EVALUATION OF THE AVAILABLE CROSS-BORDER PHYTOSANITARY MEASURES FOR THE CONTROL OF MAIZE PESTS IN MALAWI

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DECLARATION

This thesis is my original work and has not been submitted for award of degree in any other university.

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DEDICATION

This thesis is dedicated to:

My late mum, Grady Teresa Mdyetseni who worked tirelessly to educate me and always wished me to reach higher levels of education. Continue resting well mum.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
APHIS	Animal and Plant Health Inspection Service
CAC	Codex Alimentarius Commission
COMESA	Common Market for Eastern and Southern Africa.
CIAT	International Center for Tropical Agriculture
CRD	Complete Randomized Design
DARS	Department of Agricultural Research Services
DAL	Demeter Agriculture Limited
DNA	Deoxyribonucleic acid
ELISA	Enzyme-Linked Immunosorbent Assay
EPPO	European and Mediterranean Plant Protection Organization
EU	European Union
FAO	Food and Agriculture Organization
GOM	Government of Malawi
IAPSC	Inter-African Phytosanitary Council
IITA	International Institute of Tropical Agriculture
ICRISAT	International Crops Research For Semi-Arid and Tropics
IPCC	International Plant protection Convention
ISPMS	International Standards for Phytosanitary Measures
ISTA	International Seed Testing Association
LGB	Larger grain borer

LSD	Least Significant Difference
MAPHIS	Malawi Plant Health Inspection
MLND	Maize Lethal Necrosis Disease
MBS	Malawi Bureau of Standards
MML	Monsanto Malawi Limited
Min. TIT	Ministry of Tourism, Industry and Trade
M.S.C.E	Malawi School Certificate of Education
NAPPO	North American Plant Protection Organization
NPPO	National Plant Protection Organization
OIE	Office of international Epizooties
PCR	Polymerase chain reaction
PQPS	Plant quarantine and Phytosanitary capacity services in Malawi
PRA	Pest Risk Analysis
RNA	Ribonucleic acid
RPPO	Regional Plant Protection Organization for Phytosanitary Measures
SADC	Southern African Development Community
SEEDCO	Seed Company
SPS	Sanitary and Phytosanitary measures
WTO	World Trade Organization

GENERAL ABSTRACT

Pests cause significant losses in maize worldwide and are barriers to the achievement of global food security. Cross-border agricultural trade is ranked as a major factor that places maize at risk as it creates pathways for the spread of different maize pests. This study, was therefore, carried out to determine the common pests affecting maize and the available phytosanitary measures for the management of maize pests across the borders of Malawi. A survey was conducted in 2018 to determine phytosanitary measures and phytosanitary capacity at border points, major towns, regulatory and research institutions in Malawi. Data collection points included manned points between Tanzania, Zambia and Mozambique. The major cities covered were Mzuzu, Lilongwe and Blantyre while the institutions included government regulatory organizations and private organizations that work in the phytosanitary systems. The information obtained comprised of phytosanitary activities, trade patterns on maize, staffing in relation to plant health, capacity and available facilities within the organizations.

Most of the training courses (63%) that were offered in phytosanitary disciplines were attended by the government organizations. Major Phytosanitary activities were done by the Malawi National Plant Protection Organization and maize under importation was inspected more than those in transit and exportation. Majority (67%) of the imported maize originated from Mozambique, Tanzania and Zambia. The phytosanitary facilities in Malawi are not well equipped. Larger grain borer (*Prostephunus truncatus*) and common maize weevil (*Sitophilus zeamais)* were the most common insect pests contaminating maize while flour beetle (*Tribolium castaneum*) and grain moth (*Sitotroga cerealella*) were the least. There were no significant differences in the population of insect pests before incubation in all the surveyed districts.

However, there was a significant difference after incubation for the larger grain borer and common maize weevil. The largest number (1.5) of insect pest infestation for larger grain borer was reported in Karonga and the least was in Mzuzu. Largest (3.7) infestation for maize weevil was reported in Nkhatabay whilst the least was in Lilongwe district. There were significant differences in the total number of damaged kernels before and after incubation. The greatest damage (2.9) on unincubated kernels was observed in Blantyre while the least was observed in Mulanje. However, after incubation, the highest (5.5) kernel damage was observed in Karonga whilst the least was observed in Mulanje. Common fungal pathogens isolated from the kernels were *Fusarium* (70%), *Aspergillus* (29%) and *Penicillium (*1%). The highest percentage of kernel infection with *Fusarium* was in Dedza and Lilongwe whilst for *Aspergillus* were in Mzuzu. The *Aspergillus* spp isolated were *A. niger* (29%), *A. flavus* (22%) and *A. parasiticus* (5%) while the *Fusarium* spp isolated was *Fusarium verticilloides.* The study reveals that Malawi faces a lot of challenges in the implementation of phytosanitary measures in the management of maize pests. Therefore, there is need for the government to initiate programes to enhance plant health system for example capacity building, improve facilities and inspection practices and increase funding in the phytosanitary system.

Key words: cross-border trade, maize pests, phytosanitary measures, phytosanitary capacity

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Maize (*Zea mays*) is the number one food crop that dominates the human diet globally (Kangethe *et al.*, 2016; Jimma *et al*., 2016). Studies have reported that maize calories provide almost 30% of food to more than 4.5 billion people in most developing countries (Kangethe *et al.*, 2016). In Malawi, maize is largely grown by smallholder farmers followed by cassava, sweet potatoes, and sorghum (Chirwa *et al*., 2013a). According to Chirwa *et al*. (2013a) maize is grown in most of the 70% cultivable land, with a production of 2.4 metric tons per year in good harvest and whose per capita consumption is 133 kg. This accounts for over 54% of the calorific intake in most Malawian households compared to other regions where maize contributes 20-35% of the calorific intake making maize the main focus of food security policy (Simwaka *et al*., 2011).

Significant losses in maize production worldwide are largely attributed to pests which are also considered as barriers to the achievement of global food security and poverty reduction (Bebber *et al.* 2014). More than sixty diseases and a number of insect’s species affect maize worldwide and are transmitted in different ways (Jimma *et al*., 2016). International agricultural trade is one of the pathways of pest’s transmission and major factors that puts maize at risk as it creates pathways for their spread between regions (Sundström *et al*., 2014). Importation of maize grain into Malawi solely occurs when there is a reduction in maize production which creates a need to meet the seasonal demand, political interest, intermarriages and price that drive the demand and supply potentials (WTO, 2011).

Poor harvests between the years 2009 to 2015, were reported by Jury and Mwafulirwa (2002) to occur due to the intense El Nino weather. This caused Malawi to importing maize from various countries such as Zambia, Tanzania, Mozambique, Kenya, Mexico and United States of America (GOM, 2010). Importation of agricultural produce puts the country at risk of introducing pests (FAO, 2003). As a way of preventing this, the Word Trade Organization Sanitary and Phytosanitary measures (WTO-SPS) have been put in place as biosecurity measures (Khetarpal and Kavita, 2007).

Biosecurity measures are strategic and an integrated approach encompassing policies and regulatory bodies with a common purpose of analyzing and managing risks in the sectors of food safety, plant life and health safety, animal life and animal health (Khetarpal and Kavita, 2007). It analyzes and manages risks while protecting countries and regions from emerging indigenous pests during trans-boundary movement of commodities. According to Henson *et al*. (2004), the requirements for biosecurity measures and SPS standards set by developed countries have proven to be less effective. Developing countries are unable to participate in the standards setting process owing to lack of economic and technical resources.

The Department of Agricultural Research Services (DARS) in Malawi through plant protection commodity group aims to protect the country from regulated pests during importation of maize and other agricultural commodities. Malawi Plant Health Inspection Services (MAPHIS) has an overall objective to increase agricultural productivity. This is achieved by preventing quarantine pests from being introduced, established and spread in the country and formulating easy, sound and environmentally friendly pest management practices.

1.2 Problem Statement

Organization (NPPO) of Malawi reinforces phytosanitary and biosecurity measures for all agricultural products. Pests are amongst the leading stresses to crops and have the potential of reducing crop yield, quality and quantity by 100 %. This is detrimental to Malawi's economy and also threatens the food supplies around the globe, especially in the regions where maize is a staple food crop (Pechanova *et al*., 2015). Through the Plant Protection Act of 1964, the Malawi Plant Health Inspectorate Services (MAPHIS) ensure that there is no trans-boundary movement of pests from exports and imports (Dahlstrom *et al.*, 2011). However, the use of an outdated Plant Protection Act has created loop holes within the plant health system which act as pathways of maize pests in to the country. The system requires technical and financial support for a comprehensive review of the phytosanitary measures and regulations so as to align it with regional protocols (Minde and Nakhumwa, 1998). Unmanned ports, insufficient Plant health personnel and lack of sufficient laboratory equipment makes the borders to be porous. The larger grain borer (*Prostephunus truncatus*) a highly destructive pest gained entry into Malawi through imported maize (Tefera *et al*., 2011a). According to Murayama *et al*. (2017), 40-100% loss in maize in Malawi is owed to *Prostephunus truncatus*. Pests such maize lethal necrosis, khapra beetle, western corn rootworm, downy mildew of maize, Stewart's disease, and Southern corn leaf blight and sugarcane downy mildew may gain entry into Malawi if proper phytosanitary measures are not put into place (CABI, 2015). Therefore, to protect this staple crop, strategies must be put in place to strengthen the Phytosanitary systems in Malawi (Lipa, 1995). However, there is little that has been achieved on the capacity for Sanitary and phytosanitary measures which could be the leading cause to the introduction of new pests in Malawi.

1.3 Justification

With increased globalization, maize for food, local use and processing is obtained from many different countries. It is exchanged from one region to another, traded through borders either formally or informally and if not carefully handled with proper SPS measures, may introduce pests into a region (GOM, 2010). Food security within Malawi has been achieved through formal and informal cross-border trade of maize between Malawi and other countries (Minde and Nankhumwa, 1996).

According to Jay *et al.*, (2003), the need for countries trading in maize to invest in their Phytosanitary regulatory systems worldwide is considered a strong commitment to biosecurity.

It is very important for countries to be protected against the entry risks that are related to maize health (Rippel, 2011). To achieve this, adequate resources such as well trained personnel, infrastructure, financial resources, technical and scientific expertise are required. Sanitary and Phytosanitary Standards (SPS) set by developed countries, have demonstrated to be less effective in most developing countries like Malawi (Msiska, 2013). The available SPS authorities in most developing countries are not enough. They also lack scientific strategies which pose a big challenge to the achievement of the stated mandate on everyday basis without delays and perceived conflict of interest. The dangers of not following the right SPS procedures when importing maize in Malawi are not widely known by most farmers, individuals, traders, companies, some government officials and even politicians who import and export (Dahlstrom *et al.*, 2011). Consequently, research is required to scrutinize the effectiveness of cross-border phytosanitary measures and gaps that are contributing to spread of pests through importation of maize.

The information gathered from this research will help in strengthening the plant health system in Malawi. Additionally, scientific strategies and other forms of practices which can be employed to eradicate the incidence of introducing pests will be adopted thus improve food security and promote international trade in Malawi.

1.4 Objectives

The general objective was to contribute to the improved phytosanitary system in Malawi by evaluating the available cross-border Phytosanitary measures involved in importation of maize.

The specific objectives

i. To evaluate available cross-border phytosanitary measures used in managing maize pests in Malawi

ii. To determine pests of Sanitary and Phytosanitary concern affecting imported maize across the Malawi border.

1.5 Hypothesis

i. The Phytosanitary measures in Malawi are not effective in management of maize pests.

ii. Importation of maize in Malawi brings in pests of sanitary and phytosanitary concern.

CHAPTER TWO: LITERATURE REVIEW

2.1. Importance of maize in Malawi

Maize is a major staple food crop in most sub- Saharan countries inclusive of Malawi where it is mainly grown by smallholder farmers (Mango *et al*., 2018). Maize calories provide 30% of food to more than 4.5 billion people in most of the developing countries (Kangethe *et al.*, 2016). A production of 2.4 metric tons per year in Malawi is credited to its growth in 70% of cultivable land by 97% of the farmers (Chirwa *et al*., 2013a). The decline in maize production is as a result of drought, flooding and spread of different insect pests such as larger grain borer, common maize weevil and fall armyworms makes it the commonly traded staple crop in Malawi from other countries in the region (Mango *et al*., 2018). The caloric intake of maize accounts to over 20-54% in Malawian households and other maize producing regions. Its per capita consumption per person is approximately 133kg (Msowoya *et al*., 2014).

2.2. Trade agreements in Malawi

Malawi is a member of the World Trade Organization (WTO), the international body that organizes and oversees global rules for trade operated between nations and is party to its protocols. The agreements are legal ground rules for international trade for agricultural products including maize (Dahlstrom *et al*, 2011). According to Crush and Frayne, (2010), Malawi also has trade agreements with the European Union (EU) and is a member of SADC and has ratified the SADC free trade protocol. Malawi has also committed itself to the establishment of the Common Market in Eastern and Southern Africa Region under COMESA (Dahlstrom *et al*, 2011) .

Apart from these regional trade agreements, Malawi has signed trade agreements with Zimbabwe, South Africa and Botswana (Frick and Chapman, 2017). She also maintains joint permanent commissions with Mozambique and Zambia, where trade issues, among others, are discussed. Malawi is negotiating bilateral trade agreements with Mozambique, Tanzania and Zambia. Clearly, Malawi and other states parties to SADC and COMESA are committed to promoting intra-regional trade (Frick and Chapman, 2017).

2.3 Cross-border trade of maize in Malawi

According to Mango *et al*. (2018), maize is the most formal and informal traded staple commodity in most Southern Africa countries Malawi inclusive of which informal trade accounts for 80% of the maize traded. Formal and informal cross-border maize trade plays a significant role in averting widespread food insecurity in Malawi (Nankhumwa and Teddie, 2014). It has been in practice for several years and is significant in providing local, national and regional food security for agricultural and non-agricultural commodities between Malawi and neighboring countries.

According to Mango *et al*. (2018), maize trade has provided three types of opportunities to most Malawians. Immediately after harvest, it provides markets for surplus farm produce and income to the local producers. During the long period between harvest and planting, it provides the producers with opportunities to invest their capital in other non-agricultural activities and finally, the imports of grains, provide food to scarcity households. The presence of cross-border trade, particularly in maize has stimulated the production of maize on either side of the borders of Malawi and neighboring countries by providing a market for surplus production. For the deficit households and regions, the trade increases the availability of the commodity on the local markets (Mindel and Nakhumwa, 1998).

Based on its transparency and the obligations under Sanitary and Phytosanitary (SPS) agreements, the National Notification Authority (NNA) has been established in Malawi and is located in the Ministry of Industry and Trade. Other designated SPS enquiry points are the Malawi Bureau of Standards (MBS) for food safety, the Department of Animal Health and Livestock Development (DAHLD) and plant health in the Chitedze Agricultural Research Station (Thopacu, 2017). All Phytosanitary measures concerned with agricultural products are under the responsibility of Ministry of Agriculture, Irrigation and Water Development-Department of research services. While the Malawi Plant Health Inspectorate Service (MAPHIS) is responsible for issuing the Phytosanitary certificates (GOM, 2010) import and export licenses on the other hand, are issued by the Ministry of Trade and Industry.

2.3 Pests of Phytosanitary significance affecting maize grain in Malawi

These are pests that are intentionally or unintentionally introduced in a country through different pathways (Msiska, 2013). According to Sharma and Thakur (2007) they are either regulated or non-regulated pests which cause losses on maize yield both in the fields and in storage. Such pests include the maize lethal necrosis disease, maize streak viruses, maize smut, maize rust, bacteria wilt of maize, maize weevils, larger grain borer, flour beetle, grain moth and fungal diseases (Sori and Ayana, 2012). (Table 2.1).

According to Sori and Ayana (2012) insect pests are the principal cause of maize loss globally. It is estimated that 10% loss in developing countries is due pests to (Sori and (Ayana 2012). The most important pests causing damage in the field and at storage are lepidopteran stalk borers and coleopteran weevils. During a study undertaken by the major post-harvest storage insect pests of quarantine importance observed were the larger grain borer and common maize weevil. Studies by Murayama *et al*. (2017) indicate that Malawi presently looses about 40-100% due to larger grain borer.

