PESTICIDES APPLICATION PRACTICES AND RESIDUES IN SPRAYED TOMATOES AND THEIR SAFETY TO CONSUMERS

DANIEL WILLIAM NDIYO

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SCIENCE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2012

ABSTRACT

Pesticides have been used intensively in tomato growing activities for pests and fungal control. However, health concerns have been reported as a result of pesticides use. This study was conducted to assess pesticides application practices and residues levels in harvested tomatoes grown in Kilolo District. Seventy one of farmers (about 12%) were interviewed using a structured interview schedules and 40 (about 6.8%) tomato samples were taken from 40 farmers for laboratory analysis. Data were analyzed using SPSS version 16.0. The results showed that; 3 insecticides and 5 fungicides were used in the study area. Non-recommended pesticides application practices like; mixing of more than one pesticide, short pre-harvest waiting time, use of inappropriate personal protective gears such as wearing dust masks instead of chemical masks were reported. Various health effects including; skin irritation (85.30%), chest pain and flu (58.80%), eye irritation (41.20%) and headache (30.90%) were reported. In laboratory analysis, endrin residues were detected in 14.00% of the samples. No residues of pesticides used in the study area were detected. Fortified samples were also analyzed; the results showed that, the residues for profenofos were high in the peels (97.0% and 71.9%) at 0 day and after 1day respectively, 41.1% and 44.5% in peels and pulp after 5 days, respectively. Washing of tomato showed no significant effect in the reduction of profenofos residues (only 17.1% loss). Lambdacyhalothrin residues were only detected in the peels 49.5% at same day of spray and 38.0% after 5 days. This study recommends that; farmers should follow the recommended pesticides application practices including, pre-harvest waiting time and protection measures. In addition, consumers should peel tomatoes in order to reduce levels of pesticide residues. Further study should be conducted to establish the source of endrin residues as it is not registered in Tanzania.

DECLARATION

I, Daniel William Ndiyo, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Mr. Daniel William Ndiyo   Date

(MSc. Candidate)

The above declaration confirmed

Prof. Nicholas B. Shayo   Date

(Supervisor)

COPYRIGHT

No part of this dissertation may be reproduced, stored in any retrieval system or transmitted in any form or by any means without prior written permission of the author or Sokoine University of Agriculture on that behalf.

ACKNOWLEDGEMENTS

This study would not have been possible without the help and cooperation of many. In the first place, I wish to thank the almighty God because this work could not be possible without His Grace through good health and settled mind. I wish to acknowledge the good support from my employer, the Chief Government Chemist for the permission and financial support to attend this course.

My profound and exceeding gratitude goes to my supervisor Prof. N. B. Shayo for his tireless technical guidance, patience, constructive criticisms, moral, critical comments and suggestions throughout this course. Also to the Coordinator of Postgraduate Studies, Prof. H. Laswai and all staff at the Department of Food Science and Technology for the technical guidance and moral support towards accomplishing of this study.

I would also like to extend my sincere acknowledgement to leaders of Kilolo District; the District Administration Secretary, the Head of Agriculture and Livestock Division and Village Executive Officers of the 11 Villages covered in this study for their facilitation to make this study possible.

Last but not least, I would like to express my sincere appreciation to the office and staff of the Tropical Pesticides Research Institute particularly Chemistry Laboratory for the good support and commitment during laboratory work.

DEDICATION

This work is dedicated to my family particularly my: wife Margareth C. Ndiyo and my children; Doreen L. and Dennis C. Ndiyo, beloved parents and in-laws particularly Mr. John Sammang'ombe whom I shall always remain gratefully to their great support, prayer and patient during all the time of the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS

AGENDA	AGENDA for Environment and Responsible Development
ANCAP	African Network for Chemical Analysis of Pesticides
ANOVA	Analysis of Variance
bw	body weight
DPR	Department of Pesticides Regulation
FAO	Food and Agriculture Organization
GCLA	Government Chemist Laboratory Agency
GC-MS	Gas Chromatograph/Mass Spectrometry
IARC	International Agency for Research on Cancer
IPKDC	Investment Profile, Kilolo District Council
IUPAC	International Union for Pure and Applied Chemistry
KDC	Kilolo District Council
kg	kilogramme
MAFC	Ministry of Agriculture, Food Security and Cooperatives
mg	miligramme
ml	milllitre
MPEE	Ministry of Planning, Economy and Empowerment
MRL	Maximum Residue Limit
NGOs	Non-Government Organizations
NPIC	National Pesticides Information Centre
POP	Persistent Organic Pollutant
rpm	rotation per minute
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture

