomol., 259–280 (1973)

32. Tanzania Define Tanzania at Dictionary.com". Dictionary.reference.com. Retrieved 19 February 2014.
33. Thika, K. (2012). Does educational level influence the choice of farming as a livelihood career? Results of an empirical study from coastal lowland Kenya.
34. UNDP Climate Change Country Profile: Ghana". ncsp.undp.org. Archived from the original on 21 September 2013. Retrieved 24 June 2013.Congress Cataloging-in-Publication Data. 1995. p. 63.
35. Van Lenteren, J.C., Woets, J.: Biological and integrated pest control in greenhouses. Ann. Rev. Ent. 33, 239–250 (1988)
36. Van Lenteren, J.C.: Integrated pest management in protected crops. In: Dent, D., (ed.), Integrated pest management, Chapman & Hall, London, 1995, pp. 311–320
37. Van Lenteren, J.C.: Measures of success in biological control of arthropods by augmentation of natural enemies. In: Wratten, S., Gurr G. (eds.), Measures of Success in Biological Control, Kluwer Academic Publishers, Dordrecht, 2000, pp. 77–89
38. Wilkin, Paul; Demissew, Sebsebe; Willis, Kathy; Woldeyes, Feleke; Davis, Aaron P.; Molla, Ermias L.; Janssens, Steven; Kallow, Simon; Berhanu, Admas (2019). "Enset in Ethiopia: a poorly characterized but resilient starch staple". Annals of Botany. 123 (5): 747–766. doi:10.1093/aob/mcy214. PMC 6526316. PMID 30715125.
39. Yang, Z. (2018), “Social network and the adoption of green production technology: evidence from farm households in six provinces in the Yangtze river basin”, China Rural Survey, Vol. 4, pp. 44-58.
40. Zorita, Eduardo; Tilya, Faustine F. (12 February 2002). "Rainfall variability in Northern Tanzania in the March–May season (long rains) and its links to large-scale climate forcing" (PDF). Climate

APPENDICES

Appendix A: Pest/Pathogens Identified

Country	Pest/Pathogens	Freq	%
Ethiopia	Worms	14	26%
	Insects	10	19%
	Bacteria	2	4%
	weeds	1	2%
	Fungi	1	2%
	Animals	4	8%
	Rust	20	38%
	Wilt	1	2%
			100%
Burkina Faso	Insects	7	88%
	Striga	1	13%
Ghana	Birds	1	3%
	Fall army worms	29	97%
Kenya	Birds	2	2%
	Worms	16	18%
	Insects	43	49%
	Striga	6	7%
	Rodents	7	8%
	Animals	6	7%
	Fungus	6	7%
	Bacteria	4	5%
Tanzania	Worms	10	40%
	Insects	13	52%
	Fungi	2	8%