Table 2.1: Pest list and fungal pathogens associated with maize in Malawi, Zambia, Mozambique and Tanzania

Common Name	Associated with (Maize grain)	Host Country	conducive in Climate Malawi	Possibility of spread	Crop losses possibility	Loss of trade	Possibility of the pest to spread	Status	Sources
Prostiphanus truncatus	larger grain borer	Yes	Yes	Yes	Yes	High	Yes	Major	CABI (2007, 2012
Sitophilus zeamais	maize weevil/rice weevil	Yes	Yes	Yes	Yes	High	Yes	Major	CABI (2007, 2012
Sitotroga cerealella	grain moth	Yes	Yes	Yes	Yes	Medium	Yes	Intermediate	CABI (2007, 2012
Tribolium castaneum	flour beetle	Yes	Yes	Yes	Yes	Medium	Yes	Intermediate	CABI (2007, 2012
Aspergillus flavus	aspergillus ear rot	Yes	Yes	Yes	Yes	Medium	Yes	Intermediate	CABI (2007, 2012
Aspergillus niger	storage rot of maize	Yes	Yes	Yes	Yes	Medium	Yes	Intermediate	CABI (2007, 2012
Aspergillus parasiticus	storage rot of maize	Yes	Yes	Yes	Yes	Medium	Yes	Intermediate	CABI (2007, 2012
Penicillium	Penicillium ear rot	Yes	Yes	Yes	Yes	Medium	Yes	Minor	CABI (2007, 2012
Fusarium verticillioides	fusarium	Yes	Yes	Yes	Yes	Medium	Yes	Minor	CABI (2007, 2012

Source: CABI (2007; 2012)

These pests have been categorized as those that cause great loss at storage and in trading (Tefera *et al*., 2011a). Other insect pests categorized as intermediate were the grain moth and the flour beetle whose loss is minimal in comparison to the larger grain borer (Raoul and Leonard, 2013).

Fungi are among the sixty important pathogens that affect maize (Dudoiu et *al*., 2016). Ranked second after insects, fungi are other principal factors that lead to deterioration, poor quality and yield loss of farmers' maize during the germination and storage period (Garuba et *al*., 2014). Storage fungal pathogens identified during this study were the *Aspergillus* spp, *Fusarium verticillioides* and *Penicillium.* These are the most predominant species attacking maize (Odhiambo *et al*., 2013). According to Garuba *et al*. (2014) *Aspergillus, Fusarium, Penicillium* produce mycotoxins and toxic metabolites which reduce quality and viability when transmitted in maize seed. They play a significant role in the quantity and quality of agricultural produce by etiologically causing diseases such as seed rot, seedling blight, Bipolaris leaf spot and Cuvularia leaf spot (Debnath, 2012). The symptoms expressed are affected by age of the plant, species of the plant and environmental factors that favour development of such disease. The etiological agents of these diseases penetrate the host plants directly. By use of mechanical force or indirectly gain entry through openings such as wounds and the available natural openings which include the lenticels, hydathodes and stomata (Ami *et al.,* 2013). According to Odhiambo *et al.* (2013) fungal pathogens do not only reduce maize yield, affect germination, storage and quality. They also have a potential of affecting trade, human and animal life by causing health problems if there is a general increase in consumption of contaminated maize with mycotoxins which cause different diseases. Manna, (2017) further clarifies that at storage, the fungi are mainly associated with the grain thereby causing their deterioration or they simply remain viable to affect germination of seeds when planted. In most times, the development of fungi can be affected by moisture content of the maize, temperature, storage time and degree of fungal contamination prior to storage. Fungal dissemination is aided by the movement of mites and insects while in the presence of contaminated maize.

2.4. Sanitary and phytosanitary measures for imported agricultural commodities

According to Manzella and Vapnek (2007) these are measures applied essentially to all WTO members to protect human, animal and plant life within its territory from risks which affect international trade. The three main risk pathways in this case involve importation of food, plants and their products and animals with their products. The risks, however, may come through the entry, establishment and spread of pests that include weeds, diseases and disease carrying organisms and additives. Globally, SPS measures ensure that they include import and export restrictions or maximum levels of allowance of a particular product being traded (WTO, 2005). These play a vital role in the protection of domestic, human, animal or plant life or health by following the necessary SPS measures (Hain *et al*., 2015).

As proof of conformity to phytosanitary measures, the National Plant Protection Organization has several responsibilities. These include issuance of documents such as export certificates and import permits as an indication that the consignments meet specified import and exportation requirements in this case the exported and imported maize (Kennedy, 2000). The NPPOs are also responsible with bilateral agreements when there are differences between the views of the importing country and exporting country (Msiska, 2013).

According to Msiska (2013), the NPPO also ensures inspection of consignments and all regulated agricultural articles to ensure that they are free from any regulated and non-regulated pests. For those that do not conform, they are detained and put under quarantine for further observation, disinfected or sent back to the country of origin at the expense of the owner. At the NPPO level, surveillance is done with the objective of reporting occurrence, outbreak, spread and control of pests associated with maize (Theyse, 2009). The NPPO conduct pest risk analysis before exportation and importation of maize, thus maintaining both pest free areas and areas of low pest prevalence. The NPPOs ensure there is phytosanitary security of consignments after certification, train and develop staff and manage the available information within its territory. They are responsible of conducting research on the gaps within the field of plant protection, issuing regulations for phytosanitary and providing the national plant protection contact point (Sharma and Thakur, 2007).

2.5 Regulatory organizations in phytosanitary measures for imported agricultural products in Malawi

The WTO agreement on the application of Sanitary and Phytosanitary Measures (SPS agreement) seeks to facilitate safe trade in food and agricultural products. It provides rules that allow countries to take necessary measures to protect human, animal or plant life and health against trade-related risks. They also provide assurances that do not result in unnecessary barriers to trade (Thopacu, 2017). Malawi therefore is a member of several regulatory bodies within the region and in the country.

2.5.1 Southern African Development Community (SADC)

The Southern African Development Community (SADC) is a regulatory body that was formed in a bid to address problems associated with trade for agricultural products including maize among member states of the Southern African region (Joubert, 2014) .Among these, is the lack of compliance to Sanitary and Phytosanitary (SPS) measures linked with trading agricultural commodities. SADC member states have adapted measures to facilitate cross-border cooperation through creation of mutually beneficial trade arrangements for maize (Joubert, 2014). SADC act as an instrumental tool for the implementation of SPS measures. SADC eliminates barriers to trade by easing custom procedures and harmonizing trade policies (Joubert, 2014). Malawi's regional trade is conducted under the framework of bilateral and regional trading arrangements. In addition to the SPS agreement, regional trade in maize is also governed by the SADC trade protocol and bilateral agreements signed with major trading partners. The main instruments used for trade in the maize product are the bilateral trade agreements between Malawi and the SADC member countries (Thopacu, 2017).

2.5.2 Common Market for Eastern and Southern Africa (COMESA)

Established in 1994, COMESA is a regional organization that ensures SPS capacity for private and public sectors of member countries Gebrehiwet *et al*., 2007; Ancharaz *et al*., 2010). It is a strategic response that aids in maintaining regional as well as international market access for food and agricultural products (Gebrehiwet *et al*., 2007; Ancharaz *et al*., 2010). According to Ancharaz *et al*. (2010) one of COMESA's goals is to provide a market which facilitates economic development and food security among member states by allowing member states to trade freely with each other. Other objectives include, attaining sustainable growth and development through the development of production and marketing structures. It promotes joint development in all fields of economic activity through the adoption of macroeconomic policies and programs and in the creation of an environment that favors foreign, cross-border and domestic investment (Gebrehiwet *et al*., 2007). Additionally, it promotes research and adoption of science and technology for development as well as peace, security and stability among member states (Gebrehiwet *et al*., 2007). Thus, strengthening relations between the common market and the rest of the world. The framework of bilateral and regional trading arrangements of the SPS agreement, govern regional trade in Malawi (Frick and Chapman, 2017). In addition the COMESA treaty and bilateral agreements signed with major trading partners also have impact on trade in the country (Frick and Chapman, 2017).

2.5.3. National Plant Protection Organization for phytosanitary measures (NPPO)

National Plant Protection Organization (NPPO) is a requirement for IPPC contracting parties and an obligation of the WTO (Van, 2000; Gebrehiwet *et al*., 2007). They are establishment of to prevent the introduction and spread of pests. They have a role as national notification authority which enhances transparency to trading partners by providing effective communication through issuing any information associated with the SPS measures of a given country. This information is relayed to domestic producers and exporters of the member country and other trading states.

The national enquiry point also engages in requesting copies of the relevant legislation and changes being considered from other members and channeling questions and comments from the domestic producers to other members (Van, 2000). Additional responsibilities include issuance of phytosanitary certificates for importing and exporting agricultural products. They inspect consignments and regulated agricultural articles, disinfecting consignments that do not comply with SPS measures to meet phytosanitary requirements. They carry out a surveillance to report any occurrence, outbreak, spread and control of those pests associated with maize (Van, 2000). The NPPO conduct pest risk analysis, maintain pest free areas and areas of low pest prevalence. They ensure that the integrity of the consignments is intact, identify research gaps as well as conduct research in the field of plant protection (Sharma and Thakur, 2007). Each member country has the responsibility of ensuring that sufficient resources are assigned and the NPPO personnel are competent so that they are eligible to comply with its obligations in terms of IPPC.

The officers managing the NPPO activities are plant protection research scientists and research technicians whose core function is to conduct research in pest management, post-harvesting and quarantine management (GOM, 2010). The plant protection research facilities represent the NPPO facilities. The NPPO members in phytosanitary inspections are based at selected borders which are manned, by the professionals who are spread between Chitedze, Bvumbwe and Lunyangwa Research Station (GOM, 2010).

2.6 Phytosanitary legislation and policies in Malawi

The phytosanitary legislation and policies in most countries are based on the international Plant Protection Convention and the World Trade Organization Sanitary and Phytosanitary agreement Measures (Eschen *et al.,* 2015). There are, however, differences in country approaches to managing the risk of introducing of different alien species and this is achieved through different government legislation and policies. The government of Malawi through the Plant Protection Act – 1969 section 11 and Seed Act achieved different legislation and policies (Theyse, 2009). The act provides for plant export regulation, which governs the issuance of phytosanitary certificate for all the plants and their products, and regulated articles being exported outside Malawi. It also provides plant import regulation that governs the issuance of permission to import plant, plant products and regulated articles from other countries and the plant quarantine regulation, which provides authority to detain a consignment for further observations (Theyse, 2009).

As a nation involved in importing and exporting plants and plant products, there are numerous potential pathways for introducing maize pests that can affect agricultural production and limit access to export markets. Malawi’s NPPO therefore is responsible for framing phytosanitary measures to ensure risks of introducing pests of maize and other agricultural products are minimized. The application of phytosanitary regulatory system is therefore a vital component (GOM, 2010).

2.7 Phytosanitary capacity and services in Malawi

The national phytosanitary capacity and its available services protects a country’s agricultural resources, unmanaged plant resources and facilitates trade (Day *et al.,* 2006). According to Sharma and Thakur (1997) the International Plant Protection Convention seeks to secure common and effective action to prevent the spread and introduction of pests of plant and to promote appropriate measures for their control. This is achieved through individual countries applying the legislative, technical and administrative measures outlined in the convention text and through implementation of internationally agreed standards (Day *et al*., 2006).

According to Murina *et al.* (2014) the capacity and services to meet the SPS quality requirements and to comply with these ISPM standards are increasingly problematic to developing countries. In Malawi the capacity and available services that enhance the phytosanitary measures both in the public and private sectors are weak. The available phytosanitary facilities required to implement the phytosanitary activities and manage maize pests are lacking. Secondly, the laboratories, equipment’s and financial support is not only quite low but unavailable. Additionally, the borders are not manned effectively due to inadequate staff who are unskilled in most of the phytosanitary disciplines. This creates loop holes for the entry of maize into the country without being inspected hence increasing the likelihood of regulated and non-regulated pests gaining entry into Malawi. A strategic approach is needed, which measures near and longer term challenges and opportunities thus prioritizing investments in awareness-raising and capacity-building (Murina *et al.*, 2014).

All phytosanitary measures concerned with agricultural products in Malawi are under the Ministry of Agriculture, Irrigation and Water Development. The Malawi Plant Health Inspectorate Service (MAPHIS) is the responsible office for issuing the certificates (Thopacu, 2017). Currently, Malawi has 30 designated border points. Tanzania, Zambia and Mozambique occupying the north, west and the entire southern part of Malawi respectively. Only ten borders are manned by Plant Health inspectors (PHIs) and the rest are unmanned (GOM, 2010). The total number of Plant Health Inspectors (PHIs) is twenty six whose responsibility is to implement phytosanitary duties such as carrying out inspections on imported and exported commodities, pest risk analysis and pest surveillance as per the ISPM standards (Theyse, 2009).

Importation of maize is subjected to quarantine and inspection requirements and should be accompanied by a phytosanitary certificate and an import permit issued by the plant health inspection section. Upon arrival of the maize at the entry point, it is inspected by the PHIs on whether it complies with the SPS requirement. The plant health inspector has the right to detain the consignment for destruction, return it to the country of origin or for treatment if it does not comply with the SPS agreement. The availability of these phytosanitary measures in developing countries is negligible and poor thus the implementation of the SPS measures is inadequate (Msiska, 2013). The available SPS facilities and equipment are insufficient, and unavailable. Capacity, services and personnel in phytosanitary disciplines such as entomology, virology and bacteriology in the NPPO are unsatisfactory. This creates more loopholes for the entry, spread and establishment of both regulated and unregulated pests of maize (Msiska, 2013).

CHAPTER THREE

PHYTOSANITARY MEASURES IN MANAGEMENT OF MAIZE PESTS IN MALAWI

3.1 Abstract

Phytosanitary measures protect countries and regions from regulated and non-regulated pests during trans-boundary movement of maize and other commodities. This study was carried out to determine the available phytosanitary measures for the management of maize pests across the borders of Malawi. A survey was conducted to determine phytosanitary measures, facilities and human capacity at border points, major towns, regulatory and private institutions. Questionnaires were administered to government regulatory organizations, private organizations and other organizations that work together with the National Plant Protection Organization in relation to Sanitary and phytosanitary measures. Data collected included the phytosanitary activities, trade patterns on maize, staffing in relation to plant health, capacity and available facilities in the government regulatory bodies and other organizations working together with the phytosanitary management system. The highest number of the respondents were male (75%) with the majority (25%) being diploma holders from IITA and CIAT while a few were. Government organizations offered the training courses in phytosanitary discipline while the Malawi National Plant Protection Organization (NPPO) carried out the SPS measures activities. Inspection was majorly done on imported maize than those on transit. Maize was mainly imported from Mozambique (67%) followed by Tanzania and Zambia at (18%). Phytosanitary facilities in Malawi are not well equipped hence the need for capacity building, improving the facilities and inspection practices and increase funding in the Phytosanitary system.

Key words. Cross- border trade, Phytosanitary measures, maize pests.

3.2 Introduction

Agriculture is an important sector for achieving sustainable economic growth and reducing poverty in Malawi (Murina *et al.*, 2014). According to Henson *et al*. (2004), importation and exporting of agricultural plants and plant products create pathways for introduction of pests that limit food security and access to the export market for maize. Introduction of different forms of phytosanitary measures as compliance measures have been done in Malawi. This involves the issuance of phytosanitary certificates before importation and exportation of maize.

The National Plant Protection Organization (NPPO) of Malawi through the Plant Health Inspectorate Services (MAPHIS) is responsible of supporting phytosanitary measure (Chirwa, 2010). According to Murina *et al*. (2014) the organization ensures that all agricultural exports and imports maize specifically adhere to sanitary and phytosanitary measures in the prevention of trans-boundary movement of pests into and outside Malawi. Regardless of all the efforts in support for SPS measures in Malawi, pests have been introduced such as the larger grain borer (Tefera *et al*., 2011a). Larger grain borer is a well-known destructive pest that is causing major losses in post-harvest in many African countries (Tefera *et al*., 2011b). Malawi currently loses about 40-100% due to larger grain borer. Other common destructive storage insect's pests that affect maize grain and are regulated pests include common maize weevil, grain moth and flour beetle. According to Henson *et al*. (2004) application of SPS standards set by developed countries is not effective. This has been attributed to lack of economic and technical resources in developing countries. This study was, therefore conducted to evaluate the available phytosanitary measures and practices conducted by the Malawi NPPO in management of maize pests across the borders of Malawi

3.3 Materials and Methods

3.3.1. Description of the study site

The research was conducted in the Northern, Central and Southern regions of Malawi. Entry points bordering Tanzania, Mozambique and Zambia were selected. Three major cities in each of three regions were considered. Dedza (44°22'0"South and longitude of 34°20'0"East), Mchinji 43°43'0"South and longitude of 32°45'0"East), Nkhatabay (11°36'0"South and longitude of 34°18'0"East), Karonga (9°55'59.9880"South and longitude of 33°55'59.9880"East), Muloza and Chiponde (14°22'0"S, 35°35'0"E) borders were considered from the Central, Northern and Southern regions respectively (Figure 3.1). These regions are busy entry points where maize trade is carried out throughout the year. They offer readily available market for maize from Mozambique, Tanzania and Zambia. Dedza and Karonga, which are horticultural and rice zones respectively, are distinguished by low production of maize. High production of cassava in Nkhatabay limits maize production thus importation of maize from Tanzania

Government and private organizations sampled from the cities of Lilongwe, Mzuzu and Blantyre included National Plant Protection Organization (NPPO), Malawi Bureau of Standards (MBS) and the Ministry of Tourism, Industry and Trade. Private organizations included were the Seed Company Malawi (SEEDCO), Demeter Agriculture Limited (DAL), International Institute of Tropical Agriculture (IITA), Monsanto Malawi Ltd (MML), International Crops Research for the Semi-Arid Tropics (ICRISAT) and International Center for Tropical Agriculture (CIAT). Additionally, large scale individual companies and small scale business people importing maize in Malawi were sampled.