TPRI	Tropical Pesticides Research Institute
URT- NIP	United Republic of Tanzania – National Implementation Plan
USA-EPA	United States of America, Environment Protection Agency
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Vegetables constitute essential diet components by contributing, vitamins, iron, calcium and other nutrients, which are usually in short supply (Rajkumar *et al.,* 2006). Tomato being one among vegetables, serves as good sources of vitamins K, C and E. Tomatoes also serve as source of fibre, carbohydrate and other minerals such as potassium, iron, phosphorus and sulphur (Rajkumar *et al.,* 2006). In the recent years, tomatoes have become the focus of most farmers especially for those who grow for commercial purposes particularly in urban areas as a result of demand for high production. However, the demand for high production has been reported to be constrained by damages caused by a wide range of insect pest, nematodes, spider mites and diseases. In order to increase production and maximize profit from tomatoes, farmers practices intensive use of pesticides during the entire growing period for pests and fungus control. These practices have resulted to contamination and accumulation of pesticide residues in harvested tomatoes leading to possibilities of causing health effects to consumers especially when the maximum residues limits exceeds (Sajjad *et al.,* 2009).

The term “pesticides” has a root from the Greek word “pests” meaning plague (many dangerous diseases which spread quickly). A pesticide therefore is a substance which is used to control population of pest (Ak’habuhaya and Lodenious, 1988). Controlling in this context includes killing, repelling or halting the growth of a pest; on which a pest being defined as an organism having an undesirable effects on crops, livestock or health of man. On the other hand, pesticides as defined under the TPRI Act (1979), are any matter of any description (including acaricides, arboricides, herbicides, insecticides, fungicides, molluscides, hormonal sprays and defoliants) used or intended to be used, either alone or together with other material substances for the control of weeds, pests and diseases in plants. While pesticide residues are defined as, any substance or mixture of substances in food for man or animals resulting from the use of pesticide and includes any specified derivatives, such as degradation and conversion products, metabolites, reaction products, and impurities that are considered to be of toxicological significance (FAO/WHO, 2007).

The fight against pests began many centuries ago, on which the earliest recorded of such dated back to 2000 years ago to encient China. Around this time, the Chinese used flame or fire to control locust outbreak (Ak'habuhaya and Lodenious, 1988). Further major development was made by scientists during the 19th Century; thereafter the modern pesticides were introduced in the markets starting with all-time famous dichlorodiphenyl trichloroethane (DDT) followed by many others.

The problem of pesticide residues in tomatoes needs more attention because most of the time these are consumed either raw or without much storage time (Kumar *et al*., 2006). Also, majority of the pesticides sprayed in tomatoes to control pests are also associated with health effects to consumers, especially when farmers do not follow the recommended application practices and when the maximum residues limit exceeds. Chlorpyrifos, for example, is a registered pesticide to be used for tomato pests control in Tanzania (MAFC, 2010), however, this pesticide is a neurotoxin suspected endocrine disruptor, and it has been associated with asthma, reproductive and acute toxicity as reported by the NPIC (2009).

This study therefore, was very important to be undertaken in order to assess the pesticides application practices and ascertain the level of pesticide residues in tomatoes grown in Kilolo District and hence their safety to consumers. This is because, tomato growing activities employ permanently about 584 small and medium scale farmers in Kilolo District (KDC, 2010). The total tomato production is about 200 000 Metric tonnes annually in which it contributed to an average of 54.6% of the total cash crops in Iringa Region as reported in the KDC (2007).

1.2 Problem Statement and Justification

The purpose of pesticides use in tomato growing is to control pests and fungal diseases in order to increase production without causing health effects to consumers. This is mainly achieved through following proper and recommended pesticide application practices. However, various non-recommended practices in tomato growing activities have been reported in Tanzania, including; tomato being sprayed and immediately sold for consumption, application intervals, amount used/dosage and mixing more than one pesticide. All these contribute to pesticide residues in tomatoes.