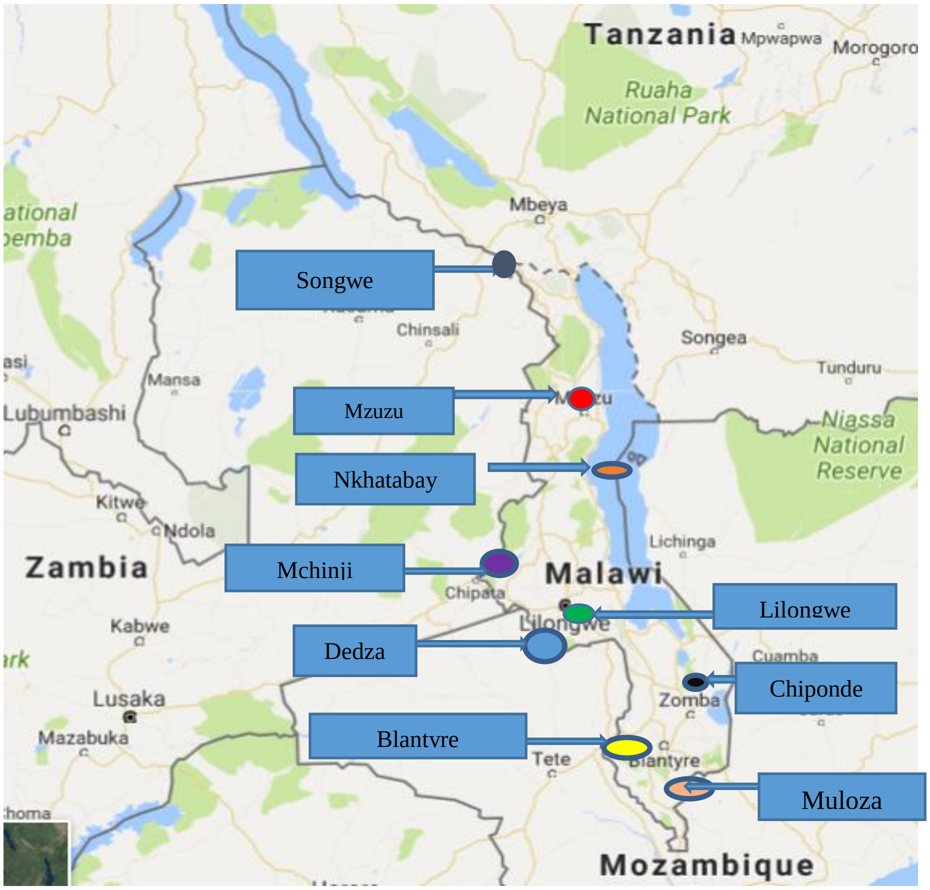

Figure 3.1: Map of the selected cities and borders ports where data was collected for the study: *Source: https://www.google.nl/maps/dir//51.99989934)*

3.3.2 Study population

The study population consisted of individuals who work with the phytosanitary system in three regions, north, central and south. The districts sampled in these regions were selected purposively. Individuals from government, private organizations, large scale individual companies and small scale business people importing maize in Malawi were considered. A total of 126 questionnaires were administered to the purposively selected respondents. A number of 36 were administered to Plant Health Inspectors (PHIs) in the borders, each organization public and private, had six questionnaires making a total of 60 while other organizations were given 12 questionnaires for each region making a total of 36.

The sample size was determined by

$$n = ewsz^2 \frac{(1-P)\,P}{e^2}$$

Where:

- n=ideal/optimal/desired sample size
- Z=tabulated z-value for a used confidence level
- p=estimate of population percentage [prevalence]
- e=desired error allowance.
- The desired error allowance for this study was 10% because it was a sub-national study. The confidence level for this study was 95% thus the tabulated z-value of 1.96 was used (Crawford, 2001).

Determination of the existing phytosanitary capacity involved administering of questionnaires to government, private organizations, large scale individual companies and small scale business personnel importing maize into Malawi. The list for respondents was taken from the records at borders, market places and offices for easy identification of respondents who deal with SPS measures and maize trade. The information obtained from the respondents included demographic characteristics, stuff positions, phytosanitary practices for maize importation, origin and its volume, available facilities and capacity in relation to phytosanitary activities. Secondly, cooperation's with other phytosanitary systems, phytosanitary training in related disciplines, information on laws and regulations, procedures followed during maize inspection and existing pests associated with maize was acquired.

The existing trade among purposively selected maize importers from both local and commercial traders was determined in two ways formal trade which is verified and informal, that is unrecorded. In both practices, the respondents were asked the factors that influence maize trade, the existing formal or informal importation practices and the knowledge of the advantages and disadvantages of both systems. The knowledge they have on SPS measures on maize importation was also assessed as well as activities involved in maize inspection, facilities at the border, maize trade practices and awareness on cross-border importation.

3.4 Data Analysis

Data collected which involved the knowledge the respondents have on SPS measures on maize importation activities involved in maize inspection, facilities at the border, maize trade practices and awareness on cross-border importation analysis was subjected to the statistical package. This was subjected for social science (SPSS) software version 20 for analysis. Descriptive statistical test was carried out through cross- tabulation which included percentage statistics tables.

3.5. Results

3.5.1 Demographic characteristics and work experience of staff in phytosanitary system of Malawi

There were variations in the Phytosanitary system in terms of gender, education level and work experience (Table 3.1). Majority (75%) of the respondents were male and out of this, 96% were from Malawi Bureau of Standards. Around 50% of the female respondents were from SEEDCO and MML. The respondents had various educational levels, majority (25%) had diploma level of education while a few (15%) had acquired Master of Science degree of education (MSc) level of education. Majority (33%) of the respondents with diploma level of education were from IITA and CIAT. Half of those with postgraduate level of education were from Ministry of Trade and Industry while (33%) of those with undergraduate level of education were from private organization ICRISAT and CIAT.

Table 3.1: Percentage of demographic characteristics, education level and work Experience of respondents in Phytosanitary system of Malawi

	Gender		Edu. Level				Experience (years)		
Organization	Male	Female	M.S.C.E	Dip	BSc.	MSc.	0-10	10-20	>20
NPPO	78.6	21.4	18.2	63.6	4.5	-	78.6	20.0	1.4
MBS	96.0	4.0	20.0	29.0	33.3	16.7	66.7	16.7	16.7
Min. TIT	85.7	14.3	5.0	23.0	25.0	50	96.0	2.7	1.3
SEEDCO	50.0	50.0	8.3	16.7	25.0	8.3	78.6	20	1.4
DAL	83.3	16.7	8.3	8.3	25.0	16.7	84.4	14.3	1.3
IITA	83.3	16.7	8.3	33.3	16.7	16.7	96.0	2.7	1.3
MML	50.0	50.0	16.7	8.3	25.0	8.3	96.2	2.7	1.3
ICRISAT	66.7	33.3	8.3	16.7	33.3	8.3	96.2	2.8	1.0
CIAT	66.7	33.3	16.7	33.3	33.3	8.3	83.3	16.7	-
Other org	93.7	2.7	58.3	16.7	16.7	3.3	96.0	2.7	1.3
Mean	75.4	24.2	16.8	24.9	23.8	15.2	87.2	10.1	3.0

NPPO=National plant protection Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade, SEEDCO=Seed company Malawi, DAL=Demeter agriculture Limited, IITA= International Institute of Tropical Agriculture MML=Monsanto Malawi Ltd., ICRISAT= International Crops Research for the Semi-Arid Tropics, CIAT= International Center for Tropical Agriculture.

The respondents had different years of work experience with majority (87%) having work experience ranging from 0-10 years while a few (3%) had experience of above 20 years. Majority of the respondents with 0-10 years of work experience were from government regulatory body, private and other organizations while about 66% were from the government organization only. Majority (20%) of the respondents with 10-20 years work experience, were from the NPPO and SEEDCO organizations. On the other hand, majority (17%) who had over 20 years of work experience were from the government regulatory body, MBS.

3.5.2 Positions of staff in the phytosanitary system of Malawi

Positions for the different organizations varied in terms of titles, designated duties they perform and responsibility for each organization. Majority (20%) of the respondents were laboratory technicians and laboratory scientists while a few (7%) were business men or women (Table 3.2).

Table 3.2: Percentage of positions of respondents in the phytosanitary system of Malawi

Organ.	Lab. Tech	Lab. Scient	Trad.Off	Sales. Rep	Sen. PHIs	Quality ass.off	Buss. Man/wmn	Ass.PHIs
NPPO	11.1	-	-	-	78.6	-	-	21.4
MBS	25.0	33.3	-	-	-	33.3	-	-
Min. TIT	-	-	16.7	-	-	-	-	-
SEEDCO	16.7	16.7	25.0	8.3	-	8.3	-	-
DAL	33.3	33.3	16.7	33.3	-	8.3	-	-
IITA	25.0	33.3	33.3	33.3	-	8.3	-	-
MML	33.3	25.0	8.3	16.7	-	8.3	-	-
ICRISAT	33.3	33.3	25.0	16.7	-	8.3	-	-
CIAT	25.0	25.0	-	-	-	-	-	-
Other organizations	-	-	33.3	33.3	-	-	72.7	-
Mean	20.3	20.0	16.0	14.2	8.0	7.5	7.3	2.1

Sen PHIs=Senior plant Health Inspector, Ass.PHIs=Assistant Plant Health Inspectors, Trade Off=Trade Officer, Quality Ass.off=Quality assistant Officer, Sales.Rep=Sales representative, Lab. Tech=Laboratory Technician, Lab. Scient=Laboratory Scientist, Buss Man/Wmn=Business man /woman NPPO=National plant protection Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade, SEEDCO=Seed company Malawi, DAL=Demeter agriculture Limited, IITA= International Institute of Tropical Agriculture MML=Monsanto Malawi Ltd., ICRISAT International Crops Research for the Semi-Arid Tropics, CIAT= International Center For Tropical Agriculture

Many of the laboratory technicians (33%) were from ICRISAT, DAL, and MML while a few of them were from the public organizations. Majority (33%) of the trade officers were from IITA and other organizations while NPPO and CIAT had no trade officers. Many of the sales officers (33%) were from DAL and IITA. Other positions included quality assurances officers, business men and women. The NPPO was the only organization with the position of Plant Health Inspectors.

3.5.3 Agencies cooperating with Phytosanitary system of Malawi

Majority (52%) of the respondents cooperated with immigration services while a few (8%) with the National Parks and Wildlife (Table 3.3).

Table 3.3: Percentage of agencies cooperating with Phytosanitary system of Malawi

Organizations	Immigration	MRA	M.Police	F. Police	Min.He alth	Vet.	Int. Bureau	N.&Wildlife
NPPO	100	90.9	90.9	90.9	95.5	86.4	86.4	86.4
MBS	100	100	100	100	100	100	83.3	-
Min. TIT	100	100	100	83.7	100	66.7	66.7	-
SEEDCO	16.7	33.3	16.7	16.7	-	-	-	-
DAL	33.3	33.3	8.3	8.3	-	-	-	-
IITA	33.3	33.3	8.3	8.3	-	-	-	-
MLN	33.3	16.7	8.3	8.3	-	-	-	-
ICRISAT	50.0	16.7	8.3	8.3	-	-	-	-
CIAT	8.3	8.3	8.3	8.3	-	-	-	-
Other organizations	36.4	36.4	11.1	11.1	-	-	-	-
Mean	52.1	46.9	36.0	34.4	29.6	25.3	23.6	8.6

MRA=Malawi Revenue Authority, M.Police=Malawi Police, F. Police=Fiscal Police, VET= Vertinary Services, N. &Wildlife=National parks and wildlife, Immigration=Malawi customs and immigration Services,Min. Health=Ministry of Health., Int. Bureau=Intelligence Bureau, NPPO=National plant protection of Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade, SEEDCO=Seed company Malawi, DAL=Demeter agriculture Limited IITA= International Institute of Tropical Agriculture MLM=Monsanto Malawi Ltd., ICRISAT= International Crops Research for the Semi-Arid Tropics, CIAT= International Center for Tropical Agriculture.

Government agencies such cooperated well with Malawi Custom and Immigration services and Malawi revenue authority. From the private organization, many (33%) of the cooperating were observed from DAL, IITA, SEEDCO and MLN while very few (8%) were from the private organization CIAT. Furthermore, the government regulatory bodies had cooperated with the Malawi police and Fiscal police border agencies. Out of this, (17%) were from SEEDCO while a few (8%) were from DAL, IITA, MLN, ICRISAT and CIAT. However, the government agencies collaborated with Ministry of Health, Vertinary Services and Intelligence Bureau while the private and other organizations did not. Similarly, the NPPO cooperated with the National Parks and Wildlife while the rest of the organizations did not.

3.5.4 Organizations involved in phytosanitary inspection activities

Majority of the inspection activities were done by the National Plant Protection Organization Out of this (74%) of activity mostly monitored and which had more interaction among the organizations were the documents used during inspection of the maize commodity by the NPPO (Table 3.4) Majority (96%) of maize inspections were done during importation compared to exportation and in transit. The NPPO had the highest role compared to MBS and Ministry of Tourism, Industry and Trade with majority (18%) of inspection activity for maize at export while many (16%) were from Ministry of Trade and Tourism.

However, there were no inspection activities conducted by the MBS organization for maize at export and in-transit while the NPPO and the Ministry of Tourism and Trade did the inspection Majority (83%) of maize inspection were done for tax collection by the Ministry of Tourism Industry and Trade while the MBS and the NPPO were not involved in this activity. In contrast, The NPPO and the MBS inspected (95%) and (33%) of maize, respectively checking on pests, food safety and quality control. All the organizations were involved in conducting maize inspection with a purpose of meeting importing and exporting requirements and out of this, majority (97%) were from the NPPO.

Table 3.4: Percentage for organizations involved in Phytosanitary inspection activities

Activity	NPPO	Min of Industry & Trade	MBS
Inspection done at the boarder			
Maize importation	95.5	8.3	16.7
Maize exportation	18.2	-	16.7
Maize in transit	13.6	-	16.7
Mean:	42.4	2.8	16.7
Inspection purpose			
Tax collection	-	83.3	-
Check pests and diseases	95.5	-	8.3
Food safety checks	9.1	-	33.3
Quality control	9.1	-	33.3
Meeting importing and exporting requirements	96	33.3	33.3
Mean:	41.9	23.3	21.6
Documents used			
Verbal instructions from –DARS	95.5	8.3	16.7
Standard Operating Procedures from institutions	9.1	8.3	33.3
International guidelines	95.5	33.3	33.3
From exporting or importing country's government	95.5	8.3	8.3
Mean:	73.9	14.6	22.9

Majority (95%) of the guidelines used by the Malawi National Plant Protection Organization during the inspection activities were verbal instructions from the Department of Agricultural Research (DARS). Majority (96%) of the international guidelines as documents for inspection were also used by the National Plant Protection Organization while the other organizations had

33%. Similarly, majority (96%) of the instructions requested from exporting or importing country's government were from the National Plant Protection Organization while (8%) were from the Malawi Bureau of Standards and the Ministry of Tourism, Industry and Trade.

3.5.5 Volume of cross-border maize trade in Malawi for 2017/2018 season

There were variations in terms of volume of maize passing through the border according to country of origin. Majority (33%) of the inspected maize were reported by the MBS while the NPPO inspected around 5% of the exported maize. Similarly, majority (35%) of the maize in transit were also reported by the NPPO (Table 3.5).

Table 3.5: Volume of maize traded in Malawi from the organizations in tonnage

	Imported mt/moth			**Exported mt/6moths**			**In Transit mt/6 moths**	
Volume	NPPO	MBS	Other org	NPPO	MBS	Other org.	NPPO	MBS
High (>100)	54.6	16.7	5.5	-	-	-	-	-
Medium (>50-100)	18.2	16.7	28.6	5.6	2.8	-	9.1	-
Low (<50)	27.2	66.7	28.6	8.3	2.8	5.6	95.5	100
Mean	**33.3**	**33.4**	**20.9**	**4.6**	**1.9**	**1.9**	**34.9**	**33.3**

Majority (54%) of the imported maize at high import in a month were reported by the National Plant Protection Organization while the least (6%) were reported by other organizations. At medium, majority (29%) of imported maize were by the other organizations. However, the Malawi Bureau of Standards reported to import majority (67%) of maize in a month at very low volume.

3.5.6 Origin and destination of cross-border maize traded in Malawi

Majority (31%) of the imported maize from different origins were reported by the Malawi Bureau of Standards while a few (3.8%) were by the National Plant Protection Organization. There were no records for exported maize in both organizations. Similarly, majority (33 %) of the maize in transit were also reported by the Malawi Bureau of Standards (Table 3.6).

Table 3.6: Origin and destination of traded maize in Malawi (%)

	Imported			**Exported**		**In transit**	
Origin	NPPO	MBS	Other org	NPPO	MBS	NPPO	MBS
Zambia	22.7	16.7	2.8	-	-	-	-
Tanzania	22.7	16.7	5.6	-	-	22.7	83.3
Mozambique	50.0	66.7	50.0	-	-	40.9	16.7
Mean	**3.8**	**31.4**	**19.5**	**-**	**-**	**21.2**	**33**
Destination							
Markets	69	66.7	91.7	100	100	100	100
Food aid	8.6	33.3	8.3	-	-	-	-
Transit	5.6	2.8	-	-	-	-	-
Consumption only	14.3	4.5	4.5	-	-	-	-
Mean	**24.4**	**26.8**	**26.1**	**25**	**25**	**25**	**25**

According to reports from Malawi Bureau of Standards majority (67%) of the imported maize originated from Mozambique followed by Tanzania and Zambia. Based on National Plant Protection Organization reports, majority of the imported maize originated from Mozambique followed by Tanzania and Zambia. There were no records for maize in transit from Zambia. However, majority (83%) were reported by the Malawi Bureau of Standards with the maize originated from Tanzania. The imported maize had various destinations. According to reports from other organizations which were small scale and large scale maize traders, majority (92%) of the imported maize were destined for markets followed by (69%) the National Plant Protection Organization and (67%) by Malawi Bureau of Standards .Based on Malawi Bureau of Standards reports, majority (33%) of the imported maize were for food aid followed by the National Plant Protection Organization and other organizations. For maize in transit, majority (5.6%) were reported by the National Plant Protection Organization followed by the Malawi Bureau of Standards. Other organizations did not have any reports for maize in transit. Based on reports from the most National Plant Protection Organization (14%) of the maize imported were for consumption followed (5%) from other organizations and the Malawi Bureau of Standards. However, according to National Plant Protection Organization and Malawi Bureau of Standards reports, at export and in transit, all the maize passing through the border were destined for markets. It is good to note that, other destinations were not reported at export and during in transit for these organizations.

3.5.7 Phytosanitary facilities used by various organization.

Private organizations SEEDCO and IITA had the highest (7%) number of laboratories followed closely (6%) by NPPO. The least number of laboratories were reported in the Ministry of Trade and Industry. Storage facilities were, however, such as refrigerators, cold-rooms and warehouses were available in all the organizations. Majority (25%) were available in MBS and ICRISAT a few government and private organizations had no disposal and inspection facilities. However, majority (92 %) were in the MBS and many (17%) were in the private organizations (Table 3.7)

Out of the mentioned laboratories, the private organizations had the highest (8%) mycological laboratories except CIAT and all the government organizations. Majority (17%) of the pathology laboratory were reported from the private organizations SEEDCO and IITA followed by (9%) from the government organization NPPO. Nematology and virology laboratories (5%) were reported from the government institution only. There was no bacteriology laboratory reported in all the organizations. However, many of the organizations had general laboratories.

Table 3.7: Percentage of Phytosanitary facilities available in different organizations

Facility	NPPO	MBS	Min.TIT	SEEDCO	DAL	IITA	MML	ICRISAT	CIAT
Laboratory facilities									
Mycology	-	-	-	8.3	8.3	8.3	8.3	8.3	-
Pathology	9.1	-	-	16.7	8.3	16.7	8.3	8.3	-
Nematology	4.5	-	-	-	-	-	-	-	-
Virology	4.5	-	-	-	-	-	-	-	-
Bacteriology	-	-	-	-	-	-	-	-	-
General Lab.	9.1	25	-	16.7	8.3	16.7	8.3	8.3	8.3
Mean	4.5	4.2	0	7	4.2	7	4.2	4.2	1.3
Storage Facilities									
Refrigerators	8.3	25	8.3	33.3	16.7	8.3	8.3	8.3	16.7
Cold-rooms	8.3	25	8.3	16.7	16.7	8.3	16.7	33.3	8.3
Warehouse	8.3	25	16.7	16.7	33.3	16.7	33.3	33.3	8.3
Mean	8.3	25	11.1	22.2	22.2	11.1	19.4	24.9	11.1
Disposal Facilities									
Incinerator	4.5	16.7	-	8.3	-	8.3	8.3	8.3	
Mean	4.5	16.7	0	8.3	0	8.3	8.3	8.3	
Inspection facilities									
sampling spears	92	16.7	-	8.3	16.7	16.7	16.7	16.7	-
Mean	92	16.7	0	8.3	16.7	16.7	16.7	16.7	0

NPPO=National plant protection of Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade, SEEDCO=Seed company Malawi, DAL=Demeter agriculture Limited, IITA= International Institute of Tropical Agriculture MML=Monsanto Malawi Ltd., ICRISAT= International Crops Research for the Semi-Arid Tropics, CIAT= International Center for Tropical Agriculture

Majority (25%) of these were reported from government organization MBS, (17%) from the private organizations SEEDCO and IITA. All the sampled organizations had storage facilities. Majority (33%) of refrigerators were reported from private organization (SEEDCO) followed by 25% from the government organization (NPPO). Similarly, the private organization reported to have highest (33%) of cold rooms and followed by the government organization NPPO followed with (25%). Majority (33%) of the warehouses were available in the private organizations SEEDCO, IITA and MML while NPPO followed with (25%). In terms of disposal facilities, majority (17%) of these were reported from the government organization the MBS while (8%) were from private organizations. Other organizations lacking these facilities included the Ministry of Trade and Industry and DAL. Inspection facilities also varied within the organizations. Majority (92%) were reported from the government organization NPPO while others (17%) were reported from the private organizations and the government organization MBS. However, the Ministry of Trade and Industry and CIAT organizations did not have these facilities.

3.5.8 Phytosanitary training in related disciplines for staff in the organizations

Among all the available courses in phytosanitary disciplines, only staff from the government regulatory bodies managed to attend the available trainings. The National Plant Protection Organization (NPPO) had the highest (63%) attendance for the refresher courses. The other organizations which included MBS and the Ministry of tourism, Trade and Industry also attended many among the courses while a few courses were not attended by these two organizations (Table 3.8). Based on reports from the three organizations, all on job training courses were attended by NPPO. Out of the listed courses, majority (7%) of the courses attended were mycology, entomology and bacteriology followed by (3%) of virology and nematology. Refresher courses attended by the organizations also varied. According to reports from the NPPO, majority (97%) of courses attended were for inspection followed by (83%) for quarantine pest and barriers to trade. The least (19%) attended course was for Pest Risk Analysis. Reports from the MBS indicated that (50%) of the courses attended were for seed management followed by (17%) for inspection and barriers to trade.

Table 3.8: Percentage of Capacity of Phytosanitary training in related disciplines for staff in Phytosanitary Organizations

Capacity	NPPO	MBS	Min. TIT
On Job Training			
Nematology	2.8	-	-
Mycology	5.6	-	-
Entomology	5.6	-	-
Bacteriology	5.6	-	-
Virology	2.8	-	-
Mean	4.5	0	0
Refresher Courses			
PRA	19.4	-	-
Inspection	97.3	16.7	-
Quarantine pests awareness	83.3	16.7	16.7
Barriers to trade	83.3	16.7	100
Seed Management	33.3	50	50
Mean	63.3	20	33.3
On job training			
PRA Concept awareness	31.8	-	-
Export and import requirements	25	-	33.3
Inspection course	25	16.7	-
Lab. Capacity	2.8	16.7	-
Acts & leg. in phyto measures	19.7	16.7	16.7
Pest Sur. in Phytosanitary system	4.5	-	-
Mean.	18.1	8.4	8.3

PRA=Pest Risk Analysis, Lab Capacity=Laboratory Capacity, Act &Leg=Acts and Legislations, Pest Surv=Pest and Surveillance, NPPO=National plant protection of Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade.

On the other hand, the Ministry of Tourism Trade and Industry attended all the courses concerning barriers to trade followed by (50%) for seed inspection. The least (17%) courses attended was for quarantine pest awareness while inspection and pest risk analysis courses were not attended. According to the NPPO report, majority (32%) of the courses attended were PRA concept awareness followed by (25%) on export and import requirement and inspection courses. The least (3%) attended course was on laboratory capacity. The MBS staff (17%) reported to attend three courses among the offered courses .These included inspection course, laboratory capacity and Acts and Legislation for phytosanitary measures Of the courses (33%) attended by the Ministry of Tourism, Trade and Tourism staff were for import and export requirements followed by (17%) for Acts and Legislation of phytosanitary measures. The rest of the courses were however not reported to be attended by this organization

3.5.9 Sources of funding, laws and regulations supporting Phytosanitary system of Malawi

Donors were the majority (63%) source of funding to the private organizations while (20%) of funding to the government organizations was from the Malawi government. It was noted that a (16%) of the source of funding was collected through own initiatives in other organizations. Majority (69%) of the private organizations used institutional laws to support their work activities Based on reports from the organizations, most (92%) source of funding went to the NPPO and Ministry of trade and Tourism (88%) was from government. According to private organizations reports, all sources of funding were from donors followed by (17%) to the government organization MBS while (31%) of the government laws were used by the government organizations (Table 3.9).However, only two organizations had generated their own funds of which majority (92%) were reported from other organizations and MBS followed with (67%)

Table 3. 9: Sources of funds, laws and regulations supporting Phytosanitary system of Malawi

Organization	Sources of Funds (%)			Laws Guiding SPS activities (%)	
	Gov.	Donors	Own.Soc.	G/ Laws	Insist. Laws
NPPO	91.7	8.3	-	100	-
MBS	16.6	16.6	66.7	16.7	83.3
Min. TIT	88.3	11.7	-	100	-
SEEDCO	-	100	-	-	100
DAL	-	100	-	-	100
IITA	-	100	-	-	100
MLN	-	100	-	-	100
ICRISAT	-	100	-	-	100
CIAT	-	100	-	-	100
Other Organizations	-	8.3	91.7	91.7	8.3
Mean	19.7	63.3	15.8	30.8	69.2

Gov = Malawi Government, Own SOC=Own sources, G/Laws=Government Laws, Insist. Laws=Institution Laws. NPPO=National Plant Protection Organization, MBS=Malawi Bureau of Standards, Min TIT= Ministry of Tourism, Industry and Trade, SEEDCO=Seed company Malawi, DAL=Demeter agriculture Limited, IITA= International Institute of Tropical Agriculture MLM=Monsanto Malawi Ltd., ICRISAT=International Crops Research for the Semi-Arid Tropics, CIAT= International Center for Tropical Agriculture.

Laws guiding the operations in the various organizations also varied. The NPPO and the Ministry of Tourism, Trade and Industry followed laws made by the Malawi government while the least (8.3%) were reported from other organizations. It was also noted that all private organizations depended on institutional laws and regulations followed by (83%) from the MBS while the least (8.3%) was reported from other organizations.

3.6. Discussion

3.6.1. Demographic characteristics and work experience of staff in the phytosanitary system of Malawi

Majority of the respondents were males with an education qualification of diploma and work experience of 0-10 years in the Malawi NPPO. Most staff in the field of agriculture were men compared to women across all the organizations. These findings concur with Westeberg (2012) who found that males were the majority and had a higher level of education compared to the females in Malawi. This may be attributed to power differences among men and women which makes it a factor for men to excel in their careers (Mudege *et al*., 2017). Most girls in Malawi are at a disadvantage due to child bearing, long distances to school, early marriages and safety which lowers school attendance level in the agriculture sector. Child bearing in most countries interfere with education which leads to career interruptions this affects the woman's professional qualification and work experience in the phytosanitary system (Word Bank, 2011). According to Kahn *et al*. (2014) women achieve less when they have or plan to raise children due to factors such as cutting short their education, dropping out of the labor force for an extended period, cutting back to part-time employment. This influence them choosing occupations that are more family friendly, devote less effort on the job, or pass up promotions as those in the agriculture sector especially in the phytosanitary system are busy scheduled.

3.6.2 Staff positions in the phytosanitary system of Malawi

Majority of the staff from different organizations were laboratory technicians and scientists. Similar studies carried out by Rigod (2013), Melo *et al.,* (2014) and Wagner (2017) show that different staff positions exist among the Phytosanitary regulatory bodies in WTO-SPS member countries. This is because the phytosanitary management system in each organization requires adequate support and these positions provide overall research capacity in plant health related disciplines. Technical assistance given by donor countries such as the United States government, has helped developing countries to build their SPS regulatory infrastructure through trainings that facilitate staffing positions hence meet their international obligations and facilitate trade in agricultural products (Jouanjean, 2013).

Laruelle and Peyrous (2012) found out that the different positions exists because the phytosanitary management system involves different staff in their organizations who have different mandates that ensure good collaboration among the organizations. The different positions in phytosanitary system have several benefits in Malawi (Rigod, 2013). Among these benefits includes the incorporation of science disciplines which contribute to the formulation of agreements of the SPS measures.

3.6.3 Border agencies cooperating with phytosanitary system of Malawi

The current study shows that the most influential border agencies that cooperate with the Phytosanitary system include the Malawi Revenue Authority, Malawi immigration services, Malawi police and the Fiscal police. These findings are in agreement with Mclinden *et al.* (2011) who reported that different border agencies offer services that are effective, transparent and customer friendly in most WTO-SPS member countries. This is a key commitment in the WTO-SPS standards for they play a role in facilitation of trade and pests control. The findings clarify that in addition to the customs, government agencies play a role of sharing the responsibilities of regulating and controlling imports, export and transit commercial goods and they have to conform to the acts and regulations.

The current findings suggest there is cooperation between organizations and agencies in Malawi borders as they offer services that are effective, transparent and customer friendly in the borders. This is achieved through cooperation as one of the key commitments that are included in the WTO-SPS standards on trade facilitation. According to Laruelle and Peyrouse (2012) study, there was cooperation among most border agencies in most WTO-SPS member countries. The study further elaborated that cooperation among border agencies is the best as it addresses the requirements for interaction, sharing of responsibilities and a good communication. It expand to various areas such as collecting and exchange of information, risk management and monitoring compliance in WTO/SPS member countries. At the national level, the agency play a role in co-operation which has facilitated the co-ordination of interventions, integration of risk management as well as in sharing of facilities and equipment. Border agencies have the mandate to facilitate the co-operation with the neighboring countries and cross border customs.

These results contradict with those of Khanderia (2015) who in his study found out that in most developed countries, there is no involvement of several oriented agencies to conduct WTO-SPS activities at the border. According to his study, several border agencies in different offices delay the trading process at the borders and suggested that a single window facility be introduced such that these agencies are situated within one office for facilitating the entire process.

3.6.4 Organizations involved in phytosanitary inspection activities

Majority of the inspection activities were carried out by NPPO staff. According to Khanderia (2015), most WTO-SPS member countries in southern Africa have available authorities that are engaged in reforming the Phytosanitary system.