In Tanzania, little is known on pesticide residues levels in tomatoes particularly from Kilolo District. Some few studies have been conducted on the non-recommended pesticides application practices in tomatoes and other vegetables as reported by AGENDA (2006). In the years 1997 and 1998, tomatoes from Kilolo District were exported to Malawi. However, these were refused in the Malawian market, as after laboratory analysis were found to contain high levels of pesticide residues (MAFC, 2010). Since then, there is no specific study carried out to prove or disapprove such claim. These study findings was aimed to enable the Government and the public to know the pesticide residues levels in ready to harvest or harvested tomatoes produced from Kilolo District, health effects resulting from pesticides application, farmers knowledge in relation to pesticides application and therefore assist to put forward recommendations for sustainable production without sacrificing human health and safety.

1.3 Objectives

1.3.1 General objective

To assess pesticide application practices and residue levels in sprayed tomatoes in Kilolo District and their respective safety to consumers.

1.3. 2 Specific objectives

i. To identify the types of pesticides used to control pests in tomato.
ii. To find out pesticide application practices during tomato growing activities.
iii. To assess farmers' awareness on the health effects of pesticides sprayed in tomato.
iv. To determine the level of pesticide residues in tomato before and after washing, and before and after peeling.
v. To assess the relationship between pesticides application practices and pesticide residue levels.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Tomatoes Production

Tomatoes (*Lycopersicon esculentum L.*) are one of the most commercially produced and used vegetable crop worldwide (Rajkumar *et al.*, 2006). The estimated annual worldwide production is about 125 million Metric tonnes produced in an area of about 4.2 million hectares (FAO, 2005). In the year 2007 for example, the FAO statistics shows that, 126 million Metric tonnes of tomatoes were produced in the world whereby, China was pointed to be the largest producer accounting for one quarter of the global output followed by United States of America and Turkey (FAO/WHO, 2007). In the case of Tanzania, tomatoes are among the major vegetable widely grown and consumed in the country particularly in urban areas. In the year 2007, Kilolo District alone was reported to be with an average annual production of 200 000 Metric tonnes accounting for 54.6% of the total cash crops in Iringa (KDC, 2007).

2.2 Nutritional Importance of Tomato

Tomatoes and tomato products are rich in health-related food components as they are good sources of vitamins K, C, E, folate and flavanoids, fibre, carbohydrate, potassium, iron and some amounts of phosphorus, sulphur and potassium (Rajkumar *et al.*, 2006). Tomato is an excellent source of lycopene, which is a very powerful antioxidant that help to prevent the development of many forms of cancer including; colorectal, prostate, breast, endometrial, lung, and pancreatic cancers (Wener, 2000).

2.3 Economic Contribution of Tomato

The economic contribution of tomato production has been realized worldwide. In the United States of America for example, the Georgia State alone in the year 2005 – 2007, tomatoes production led to an average economic contribution of 42.4 million dollars (University of Georgia, 2008). In Tanzania, tomato growing activities is widely spread in almost every region particularly in urban areas. Kilolo District is the major tomatoes growing area in Iringa Region contributing to district, region and national economies (KDC, 2007). In the year 2003/04 and 2004/05 for example, the combined districts of Iringa Rural and Kilolo accounted for 82% of cash crops harvested in the region on which tomatoes contributed 54.6% (MPEE, 2007).

2.4 Pesticides Application in Tomato Growing Activities

Pesticides are chemicals used world-wide to destroy or control weeds, insects, fungi and other pests. However, whenever there are improper pesticides applications, the resulting residues in the produce can pose significant health risks to consumers. In order that consumer’s health is protected, national programmes have been established in many countries to monitor levels of pesticide residues in domestic and imported foods and to prevent the marketing of food containing residues that either exceeds specific tolerances set by regulations or for which no tolerances have been established for that food.

Tomatoes like other vegetables and fruits growing activities are subjected to several insect pests and plant diseases attack while are in the field. Thus, the use of pesticides is a routine practice so as to control pests and increase production without bringing any health effects to consumers (ANCAP, 2004). This goal can only be achieved through proper application practices of pesticides. However, non-recommended practices on pesticides application in tomato growing activities have been reported by various studies. Waswa and Kiremire (2004) reported that, tomatoes are sprayed and immediately sold for consumption, this results to relatively high pesticide residues which remain in fruits and vegetables. Pesticide residues monitoring studies on fruits and vegetables have been reported in many countries of the world (Amoah, *et al*., 2006). For example, effects of pesticide residues in vegetables, fruits, feed, and cottonseed and fish meal at different intervals have been reported in Pakistan and India (Knezevic and Serdar, 2009).