Other studies by Doherty (2010) found that most phytosanitary system organizations in developing countries own competent authorities. It assures proper application of SPS measures in food safety, animal health and plant protection rules as they relate to international agricultural trade in the government and public organizations. The study however, contradicts with that of Lin (2010) who found out that authority in phytosanitary organizations in most European countries help in institutional coordination. This is achieved by assessing the degree co-ordination and consensus to build capacity among the government departments and agencies that are involved in policy formulation and implementation for trade.

3.6.5 Volume of cross-border maize trade in Malawi for 2017/2018 season

The largest amount of maize fleeting through the border was from imported maize unlike the exported and in transit. The imported and exported maize was reported to be handled by the Malawi Bureau of Standards and the National Plant Protection Organisation staff respectively. According to Netshifhefhe (2017) Nankhumwa (2014) and Govereh (2010) adverse weather conditions such as drought and El Niño and pest infestations such as fall army worm contribute to food crisis. They affect the seasonal production of crops which results to fluctuations and unavailability of the season crops. This results in to a country that relies on the importation of maize hence affecting phytosanitary capacity as most of the imported maize lack compliance to SPS rules and regulations. Findings by Myers (2008) reported that, intermarriages, insufficient land and border sharing between neghbourling countries is among other factors that have attributed much of formal and informal cross-border trade in most African countries. This in affecting phytosanitary capacity as most of the imported agricultural products lack compliance to SPS rules and regulations due to importation and exportation without proper documents.

3.6.6 Origin and destination of cross- border maize trade in Malawi for the season 2017/2018

The current study shows that majority of the imported maize originated from Mozambique followed closely by Tanzania and Zambia. Most of the maize in transit originated from Tanzania. The imported, exported and in transit maize varied for different destinations. Majority of the maize was destined for markets followed closely by consumption. The current finding agrees with Jayne *et al*. (2010) who found out that there are formal and informal maize imports in Malawi from regional neighbors. The imports tend to be relatively high in drought years and low in good production seasons. The seasonality therefore affects compliance of SPS standards since in drought conditions, it is very rare to comply unlike in good production season. The neighboring countries of Mozambique, Zambia and Tanzania are the major suppliers of maize to Malawi especially in the bordering regions and is destined for sale or consumption. The current study also agrees with findings of Nakhumwa and Teddie (2014) who found out that formal and informal cross-border trading in agriculture has been happening between Malawi and neighbors for a long period of time. This is very significant to local, national and regional economy as it acts as a source of income and food security in times of maize shortage. However, the informal importation poses high risk of transmitting regulated and non-regulated pests since the agricultural products are imported without legal document and being inspected.

The current study suggests that imports of maize are important in Malawi and have been happening in most times of the year especially during periods of peak food imports. The results are in agreement with Gabre-Madhin *et al.* (2001) who reported that the importation of maize occurs throughout the year especially during periods of peak. Majority of the imported maize usually originates from the neighboring countries mainly from Mozambique since a larger portion of Malawi borders are shared with Mozambique and most of the borders are unmanned. This contributes to challenges in implementing SPS issues since the importation of the agricultural products is not properly monitored. Most of the maize importation are concentrated in the second half of the year, from the month of July to December where the maize accounts for the largest share in total per capita calorie intake in the country. Intermarriages and insufficient land for cultivation attributes to the importation of maize from bordering regions especially in Mozambique. The findings are consistent with Jayne *et al*. (2010) who found out that intermarriages and inadequate land for cultivation in bordering regions of most African countries influences the cultivation of land across bordering regions. These also contributes to challenge to compliance with SPS documents during importation at harvest.

3.6.7 Phytosanitary facilities used by different organizations

The results indicated that government-based organizations NPPO and NBS had inadequate Phytosanitary facilities compared to the private organizations. The study findings agree with Spreij (2010) who found out that most developing countries in Africa have scanty SPS resources in most public and private organizations. Due to this inadequacy, developing countries are disadvantaged in assessing the scientific justification that other countries offer for their SPS standards as well as being locked out from the export market. Frick and Chapman (2017) similarly found out that most developing countries lack appropriate technical resources that help in the implementation of the Phytosanitary standards. The scanty resources, contribute to the lack of compliance to the conformity assessment test carried out according to international standards. Insufficient phytosanitary facilities experienced by most countries, limits them from meeting the proper WTO-SPS requirements for importing and exporting markets (Murina *et al*., 2014).

These research results can be compared to those of Msiska (2013) and WTO (2005) who found out that most government organizations depend solely on government funding to run their phytosanitary activities. This funding is unreliable due to the reallocation of funds, insufficient funds, shift in the government regime policies that negatively affect the implementation of phytosanitary programs. However, the non-governmental organizations secure significant investment for improved services and infrastructure from their donors.

3.6.8 Phytosanitary training in related disciplines for staff in the organizations

Most of the courses offered in Phytosanitary disciplines were attended by the staff from the government regulatory organizations (NPPO, Malawi Bureau of Standards and the Ministry of tourism, Trade and Industry) with the NPPO having the highest attendance. However, there were courses that neither of the organizations attended.

In the current study, it was noted that human resource for developing and implementing Sanitary and Phytosanitary measures are limited in Malawi due to lack of expertise in the Phytosanitary system. According to WTO (2005) human resource and expertise for developing and implementing Sanitary and Phytosanitary measures are limited in most developing countries. This makes it difficult for the countries to contribute to the scientific justification for SPS requirements. The results are comparable to those of Chapman (2017) and Stoler (2011) who found out that in most developing countries, there is insufficient knowledge on the importance of facilities that create awareness of Sanitary and Phytosanitary measures. This had led to failure in compliance with the Sanitary and Phytosanitary measures among government and non-governmental organizations. Inadequate awareness prohibits the resource allocation for the implementation of Sanitary and Phytosanitary activities required by the WTO-SPS standards.

The current findings suggest that this limited human resource in Malawi has been attributed to lack of awareness in technical assistance and capacity building. The findings are consistent to those of Day *et al.* (2006) who found out that insufficient Phytosanitary capacity through the different Phytosanitary disciplines among the various stake holders negatively affects the implementation of the IPPC and associated standards.

3.6.9 Sources of funding, laws and regulations supporting the Phytosanitary system of Malawi

According to FAO (2002) and WTO (2005) Sanitary and Phytosanitary Measures agreement for all WTO-SPS member countries is based on the funds, laws and regulations. The sources of funds required to support the Phytosanitary system differed between the private and government organizations. In both organizations, institutional laws were used to assist in the operation of their activities but differed with and among each other. The current findings show that private organizations relied on donors whereas the government organizations relied on both for their funds. Additionally, few of the government and private organizations had their own sources of funding. This in line to the findings of FAO (2002) that government organizations in developing countries depend on both government and donor funding to run their phytosanitary activities.

These findings also agrees with those of Scott (2005) who reported that the European Union (EU) provides support to developing countries, through development aid to improve Sanitary and Phytosanitary systems. As the world’s largest importer of food products from developing countries, EU’s assistance has brought mutual benefits to most developing countries. It helps developing countries with SPS-related technical assistance especially for small-scale producers. Assistance is also geared towards improving governance and meeting international standards. This helps countries take better advantage of trade opportunities and contribute to the development of the standards as the basis of SPS measures in laws and regulations. The government organizations are mandated to perform Phytosanitary activities under government guidance in most WTO-SPS member countries. Through acts such as the Seed Act and Plant Protection Act these are mandated to provide the rules and regulations for proper importation and exportation of agricultural products into Malawi.

CHAPTER FOUR

PESTS AFFECTING IMPORTED MAIZE ACROSS THE MALAWI BORDERS

4.1 Abstract

Cross-border trade is one of the major factors that puts maize at risk as it creates pathways for spread of different maize pests in Malawi. This study was carried out to identify pests associated with imported maize in order to improve the available phytosanitary measures with a purpose of reducing the introduction of pests in Malawi. Maize samples were randomly collected in border parts and were replicated four. The presence of pests were assessed through visual observation before and after incubation for 30 days. There were no significant differences in the population of insect pests before incubation in all the surveyed districts. Significant differences were observed after incubation for larger grain borer and common maize weevil. The largest average amount (1.5) of living larger grain borer insect pests was reported in Karonga and the least in Mzuzu. On the other hand, for maize weevil, the largest average amount (3.7) infestation was reported in Nkhatabay while the least was observed in Lilongwe district. Common fungal pathogens isolated include *Fusarium* (70%) *Aspergillus* (29%) and *Penicillium* (1%). The highest number of kernel infection with *Fusarium* was recorded in Dedza and Lilongwe while for *Aspergillus* was in Mzuzu. The *Aspergillus* spp isolated were *A. niger* (29%), *A. flavus* (22%) and *A. parasiticus* (5%) while *Fusarium* spp isolated was *Fusarium verticilloides.* The study provided the status and causes of storage losses by various pests on maize and consequently recommended the improvement of the Phytosanitary management system. This can be achieved through human and infrastructure capacity building, strictness of compliance with importation laws, regulations and improve funding in the Phytosanitary organizations.

Key words: *Aspergillus*, grain storage, consignment, sanitary and phytosanitary measures,

4.2 Introduction

In maize, pests cause significant crop losses worldwide and are barriers to the achievement of global food security and poverty reduction (Tago *et al.,* 2014). According to Jimma *et al*. (2016) more than sixty diseases and a number of insect species of affect maize worldwide. Global trade and exchange has contributed to the dispersal of many pests into different regions of the world where they previously did not exist (Sundström *et al*., 2014). Larger grain borer is a well-known destructive pest that is causing major losses in post-harvest in many African countries (Tefera *et al*., 2011b). According to Murayama *et al*. (2017) Malawi currently loses about 40-100% due to larger grain borer. Other common destructive storage insect's pests that affect maize grain and are regulated pests include common maize weevil, grain moth and flour beetle.

Fungal pathogens are among the sixty diseases that affect maize. Ranked second after insects, fungi are among the principal factors that lead to deterioration, poor quality and yield loss on farmer's maize during the germination, growth and storage period (Tsedaley and Adugna, 2016). Common storage fungal pathogens in maize include *Aspergillus, Fusarium* and *Penicillium* which are the most predominant species that attack maize (Odhiambo *et al*., 2013). *Aspergillus, Fusarium, Penicillium* species are known to produce mycotoxins and toxic metabolites. According to Tsedaley and Adugna (2016) when the pathogens are transmitted in maize seed, quality and viability is reduced. These fungal pathogens cause significant plant diseases such as seed rot, seedling blight, Bipolaris leaf spot and Curvularia leaf spot.

According to Odhiambo *et al.* (2013) fungal pathogens in maize not only reduce maize yield but affect germination, storage and quality, with a potential of affecting trade, human and animal life. He further states that, health problems may arise through consuming mycotoxin-contaminated maize. Fungi associated with grain at storage may cause seed deterioration and affect the germination of seed when sown. Development of fungi can be affected by moisture content of the maize, temperature, storage time and degree of fungal contamination prior to storage. Some insects and mites whenever present in the maize grain, their activities facilitate fungal dissemination.

4.3 Materials and Methods

4.3.1 Sample collection and the experimental design and layout

The maize grain samples were collected from the Central, Northern and Southern regions of Malawi, border entry points Dedza, Mchinji, Nkhatabay, Songwe, Muloza and Chiponde as well as the major cities in the regions Mzuzu, Lilongwe and Blantyre. A total of forty five maize samples were collected different times from each site. The samples of the maize kernels were used to identify living pests and fungal pathogens that were present during the importation of the maize. Sampling was done randomly and replicated four times. Complete Randomized Design (CRD) was used as the layout design in the laboratory to identify live pests and fungal pathogens.

4.4 Identification of insect pests in the maize samples and other grain contaminants

Four replications of one hundred kernels from each sample was used in the identification of insect pests and other grain contaminants (Sserumaga *et al.,* 2015). The glass jars were cleaned and disinfected with 3% of sodium hypochlorite before incubation. Using a magnifying glass, from each 100 kernels data was collected on damaged kernels at incubation, number of kernels with holes, number of kernels with moulds, number of rotten kernels and total number of grain contaminants. Data on living pests such as larger grain borer, common maize weevil, grain moth and flour beetle were also recorded. This included the total number of living pests, total number of dead pests and total number of the available pests present. After incubating the samples for 30 days at room temperature, the same data was corrected. Percentage infection of damaged kernels was calculated as follows (Sserumaga *et al.*, 2015)

$$\text{Damaged grain (\%)} = \frac{\text{Number of damaged grain X 100}}{\text{Total number of grain observed}}$$

4.5 Determination of fungal pathogens in the imported maize

4.5.1. Determination of *Aspergillus* species and other fungal pathogens in the maize kernels

The procedure involved the use of light plastic sandwich boxes (1,850 ml) which were initially sterilized in 99.9% ethanol and allowed to evaporate. One hundred kernels collected from each district were replicated thrice. The kernels were surface sterilized in sodium hypochlorite at a concentration of 2.5% for three minutes and rinsed in sterile distilled water in three consecutive petri dishes. The kernels were transferred into sandwich boxes lined with moistened three absorbent paper towel and sterilized in UV Light for 15 minutes (Marcos, 2015). The boxes were covered with plastic lids and incubated for 24 hours. To suppress the kernels germination the boxes were kept in the deep freezer (-20^{o}C) for six hours. Later the sandwich boxes were incubated at room temperature (25±1^{0}C) for period of seven days as described by Waliyar *et al.*, 2016. Number for infection of the seeds was assessed as suggested by (Carrol and Carrol, 1978) and the incidence each fungi species such as *Aspergillus*, *Fusarium* and *Penicillium* was calculated as follows:

$$\%\ \text{Infected kernel} = \frac{\text{No.of kernels infected by fungal sp}}{\text{Total number of kernels in each plate}}\ \text{x100}$$

Fungal identification was based on macro morphological characteristics such as surface of the colonies, texture and micro morphological characteristics like conidia head, shape and vesicle as used by Adithya *et al.*, 2017. Fungal growth colonies on the kernels were visualized using stereo-binocular microscope and identified to genus level.

4.5.2. Determination of Colony Forming Units (CFU) by *Aspergillus* and other fungi species in the maize kernels

The serial dilution technique was used to determine the Colony Forming Units (CFU) of fungal species in the maize kernels (Marcos, 2015). The kernels were surface sterilized for three minutes with sodium hypochlorite and rinsed with three changes of sterile distilled water and blended into fine powder. Ten grams of the milled powder was suspended in 90 ml distilled water and shaken for 30minutes with a mechanical shaker. Suspension of 1ml was transferred into 9ml of distilled water, vortexed and diluted into subsequent 9ml up to 10^{-4} dilution. Dilutions of 10^{-2}, 10^{-3} and 10^{-4} were plated in selective molten potato dextrose agar (PDA) media, gently swirled, mixed and incubated at 37^{o} C for 5-7 days as described by Dyer *et al.*, (1994). Each sample was replicated three times and growth was observed with the Jenko dissecting microscope at 2x-10x magnification Sibakwe *et al.*, (2017). Percentage infection of the milled powder from grain was assessed and the incidence each fungi species such as *Aspergillus*, *Fusarium* and *Penicillium* was calculated as follows:

Colony Forming Units was calculated using the formula by Kim and Eberwine, (2010)

$$CFU/g = A * 10^{n} / V$$

Where A = Number of colonies

10^{n} = Level of dilution at which counting was carried out

V = Volume of inoculation

4.6 Data Analysis

The data collected from assessed maize samples was subjected to Analysis of Variance (ANOVA) using GenStat software packages version 18.2 with sampling locations, treatments and samples as factors and measurements as variables. Means were separated using Tukey's Protected Least Significant Difference (LSD) test at 5% level of significance

4.7 Results

4.7.1 Insect pests infesting imported maize kernels

A wide range of insect pests were identified from the maize samples, These insect pests identified before and after incubation included the larger grain borer, maize weevils, grain month and flour beetle. There were no significant differences ($P<0.05$) in kernels infested by larger grain borer in all the sampled districts before incubation. After incubation, there was significant increase ($P<0.05$) in the number of living larger grain borer that infested the maize kernels. The greatest average number (1.5) of infestation of living larger grain borer was observed in samples from Karonga followed by Nkhatabay and Blantyre districts. The least population was recorded in samples from Mzuzu, Dedza and Mangochi. Similarly, there was a significant increase ($P<0.05$) for the total average number of available larger grain borer present in the maize samples after incubation. The greatest (4.6) infestation was observed in Karonga district while the least was observed in Dedza district (Table 4.1).

The population of common maize weevils did not differ significantly between the districts before incubation but significantly increased ($p<0.05$) after incubation. The population of living weevils significantly increased and the greatest amount (3.7) was observed in Nkhatabay followed closely by Karonga (3.6) whilst the least was recorded from Mzuzu districts (Table 4:2).

There were no significant variations in the population of grain moth and flour beetle before and after incubation for the different districts (Table 4.3 and Table 4.4).There were no significant differences in the number of living, dead and total grain moth (*Sitotroga cerealella*) in the imported maize kernels before and after incubation in all the districts. Similarly, there were no significant differences in the number of living, dead and available flour beetle (*Tribolium castaneum)* in the imported maize kernels before and after incubation.

Table 4.1: *Number of larger grain borer infesting imported maize before and after* Incubation

	Before incubation			After incubation		
District	Live(Nu)	Dead(Nu)	Total(Nu)	Live (Nu)	Dead(Nu)	Total(Nu)
Blantyre	0.4a	0.4a	0.8a	0.8ab	2.3a	3.1ab
Dedza	0.0a	0.0a	0.0a	0.1a	0.1a	0.2a
Karonga	0.2a	0.2a	0.4a	1.5b	3.1a	4.6b
Lilongwe	0.0a	0.2a	0.2a	0.5ab	1.9a	2.4ab
Mangochi	0.3a	0.1a	0.4a	0.1a	1.1a	1.2ab
Mchinji	0.1a	0.3a	0.4a	0.4ab	1.5a	1.9ab
Mulanje	0.2a	0.1a	0.3a	0.3ab	0.7a	1.0a
Mzuzu	0.3a	0.2a	0.5a	0.0a	2.1a	2.1ab
Nkhatabay	0.5a	0.3a	0.8a	1.00ab	0.9a	2.0ab
CV%	310.9	399.6	331.1	202.8	161.2	138.2
LSD (p<0.05)	0.5	0.5	0.7	0.8	1.9	2.1
F .Pr	0.571	0.852	0.562	0.002	0.177	0.023

Means were separated by Tukeys Protected Least Significance Difference (LSD) at p=≤0.05
Means followed by same letter(s) within columns are not significantly different. Sample size (100 grains)

Table 4.2: Number of common maize weevil infesting imported maize before and after incubation

	Before incubation			After incubation		
District	Live (Nu)	Dead(Nu)	Total(Nu)	Live(Nu)	Dead(Nu)	Total(Nu)
Blantyre	0.0a	0.0a	0.0a	2.4ab	0.3a	2.7a
Dedza	0.5a	0.3a	0.8a	1.7ab	0.5a	2.2a
Karonga	1.5a	0.4a	1.9a	3.6ab	0.7a	4.3a
Lilongwe	0.5a	0.1a	0.6a	0.7a	0.1a	0.8a
Mangochi	0.7a	0.1a	0.8a	1.9ab	0.3a	2.2a
Mchinji	0.3a	0.0a	0.3a	1.7ab	0.1a	1.8a
Mulanje	0.6a	0.1a	0.7a	1.7ab	0.1a	1.8a
Mzuzu	0.6a	0.2a	0.8a	1.1ab	0.1a	1.2a
Nkhatabay	0.7a	0.2a	1.0a	3.7b	0.3a	4.1a
CV%	253	342.3	239.7	124.4	233.2	122.9
LSD (p<0.05)	1.1	0.3	1.4	1.9	0.4	2.1
F .Pr	0.375	0.534	0.294	0.02	0.277	0.025

Means were separated by Tukeys Protected Least Significance Difference (LSD) at p=≤0.05Means followed by same letter(s) within columns are not significantly different. Sample size (100 grains)

Table 4.3: Number of grain moth (*Sitotroga cerealella*) infesting imported maize kernels

	Before incubation			After incubation		
District	Live(Nu)	Dead(Nu)	Total(Nu)	Live(Nu)	Dead(Nu)	Total(Nu)
Blantyre	0.3a	0.1a	0.4a	0.7a	0.3a	1.0a
Dedza	0.2a	0.1a	0.3a	0.4a	0.5a	0.9a
Karonga	0.1a	0.0a	0.1a	0.5a	0.1a	0.6a
Lilongwe	0.4a	0.1a	0.5a	0.4a	0.3a	0.7a
Mangochi	0.3a	0.1a	0.4a	0.5a	0.1a	0.6a
Mchinji	0.1a	0.1a	0.2a	0.4a	0.2a	0.6a
Mulanje	0.8a	0.3a	1.1a	0.9a	0.1a	1.1a
Mzuzu	0.1a	0.1a	0.2a	0.1a	0.1a	0.2a
Nkhatabay	0.5a	0.1a	0.6a	0.5a	0.1a	0.6a
Mean	0.3	0.5	0.4	0.5	0.2	0.7
CV%	264.4	378.3	313.3	268	289.6	252.4
LSD (p<0.05)%	0.6	0.3	0.8	0.9	0.4	1.3
F.pr	0.425	0.643	0.365	0.906	0.483	0.95

Means were separated by Tukeys Protected Least Significance Difference (LSD) at (P=≤0.05). Means followed by same letter(s) within columns are not significantly different, Sample size (100 grains)

Table 4.4: Number of flour beetle *(Tribolium castaneum)* infesting imported maize kernels

	Before incubation			After incubation		
District	Live(Nu)	Dead(Nu)	Total(Nu)	Live(Nu)	Dead(Nu)	Total(Nu)
Blantyre	0.1a	0.0a	0.1a	0.2a	0.0a	0.2a
Dedza	0.6a	0.2a	0.5a	0.9a	0.0a	0.9a
Karonga	0.1a	0.1a	0.1a	0.1a	0.1a	0.2a
Lilongwe	0.2a	0.0a	0.2a	0.5a	0.0a	0.5a
Mangochi	0.1a	0.0a	0.1a	0.0a	0.0a	0.0a
Mchinji	0.2a	0.0a	0.2a	0.1a	0.0a	0.1a
Mulanje	0.1a	0.0a	0.1a	0.0a	0.0a	0.0a
Mzuzu	0.3a	0.1a	0.3a	0.3a	0.0a	0.3a
Nkhatabay	0.1a	0.0a	0.1a	0.1a	0.0a	0.1a
Mean	0.2	0.1	0.1	0.2	0	0.3
CV%	308.9	602.1	337.2	337.2	1161.9	336.1
LSD (p<0.05)%	0.4	0.2	0.4	0.6	0.1	0.6
F.pr	0.147	0.212	0.43	0.101	0.439	0.131

Means were separated by Tukeys Protected Least Significance Difference (LSD) at p=≤0.05 Means followed by same letter(s) within columns are not significantly different, sample size (100grains)

4.7.2 Damaged kernels before and after incubation of the imported maize

There were significant variations in the number of damaged kernels for the imported maize before and after incubation. Highly significant variations (P<0.05) in grain with holes and total number of damaged kernels were observed before and after incubation. No significant variations were observed for rotten grain and in grain contaminated with moulds before and after incubation (Table 4.5). The largest average number (2.9) of damaged kernels were from Blantyre followed by Karonga districts (0.7) and the least were Mangochi before incubation. Before incubation, Blantyre had the largest (4.1) number of total damaged grains while Mulanje had the least. Largest number of damaged kernel was observed in maize samples from Karonga (5.5) followed by Nkhatabay (2.5) while the least were from Lilongwe district after incubation. The largest total number of damaged kernels were from Karonga (10.6) followed by Nkhatabay (4.6) while the least were from Mulanje (Table 4.5).

Table 4.5: Number of damaged kernels before and after incubation for the imported kernels

	Before incubation				After incubation			
	Grain with holes	Grain with molds	Rotten grains	Total damaged grains	Grain with holes	Grin with molds	Rotten Grains	Total damaged grains
Blantyre	2.9b	0.3a	0.9a	4.1b	0.5a	1.2a	1.7a	3.4ab
Dedza	0.3a	0.5a	0.5a	1.3ab	1.4ab	0.5a	1.5a	3.4ab
Karonga	0.7a	0.5a	0.5a	3.4ab	5.5b	1.2a	3.9a	10.6b
Lilongwe	0.1a	0.3a	0.7a	1.1a	0.2a	0.6a	1.5a	2.3a
Mangochi	0.5a	0.2a	0.1a	0.8a	0.4a	0.3a	1.8a	2.5a
Mchinji	0.5a	0.7a	0.0a	1.2a	0.7a	1.3a	0.6a	2.6a
Mulanje	0.0a	0.0a	0.0a	0.0a	0.7a	0.0a	0.9a	1.6a
Mzuzu	0.2a	0.4a	0.7a	1.3ab	0.8a	0.5a	1.3a	2.6a
Nkhatabay	0.5a	0.7a	0.3a	1.5ab	2.5ab	1.2a	0.9a	4.6ab
CV%	291.0	347.3	286.6	169.4	262.2	304.4	197.7	178.6
LSD ($p<0.05$)%	1.293	1.004	0.859	1.8	2.6	1.7	2.2	4.8
F.pr	<.001	0.878	0.356	0.004	0.003	0.766	0.167	0.015

Key: Treatments with different letters are significantly different @ p<0.05, Means were separated by Tukeys protected LSD – Least, significance different @ 5% confidence, g /holes=grain with holes, g/mlds=grain with moulds, g/rotten=grains rotten, Ttl dgd ken=Total damaged Kernels, Sample size (100grains)

4.7.3 Identified fungal pathogens affecting kernels in the districts

Mycological analysis of the maize samples showed a wide range of different fungal pathogens that affected the kernels from each district. The common fungal pathogens identified during direct plating and serial dilution included *Aspergillus* species such as *A. flavus, A. niger, A. parasiticus* and other fungal pathogens which were *F. verticilloides* and *Penicillium* (Figure 4.1).

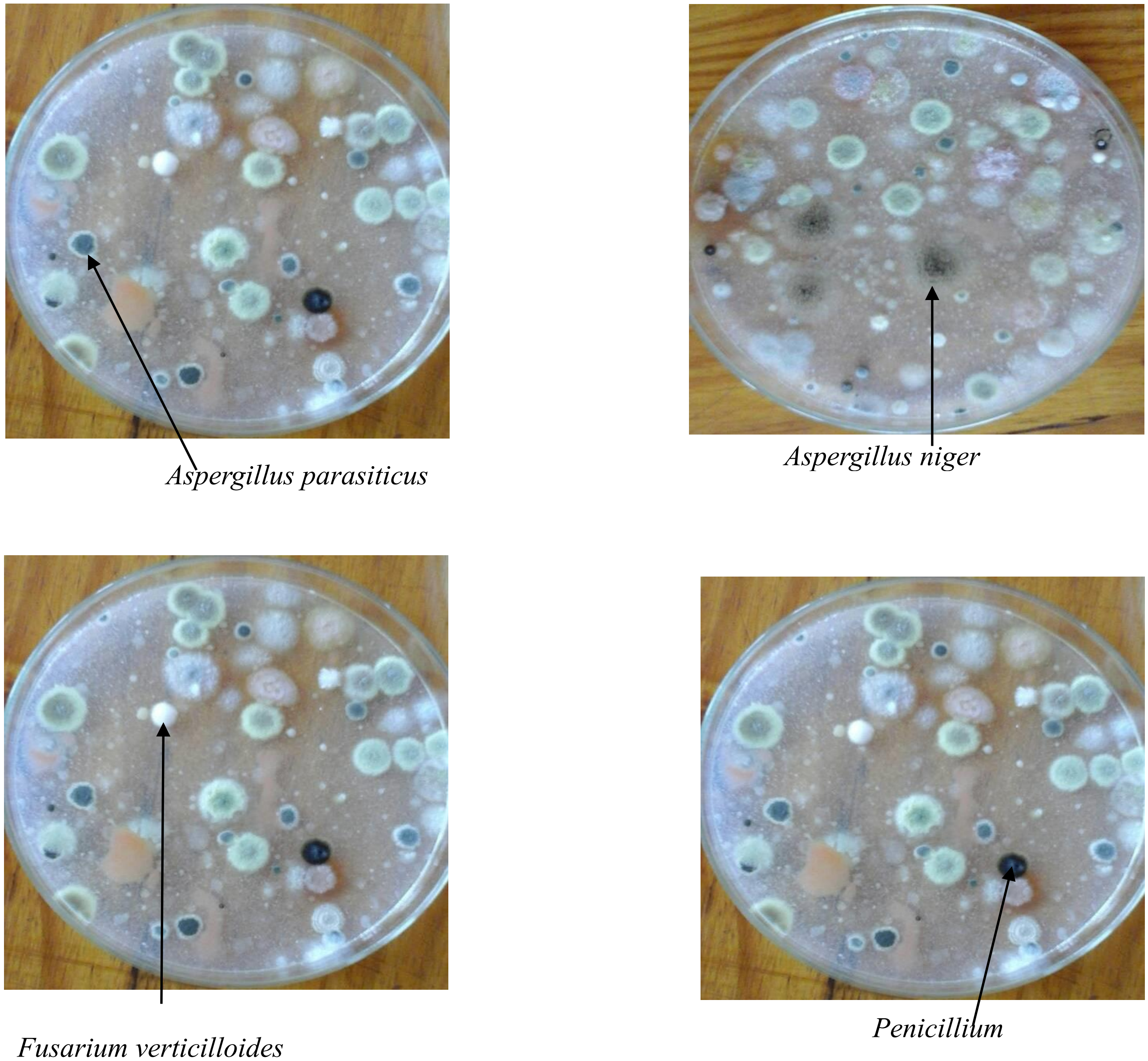

Figure 4.1: Different Aspergillus colonies and other fungal species from imported maize observed at Chitedze laboratory

The total kernel infection by different fungal pathogens varied significantly ($P<0.05$) from among the districts (Table 4.6). The kernels with largest (95.89) fungal contamination were from Mzuzu followed closely (81.79) by Dedza, while the least were from Nkhatabay. Significant differences ($p<0.05$) of kernels infected with *Aspergillus flavus, Aspergillus niger* and *Fusarium* were observed across the different districts. The largest number of kernels affected with *A. flavus* were from Mzuzu (4.2) followed by Nkhatabay (3.5) and the least in Mchinji. The largest number (36.7) of kernels infected by *A. niger* were from Mzuzu, followed by Mangochi (25.8) and the least from Lilongwe. The largest number (62.5) for kernels infected with *Fusarium* was from Dedza and Lilongwe while Mchinji had the least. However, no significant differences was noted in kernels infected with *Aspergillus parasiticus* and *Penicillium* species (Table 4.6).

Table 4.6*:* Number of imported maize kernel infected with different fungal species:

District	*A.flavus*	*A.niger*	*A.parasiticus*	*Fusarium*	*Penicillium*	Total of infect. Kernels
Blantyre	0.6a	20.2cd	0.2a	45.3ab	0.2a	66.56ab
Dedza	0.9a	16.9bcd	1.1a	62.5b	0.1a	81.57bc
Karonga	2.9abc	14.8bc	0.2a	53.8ab	0.2a	71.88b
Lilongwe	1.7ab	6.3ab	0. 9a	61.5b	0.3a	70.71ab
Mangochi	0.7a	25.8de	1.1a	45.3ab	0.1a	73.02b
Mchinji	0.4a	21.7cd	0.8a	40.7a	0.1a	63.69ab
Mulanje	1.3ab	23.5cd	0.9a	47.9ab	0.2a	73.78b
Mzuzu	4.2c	36.7e	0.3a	54.7ab	0.0a	95.89c
Nkhatabay	3.5bc	0.00a	0.4a	46.1ab	0.0a	49.96a
CV	121.9	51.5	142.0	34.1	323.9	121.9
LSD (p<0.05)	1.580	6.861	0.6873	12.55	0.3311	1.580
F pr.	<.001	<.001	0.014	0.005	0.722	<.001

Treatments with different letters are significantly difference @ p<0.05. Means were separated by Tukeys protected LSD -Least significance difference @ 5% confidence

The number of colony forming units that were observed during the mycological analysis differed across the districts. Significant differences (P<0.05) were observed in the number of colony forming units of *A. flavus*, *A. niger*, *A. parasiticus* and *Fusarium* (Table 4.7). However, no significant differences were observed in percentage of colony forming units of *Penicillium* species. The largest colony forming units of *A. flavus* (1,022) were from Nkhatabay while the least were observed in Mchinji. Dedza had the largest number of colony forming units of *Aspergillus niger* (768) *and Aspergillus parasiticus* (1,297) while Nkhatabay had the least. The number of colony forming units of *Fusarium* species was largest in Karonga (1,454.7) followed by Mchinji (917) while the least were from Blantyre district. There were no significant differences in the total colony forming units among the districts.

Table 4.7: Number of colony forming units of different Aspergillus species and other fungal Pathogens

District	*A.flavus*	*A.niger*	*A.parasiticus*	*Penicillium.*	*Fusarium*	Total C.F.U
Blantyre	847bc	246ab	436ab	18.3a	244.5a	1790.a
Dedza	104a	768c	1297b	23.3a	313.5a	2506 a
Karonga	418ab	213ab	249ab	34.9a	1454.7b	2370 a
Lilongwe	442ab	475bc	132ab	2.3a	617.5ab	1670a
Mangochi	692abc	321abc	175ab	15.7a	501.6a	1705a
Mchinji	101a	364abc	998ab	80.9a	917.4ab	2461a
Mulanje	415ab	464bc	61a	34.5a	604ab	1579a
Mzuzu	222a	367abc	151ab	84.9a	551.0a	1377a
Nkhatabay	1022c	0.0a	529ab	10.7a	782.5ab	2344a
CV%	192.4	111.3	230.4	284.3	115.2	85.0
LSD (p<0.05)%	658.7	287.7	745.1	69.69	553.6	1214.6
F pr.	0.068	<.001	0.011	0.195	0.002	0.431

Treatments with different letters are significantly different @ p<0.05, Means followed by same letter(s) within columns are not significantly different, Means were separated by Tukeys protected LSD -List significance different @ 5% confidence, C.V= Coefficient variation, C.F.U Total: Total of colonies available in maize samples

4.8. Discussion

4.8.1 Insect pests infesting maize kernels

Insect pests of quarantine importance observed in the samples of imported maize include larger grain borer, common maize weevil, grain moth and flour beetle. The results showed that the population of these pests increased after incubation. The results concurs with Tefera *et al*., (2011a) who found that there was an increase of population of larger grain borer and common maize weevil in the maize samples due to favorable storage environment. The storage methods can increase the population of living larger grain borer and common maize weevil. These storage facilities especially when unsealed create a favorable environment as carrier of larvae, eggs, breeding and multiplication of the pests of phytosanitary importance because they have an easy entry and exit loophole. According to Khakata (2018) genetic nature of maize increases the population of living larger grain borer and common maize weevil in storage. This is attributed to the nature of the pericarp which tends to be very soft and is easily attacked by the insect pests. Temperatures of 27^{o}C -32^{o}C and 38^{o} C increases the population of maize pests at storage (Tefera *et al.,* 2011b). Additionally, when untreated maize is stored, the population of common maize weevil and larger grain borer increases. This is because untreated maize is more prone to insects' damage and favors their development unlike the treated maize (Suleiman *et al.*, 2016). The condition of the maize at harvesting contributes to the increase in the population of maize storage pests (Tefera *et al*., 2011b). For long-term storage and trade, mature, good-quality and low moisture level maize grain should be used.

The current study contradicts the findings of Bell (2014) who observed that the population of the larger grain borer and common maize weevil decreased with storage. The author explained that this was attributed mainly attributed to the resistance as natural characteristics of the maize grain.

This resistance is due to the kernel hardness, diphenolic acids and phenolic acid content in maize which is associated with insect resistance Bell (2014).

The population of grain moth and flour beetle was not affected when the maize grain was incubated. Different relative humidity affect the population of grain moth and flour beetle (Tefera *et al.*, 2011a; CABI, 2011; Uke and Udo, 2008). The humidity affects the duration of the egg stage, oviposition and pre-oviposition stages of the pests. According to CABI (2011), the ideal conditions for the development of each stage (3 days for the eggs, 16 days for the larvae and 5 days for the pupae) are 35^{o} C and 60-80 % relative humidity. Additionally, low temperatures limit the multiplication of grain moth and flour beetle in stored maize grain. Secondly, the lifecycles of the pests may affect the buildup of the pests (Tripath, 2018). The grain moth and flour beetle larvae complete their development inside a single damaged grain. Therefore it is not visible externally until the late stages of the infestation when translucent windows appear in the grain when the larva emerges out from the chamber beneath the surface of the grain.

4.8.2 Damaged kernels at incubation for the imported Maize

The current study shows that damaged maize kernels were observed to increase after incubation. These findings are in agreement with earlier work of Bell (2014) who found out that maize grain in most African countries is exposed to insect pest attack in the field, at harvest and storage. Storage pests like the larger grain borer, common maize weevil, flour beetle and grain moth damage the maize kernel when the larvae bore into the grain, during egg-hatching or larvae and adult emergence. The presence of the insects affect trade as they contribute to decrease in the quantity and quality of the maize grain in stored. These pests occur in storage as a result of high temperatures and humidity and their ability to tolerate dry conditions and this allows them to develop fully and rapidly thus increasing the chances of making holes (Tefera *et al*., 2011a). Additionally, the inadequate use of pesticides by farmers due to low technical expertise leads to the storage of untreated seeds which are prone to pest damage. Unsafe storage conditions increases the chances of grain damage (Befikadu, 2014). Storage structures used by most farmers are traditional and poorly constructed. This exposes the stored grains to different deterioration agents or conditions hence contributing to SPS issues of concern.

4.8.3 Identified fungal pathogens in the maize samples

Mycological analysis of the maize samples showed the presence of fungal pathogens namely *A. flavus*, *A. niger*, *A. parasiticus*, *Penicillium* and *Fusarium* spp. Among these pathogens, species *Fusarium* was the most predominant while *Penicillium* was the least. These fungal pathogens differed in the infestation level that affected the kernels across the districts. Mannaa (2017) and Jimma *et al.* (2016) also found that fungal contamination in cereal grains is very common. Nyasetia (2015) and Ozay *et al*. (2008) identified that *Fusarium* spp. and other fungi infection had contaminated the maize and hazel nuts kernels in storage. A research carried out by Tsedaley and Adugna (2016) showed that the most predominant fungal species isolated from maize kernels belonged to *Fusarium* spp.

The fungal contamination is mainly attributed to pre-harvest and post-harvest stages. At pre - harvest stage the fungal development are governed mainly by interactions with host plants, genotype, soil types, and biological factors. At the postharvest stage, fungal growth and development are governed by the substrate status, environmental factors, and biotic factors. The grain type and condition, environment, and biological factors can also influence the occurrence and predominance of mycotoxigenic fungi in stored grains.

The presence of fungal pathogens is influenced by the percentage of the available damaged kernels, presence of foreign matter and impurities, presence of microorganisms, insects and mites, period of storage, grain moisture content, the relative humidity, storage atmosphere, and length of storage (Nyasetia, 2015; Ozay *et al*., 2008). As a result of these conditions, the maize kernels lose mass, volume and strength and also experience nutritional degradation, discoloration, development of unpleasant odors, heat and chemical changes. Late harvesting has also attributes to high fungal population levels and other fungi infection in maize. The findings agree with Wanjiku (2016) who found out that the primary cause of fungal contamination for the stored maize was due to late harvesting.

According to Suleiman *et al*. (2015) when the maize is stored while relatively moist and warm; may lead to rapid deterioration of the grains and promote the growth of microorganisms. They also report that in tropical and subtropical countries, a large proportion of the grain is harvested and stored under hot and humid conditions and most farmers lack proper knowledge, equipment and methods of drying grains. Subsequently, since maize is hygroscopic in nature tends to absorb or release moisture. Exposure to moist and humid conditions during storage will cause the kernel to absorb water from the surroundings leading to increased maize moisture content, which result in enhanced deterioration.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

The data collected showed that the available phytosanitary facilities required to implement the phytosanitary activities and manage maize pests are lacking. Secondly, the laboratories, equipment's and financial support is not only quite low but unavailable. Additionally, the borders are not manned effectively due to inadequate staff who are unskilled in most of the phytosanitary disciplines. This creates loop holes for the entry of maize into the country without being inspected hence increasing the likelihood of regulated and non-regulated pests gaining entry into Malawi.

The study also shows that both maize insect pests and fungal pathogens are associated with maize imported into Malawi. The regulated pests included the larger grain borer and common maize weevil while the intermediate pest identified was the grain moth and flour beetle. Common fungal pathogens identified that are non-regulated include *A. flavus*, *A. niger*, *A. parasiticus, Penicillium* and *Fusarium.*

The maize kernels from cities in the Northern and Southern regions of Malawi had the largest infestation of living pests and total damaged kernels. Karonga had the largest amount of living LGB, total damaged kernels and grains with holes. Maize kernels from Nkhatabay had the largest infestation of maize weevil while those from Blantyre had the highest damage after incubation. Fungal infestation of maize kernels was largest in cities from Northern and Central regions of Malawi. The largest number of species of *Aspergillus* was isolated from kernels obtained from Mzuzu while *Fusarium* species were isolated from kernels obtained from Lilongwe and Dedza.

The presence of these pests is a reason for concern because most of these affect maize at storage which reduces quality and quantity. The pests also play a role as trade barriers in the region and are also issues of SPS concern. The presence of *Aspergillus, Penicilium* and *Fusarium* fungal pathogens in maize kernels may pose a threat to food safety. This is because they are producers of major mycotoxins which have adverse effects to animal and human health. The results from this research therefore will assist in the improvement of the effectiveness of the Malawi's phytosanitary system. Thus more initiatives that are scientific will come in and possibly improve the old management system through the awareness this research has created and the gaps that have been identified.

5.2 Recommendations

i. There is need to enhance the phytosanitary capacity of Malawi through improved collaboration among government, international and private institutions with regard to maize trade and other phytosanitary issues.
ii. There is need for the Malawi government to increase funding and improve the available facilities along the borders so that pests can be identified before a consignment is allowed entry into the country.
iii. There is need for the establishment of standard operating procedures in the Malawi Plant Health Inspection Services (MAPHIS).

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APPENDIX 1: for the Malawi NPPO
Questionnaire one: Maize importation and capacity of Malawi's NPPO Plant Health inspectors/staff

This questionnaire has been designed to collect data on maize importation and capacity of Malawi NPPO and the plant health inspectors Phytosanitary regulatory system

The results will be used for postgraduate research study purposes only. The purpose of the research is to collect data on Malawi's effectiveness of cross-border Phytosanitary measures in control of maize pests in Malawi so that Malawi should comply with WTO SPS Measures.

***Questionnaire No.* ----** Date of interview / /2017/2018
Region Name: ______________________________
District Name: ______________________________
Name of respondent: ______________________________
Position of respondent: ______________________________
Border Name: ______________________________
Institution ______________________________
Department name: ______________________________

A.RESPONDENT PARTICULARS

1. Gender.

1. Male	2. Female

2. Education Level **(Mark the appropriate answer)**

1.M.S.C.E	2.Diploma	3.Degree	4.Masters	5. others

3. For how long have you been working as a plant health inspector? (Mark the appropriate answer

1. 0-10 years	2.10-20yrs	3.20-30years	4.30-40 years

B. ORGANIZATION AT BORDER

4. Do your duties or professional activities directly relate to? (Tick where appropriate)
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
□□Customs matters
□□Exporting

□ □Importing
□ □Phytosanitary regulatory inspections (horticulture and/or forestry)
□ □Fisheries
□ □Animal health
□ □Environmental matters
□ □Other Please specify __________

5.How many border agencies are there at the port at which you are based and which ones do you cooperate with? *Tick where appropriate*

	tick those at your order	tick those you cooperate with
Phytosanitary		
Environmental		
Fisheries		
Veterinary		
Marketing		
Forestry		
Immigration		
Customs		

6. Do you undertake inspections on imported or exported Maize? Yes/No

(a) If yes, for what purpose(s) do you inspect the maize? (Tick where appropriate)
□ □Tax/revenue
□ □Pests and diseases
□ □Food safety checks(Characteristics that pose hazard to the end user)
□ □Quality control (Characteristics that pose hazard to the end user)
□ □Meeting importing/exporting countries' Phytosanitary requirements
□ □Others (please specify): ______

7. Apart from inspection of imported and exported agricultural products at the border, What other Phytosanitary measures do you conduct?

□ □Diagnosis of pests in the laboratory
□ □Fumigation of agricultural products
□ □Inspection of agricultural fields
□ □Testing of imported agricultural products
□ □Others (please specify): ______

8. (a) Are there documented procedures related to your inspection activities? Yes/No

If yes, what are the documents checked?

□ □Import Permit

Phytosanitary Certificate
Fumigation certificate
Orange certificate
Others (please specify): __________

(b) If not, on what do you base your inspection procedures (tick as many as apply to you)?
Verbal instructions from DARS
Standard Operating Procedures from MBS
International guidelines
Directions from an exporter or importer
Instructions from an exporting or importing country's government
Others (please specify): __________

C. PEST STANDARDS IN MALAWI

9. (a) Does the Malawi NPPO have a national guidelines consistent with the international standard to establish pest free areas, place of production and pest free production site for specific pests which are known to occur within the country?
Yes/ No Comment for your answer…………………………………………………………….

If yes , List the pests declared in the following areas

Pests for which pest free areas have been declared.	**Pests in which pests free places of production have been declared**	**Pests free production sites that have been declared by the NPPO**

(b). Do you think there is a need to establish free places, areas and sites to protect other areas from established pest in other parts? **Yes/No.** If yes, list the pests below.
……………………………………………………………………………………………..

(c) Does the Malawi NPPO have the expertise to declare that an area meet all the requirements to be declared as a pest free area? **Yes/No**
(d) Does the NPPO have the resources and system manuals to monitor the establishment and maintenance of pest freedom and appropriate buffer zones**? Yes/no**
Give a reason/s for your answer
……………………………………………………………………………………………….
(e) Does the NPPO have procedures to monitor the establishment and maintenance for product identity and consignment integrity? **Yes/No**

D.MAIZE DATA AT YOUR BORDER
. Maize Imports
10. What are the imported quantities of the maize imports?

	A	**B**	**C**
High (>100mt/moth)			
Low(between 50 &100mt/moth)			
Medium (< 50mt/moth)			
Others specify			

11. What are the frequencies of the imported maize?

	A	**B**	**C**
High (once or more weeks)			
Low (once of more per moth)			
Medium (once or more after six moths**)**			

Others Specify:

12.For the imported maize specify the origin:

Country(ies) of origin

Grain ______________________________
Seed ______________________________

13. What is the destination/end use of these imports locally?

	A	**B**	**C**
Markets			
Private companies			
Transit			
Others specify			

14. Do the maize imported usually comply with the Malawian Phytosanitary import requirements?

Yes/No/Don't know
(a) If not, what has been the non-compliance?

	A	B	C
Improper documentation:			
Regulated pests			
Weeds			
Regulated Pathogens			
Others (specify)			

15. Have you ever intercepted any pests? Yes/No
(a) If yes, what action/ Phytosanitary measures did you take to the interception?
□□Collect samples for further laboratory analysis or identification
□□Re-export the consignment
□□Notify exporting country
□□Destruction of consignment
□□Re-sort and clear uncontaminated goods
Others (please specify)

16. Have you reported the interceptions of regulated pests? Yes/No
(a) If yes, where did you report the interceptions?
□□NPPO of the exporting country
□□The exporter
□□The importer
□□The NPPO of the importing country
Others (please specify): ________________

17. If no to Q. 9, please explain the circumstances in which you allow the maize to be imported? ---
----

Maize Export

18. Is maize exported outside Malawi? Yes/No

19. What are the exported quantities of the main exports?

	A	B	C
High (>100mt/moth			
Medium (between 50 &100mt/moth)			
Low (< 50mt/moth)			
Others (Please specify):			

20. What are the frequencies of the maize exported?

	A	B	C
High (once or more weeks)			
Low (once of more per moth)			
Medium (once or more after six moths**)**			

Others Specify:

21. For the exported maize, specify the destination country.

Country(ies) of Destination

Seeds ____________

Grain ____________

Others (please specify): ____________

22. Do the exported maize usually comply with the trading partners import requirements? Yes/No/Don’t know

(a) If not, what has been the main cause non-compliance?

	A	B	C
Improper documentation:			
Regulated pests			
Weeds			
Regulated Pathogens			
Others (specify)			

23. (a) Have you ever intercepted any pests during maize export(regulated and quarantine)? Yes/No

If yes, name the pests intercepted among this list

- Maize lethal necrosis
- Larger grain borer
- Maize weevils
- Rust
- Fall army worm
- Grain Moth
- Others (please specify): ___________

(b) What do you do when you intercept a pest?
□ □Collect samples for further laboratory analysis or identification
□ □Deny exit of the export by refusing to issue official documentation
□ □Detain the consignment for re-sorting and re-inspection
□ □Others (please specify): ___________

24. Have you reported the interceptions to the exporter or DARS? Yes/No
(a).What were the reasons for the interceptions?
□ □High moisture content
□ □Presence of pests
□ □Lack of required treatment
□ □Fraud
□ □Others (please specify): _________

(b) If yes, has there been any advice as to what action to take? Please specify
(c) If not, what is the reason for not reporting? Please specify

25. Do you have documents setting out the importing countries' Phytosanitary Requirements? Yes/No
(a) If yes, where were these sourced? _______________
(b) If not, how do you ensure compliance to their Phytosanitary requirements? _____

Maize on transits
26. Do Maize in transit Malawi pass through your border? and do you conduct Inspection on transits? Yes/No
(a) If yes, do you inspect for?
□ □Documentation
□ □Pests
□ □Quality
□ □Others (please specify): _________

27. What are the countries of destination for the plants and plant products?

	Country(ies) of destination
grain	________________
Seed:	________________
Others (please specify):	_____________

28. For the maize transiting Malawi that you inspect, specify the country(ies) of origin:

	Country(ies) of origin
Grain:	____________
Seed:	____________
Others	

29. What are the quantities of the transits?

	A	B	C
High (>100mt/moth			
Medium (between 50 &100mt/moth)			
Low (< 50mt/moth)			
Others (Please specify):			

30. What are the frequencies of the transits?

	A	B	C
Once or more/moth			
Medium (Once/moth)			
Low (< Once every 6 moths)			
Others (Please specify):			

31. If no to Q. 24, please explain why no inspection on transits is conducted.

From any data available of imported maize for the past 24 moths,

32. What are the pests most commonly intercepted on imported maize?

	A	B	C
Insects			
Pathogens			
Weeds			
Others (Please specify):			

33. If no interception records are kept, what is the reason?

D. Plants and plant import requirements

34. Are you aware of the concept of pest risk analysis? Yes/No
(a) If yes, please briefly explain its relevance to your job: ___________________

35. What sources of information and expertise (specifying Organization they belong) are
Used for completing PRAs in Malawi? Please tick where appropriate.

Source of Information	**Expertise**
Scientific journals,	Entomologists
CPC CABI,	Pathologists
CD ROMs	Nematodes
Internet	Weed science

Books	Environmentalists
Others	others

E.CAPACITY DEVELOPEMNT

Staffing

36. Staff availability in plant protection and plant health services present at this border.

(a) Scientists
Level of education
□□Entomologists
□□Plant pathologists
□□Mycologists
□□Virologist
□□Bacteriologist
□□Others (Please specify)

(b)Technicians and level of education……………………………………………..

(c) Supporting staff and level of education……………………………………………

Laboratory

37. Do you have a laboratory facility at your port for identification of interceptions? **Yes/No**

If yes:

(a) How many laboratories for Agricultural institution?
□□□
□□2
□□None

(b) Is it accredited or specialized **Yes/No. If yes,** which body accredited it and which date?
……………………………………………………………………………………..

(b). What is the laboratory specified for?
□□Fungi
□□Nematology
□□Virology
□□Molecular
□□□□□□□□□□□□

□□Others (Please specify)

(b). Do you have any knowledge in the use of the available laboratory equipment **?yes/No**
If yes to **(b)** Describe which equipment**…………………………………………………….**
(c). What organisms can be identified in the laboratory?

□□Insects and/or mites
□□Fungi/
□□Nematodes
□□Viruses
□□Bacteria
□□Others (Please specify)

(d). Interms of laboratory technology, which is your area of specialization?

□□Mycology
□□Virology
□□Nematology
□□entomology
□□Bacteriology
□□Others (Please specify)

(e). Major type of equipment available

□□Microscope
□□Lamina flow cabinet
□□PCR Machines
□□Microscope
□□Autoclave
□□HPLC
□□Gas chlomatology
□□Others (Please specify)

38. (a) If you are involved in identifying pests, what are the sources of your information for pest identification?(include books and internet)

□□Taxonomic binomial keys
□□Taxonomic Organization
□□Scientific journals
□□CPC CABI
□□CD ROMs
□□Internet
□□DARS
□□Manuals for plant health inspection
□□Books
□□Brochures
□□Others (Please specify)

(b). How often are these sources of information revealed?

- 0-5 years
- 5-10 year
- More than ten years
- Never
- Others (Please specify)

(c). If no to (a), how are intercepted organisms identified?(Explain your answer)

……………………………………………………………………………………………………

………………………………………………………………………………….

Finances

39. What are the sources (indicating main ones with an *) of funding that enable you to do Your Phytosanitary work?

□□Government
□□Importers
□□Exporters
□□Others (please specify)

40. How often does your office receive funding?

□□Mothly
□□Quarterly
□□Every six moths
□□Others (please specify)

41. Is there sufficient funding for your Phytosanitary activities? Yes/No

□□Adequate
□□Fair
□□Not adequate

If funding is not adequate, please explain?

Storage/Disposal/inspection Facilities

42. Do you have storage and disposal facilities at your border that complies with Malawi's Phytosanitary import requirements? Yes/No

(a) If yes, what storage and disposal facilities are these?

STORAGE FACILITY	**DISPOSAL FACILITY**
Warehouse	Treatment
Guard room	Incinerators
Others	Disposal sites etc.
	Others:

(b) If no to Q38, how do you dispose of plants and plant products that do not comply with Malawi's Phytosanitary import requirements?

43. Does your Border have inspection facilities? Yes/No

(a) If yes, what inspection facilities are there?

□□Secure inspect proof inspection room
□□Magnifying glasses
□□Microscopes
□□Benches
□□Others (Please specify): __________

F. Other work related matters

Training

44. Do you have any qualifications relevant to your Phytosanitary role? Yes/No (if yes Please specify)

45. Have you received job-on-training/refresher courses in plant protection/Phytosanitary matters? **Yes/No**

46. If yes, who were the trainers?

□ □DARS
□ □University
□ □International workshops (Please specify type and place)
□ □Others (Please specify): __________

47. Which job-on-training plant protection/Phytosanitary disciplines were you trained in?

□ □Entomology
□ □Mycology
□ □Nematology
□ □Virology
□ □Bacteriology
□ □Others (Please specify): ________

National legislation

48. (a) What laws support you and your work in Phytosanitary related duties?

□ □Plant protection Act
□ □Seed act
□ □Biosafety act
□ □Others (Please specify): ________

(b) What regulations and from which bodies supports you and your work in Phytosanitary related duties?

□ □COMES
□ □SADC
□ □WTO-SPSS
□ □IPCC
□ □Others (Please specify): ________

49. How familiar are you with the Malawi Phytosanitary legislations?

50. Does the law give you powers to implement Phytosanitary regulatory work?
Yes/No/Don't know

Please explain your answer……………………………………………………………………….

51. Do you collaborate with neighboring countries in addressing SPS compliance issues?
Yes/No. Explain your answer please…………………………………………………………

Thank you!!

APPENDIX 2. Questionnaire Two : for private and regulating organizations
Maize importation and
Capacity of institutions dealing with imports and exports.

This questionnaire has been designed to collect data on maize importation and capacity of Malawi NPPO and the plant health inspectors Phytosanitary regulatory system

The results will be used for postgraduate research study purposes only. The purpose of the research is to collect data on Malawi's effectiveness of cross-border Phytosanitary measures in control of maize pests in Malawi so that Malawi should comply with WTO SPS Measures.

***Questionnaire No.* ----** Date of interview / /2018
Region Name: ________________________________
District Name: ________________________________
Institution ________________________________
Department name: ________________________________

A.RESPONDENT PARTICULARS

1. Sex.

1. Male	2. Female

2. Education Level **(Mark the appropriate answer)**

1.M.S.C.E	2.Diploma	3.Degree	4.Masters	5. PhD

3.Work experience (Mark the appropriate answer

1. 0-10 years	2.10-20yrs	3.20-30years	4.30-40 years

B. ORGANIZATION OF THE INSTITUTION

4. Do your Organization or professional activities directly relate to? (Tick where appropriate)
□□Immigration matters
□□Customs matters
□□Exporting
□□Importing
□□Phytosanitary regulatory inspections (horticulture and/or forestry)
□□Fisheries
□□Animal health
□□□□□□□□□□□□□□□□□□□□□□□
□□Other Please specify ___________

5.Which organizations in Malawi
do you cooperate with? *Tick where appropriate*

tick those you cooperate with
Phytosanitary
Environmental
Fisheries
Veterinary
Marketing
Forestry
Immigration
Customs

5. Do you deal with maize importation issues in Malawi? Yes/No

(a) If yes, for what purpose(s)/ issues do you deal with maize Importation? (Tick where appropriate)

 Tax/revenue
 Pests and diseases
 Food safety checks
 Quality control
 Meeting importing/exporting countries' Phytosanitary requirements
 Others (please specify): ______

6. Are there documented procedures related to your institution during importation of maize ? Yes/No

(a) If not, on what do you base your agricultural products importation procedures (tick as many as apply to you)?

 Verbal instructions from -DARS
 Standard Operating Procedures from -MBS
 International guidelines
 Directions from an exporter or importer
 Instructions from an exporting or importing country's government
 Others (please specify): __________

C. SERVICES IN RELATION TO WTO SANITORY AND SANITORY MEASURES FOR MAIZE IMPORTS

7. What are the imported quantities of the maize imports for the past 24 months?

	A	B	C
High (>100mt/moth)			
Low(between 50 &100mt/moth)			
Medium (< 50mt/moth)			
Others specify			

8. What are the frequencies of the imported maize?

	A	B	C
High (once or more weeks)			
Low (once of more per moth)			
Medium (once or more after six moths**)**			

Others Specify:

9.For the imported maize specify the origin:

Country(ies) of origin

Grain ____________________________

Seed ____________________________

10. What is the destination/end use of these imports locally?

	A	B	C
Markets			
Private companies			
Transit			
Others specify			

11. Do the maize imported usually comply with the Malawian legal policies/Phytosanitary import requirements?
Yes/No/Don't know
(a) If not, what has been the non-compliance?

	A	B	C
Improper documentation:			
Regulated pests			
Weeds			
Regulated Pathogens			
Others (specify)			

(b). If not the circumstances stated above, please explain other circumstances in which you allow the maize to be imported in Malawi? --

(c).What do you think are the dangers of such scenarios? And how best these scenarios can be dealt with (please explain)---

D.BIOSECURITY MEASURES IN AVOIDANCE OF MAIZE PESTS IMPORTED

12. Have you ever come across issues of quarantine/regulated pests being reported
In borders from a consignment being imported at your institutions? Yes/No
(a) If yes, what action(s) did you take on the reported scenario?
□□Collect samples for further laboratory analysis or identification
□□Re-export the consignment
□□Notify exporting country
□□Destruction of consignment
□□Re-sort and clear uncontaminated goods
Others (please specify)

13. Have you ever reported any existence of regulated pests from Malawi internationally? Yes/No

(a) If yes, where did you report the interceptions?

□□NPPO of the importing country where the consignment of regulated pests come from
□□The International Plant Protection convention (IPPC)
□□The Regional Organization for Phytosanitary measures (RPPO'S)
□□The NPPO of the importing country
□□The importer
□□The exporter

Others (please specify): _________________

14. What measures do you undertake when a regulated pest has been reported within/ outside Malawi to be specific in this case maize?

□□Bun of importation/ exportation of the agricultural product
□□Surveillance if the pests really exists within the country for recommendations of control measures
□□Quarantine of the imported agricultural product before allowance of the entry into the country.

Others (please specify): _________________

15. Is the concept of pest risk analysis applied in your institution before authorization of the importation of agricultural products maize in particular? Yes/No

(a) If yes, please briefly explain its relevance to your job: __________________

16. What sources of information and expertise (specifying Organization they belong) are
Used for completing PRAs in Malawi? Please tick where appropriate.

Source of Information	**Expertise**
Scientific journals,	Entomologists
CPC CABI,	Pathologists
CD ROMs	Nematodes
Internet	Weed science
Books	Environmentalists
Others specify:	Others specify:

17. Do you have a laboratory facility at your institution where reported regulated pests are identified?
Yes/No
(a) If yes, what organisms can be identified in the laboratory?
□ □Insects and/or mites
□ □Fungi
□ □Nematodes
□ □Viruses
□ □Bacteria
□ □Others (Please specify)

I8. If you are involved in identifying pests, what are the sources of your information for pest identification?(include books and internet)
□ □Taxonomic binomial keys
□ □Taxonomic Organization
□ □Scientific journals
□ □CPC CABI
□ □CD ROMs
□ □Internet
□ □DARS
□ □Books
□ □Brochures
□ □Others (Please specify)

19. Do you have storage and disposal facilities at your institution that complies with Malawi's Phytosanitary import requirements, policies and laws? Yes/No
(a) If yes, what storage and disposal facilities are these?

STORAGE FACILITY	**DISPOSAL FACILITY**
Warehouse	Treatment
Guard room	Incinerators
Others	Disposal sites etc.
	Others:

E. OTHER WORK RELATED MATTERS.

20. Finances
What are the sources (indicating main ones with an *) of funding that enable you to do Your work at the institution?
□ □Government
□ □Importers
□ □Exporters
□ □Others (please specify)

21. **Training**
(a) Do you have any qualifications relevant to your role in this institution? Yes/No (Please specify)

(b). Have you received job-on-training in plant protection/Phytosanitary matters? Yes/No

(c). If yes, who were the trainers?
□□DARS
□□University
□□International workshops (Please specify type and place)
□□Others (Please specify): _________

22. Does the national law for importation and exportation give you powers to implement regulatory work at your institution?
Yes/No/Don't know

Please explain your answer.

THANK YOU VERY MUCH!!

Appendix 3:-Other organizations
Questionnaire Three: Maize practices conducted by importers during importation of maize

This questionnaire has been designed to collect data on maize importation and practices conducted by maize importers during importation of maize in Malawi. The results will be used for postgraduate research study purposes only. The purpose of the research is to collect data on Malawi's effectiveness of cross-borderPhytosanitary measures in control of maize pests in Malawi so as to verify if they comply with WTO SPS Measures.

***Questionnaire No.* ----** Date of interview…. /… /2018
Region Name: ______________________________
District Name: ______________________________
Border/respondent ______________________________
____

Respondent Particulars

1. Gender of respondent

1. Male............	2. Female..........

2. Occupation
1. Business man 2. Farmer 3. Others…………………….

3.Rank

(i)-Small scale importer(individual) (ii) Large scale importer (company)

B. Marketing Related Questions:

4. How long have you been importing maize outside Malawi? Tick X under your choice.

Less than three years	3 to 5 years	6 to 8 years	9 to 10	More than ten years

5. What is the primary objective of importing the maize in Malawi"? Tick X in front of your choice.

As a major income from sale

For personal consumption

As a supplementary income from sale of the pro

Others specify:

6. What are the imported quantities of the maize most of the times?

A B C

High (>100mt/moth)
Low(between 50 &100mt/moth)
Medium (< 50mt/moth)
Others specify

7. How often do you import the maize?

A B C

High (once or more weeks)
Low (once of more per moth)
Medium (once or more after six moths**)**
Others Specify:

8. For the imported maize specify the origin:

	Country (s) of origin
Grain	____________________________
Seed	____________________________

9. Do your deal with any of these Organization when importing the maize outside Malawi? (Tick where appropriate)

□□Immigration matters
□□Customs matters
□□Exporting
□□Importing
□□Phytosanitary regulatory inspections (horticulture and/or forestry)
□□Fisheries
□□Animal health
□□Environmental matters
□□Others please specify ___________

10. During the past 3-5 years what has been the trend for maize importation? Tick X in front of your choice.

Has been getting increasing/getting to higher demand

Has been getting decreasing/getting to lower demand

Has been the same/no change

Sometimes up and sometimes down- fluctuating demand

b. Explain your answer please…………………………………………………………………………

C. KNOWLEDGE ON SPS MEASURES

11. Are you aware of sanitary and Phytosanitary procedures that one needs to follow before importing agricultural produce? Yes/No (explain your answer please)
Specify)

…………………………………………………………………………………………………..

12. Have you ever heard of regulated maize pests that can be transferred from one area to the other through importation and exportation of maize? Yes/No
If yes give examples of such pests. How do you think they are transmitted from one area to the other?

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

13. Have you ever had any awareness message from government/private institutions, posters/ banners on importation and exportation of maize? Yes/ no.

If yes how, when and where?
……………………………………………………………………………………………………

……………………………………………………………………………………………………

14. In your own views, how best do you think maize importation should be done in Malawi?

……………………………………………………………………………………………………..

THANK YOU!!