This problem has led to governments and international organizations to establish Maximum Residue Limits (MRLs), limiting the amount of pesticides in foods. Some of the pesticides sprayed in tomatoes and their recommended MRL include; Cypermethrins is in the range of 0 to 0.02 mg/kg bw per day and Cyromazine is in the range of 0 to 0.06 mg/kg bw per day (FAO/WHO, 2006). The MRL for Chlorpyrifos is 0.01 and that of Profenofos is in a range of 0 to 0.03 mg/kg bw per day (FAO/WHO, 2007).

2.5 Registered and Application of Pesticides in Kilolo District

The pesticides use in Kilolo District is not different from other parts of Tanzania and other countries (Table 1). The MAFC (2010) reported that, a sample of visited farmers from Kilolo District confirmed to use huge volume of pesticides, sometimes by mixing three times of the recommended dosage to increase efficacy to pests, the practice which is likely to lead to relatively high pesticide residues in ready to harvest tomatoes and affect their respective health and safety of consumers. Most of the registered pesticides for use in tomato growing activities are also associated with health effects if not appropriately used. Below are the summaries of health effects related to some of these pesticides.

Table 1: **Some of the registered pesticides for use in tomato growing in Tanzania**

Trade Name	**Chemical Name**	**Applications**
Antokil 5EC	Chlorpyrifos 50g/L	Control of tomatoes fruit worms
Farmgurds 344SE	Cypermethrin 144g/L	Control of bollworms and aphids
Kungfu 5EC	Lambdacyhalothrin5g/L	Control of insect pests in tomato
Dimethoate 40EC	Diamethoate 400 g/L	Control of white flies in tomato
Mupacron 50EC	Profenofos 500g/L	Control of pests in tomato
Trigard 75WG	Cyromazine 750g/kg	Control of tomato leaf minor
Fungozeb 80WP	Mancozeb 800g/kg	Control of fungal diseases in tomato
Ebony M72	Metalaxyl 80g/kg and Mancozeb 640g/kg	Control of fungal diseases in horticultural crops
Vertigo 1.8EC	Abamectin 18g/kg	Control of insect pests on horticultural crops
Bayfidan 250EC	Tridimenol 250g/kg	Control of fungal diseases in tomato
Banko 720 SC	Chrolothalonil 720g/kg	Control of late blight diseases in tomatoes
Kumulus 80%	Sulphur 800g/kg	Control of fungal diseases in tomato

Source: MAFC (2011)

2.5.1 Profenofos 720g/kg

This is an organophosphate insecticide used for control of insect pests in tomato. If this pesticide is not properly used, it is associated with the following health effects; inhibits cholinesterase enzyme activity in the nervous tissue. When in contact with skin, inhalation of spray or when swallowed, it is harmful and toxic (Dow AgroSciences LLC, 2002).

2.5.2 Lambdacyhalothrin 5g/kg

This is an insecticide used to control insect pests in tomato and roses. Proper use and application of this pesticide in very important as it is associated with various health effects. It is harmful and may cause lung damage if swallowed, toxic by inhalation, irritates the respiratory system and skin, and can cause risk of serious eyes damage. It is also very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment (GAT Microencapsulation AG, 2009).

2.5.3 Abamectin 18g/kg

This pesticide is used as an insecticide in tomato growing activities. The proper use and application of this insecticide is of great importance, as if not properly applied and used, it is toxic when inhaled, harmful when swallowed and, if in large amounts and aspiration of the solvent into the lungs occurs, chemical pneumonitis can develop (Villa Crop Protection, 2008). But when small amounts of the product aspirated into the respiratory system during ingestion or vomiting it can cause mild to severe pulmonary injury. The product is also harmful by skin contact and due to its inert nature; it can cause mild to severe irritation to the skin and dermatitis through defatting of tissue and skin sensitization. When there is eyes exposure, the product is a severe irritant to eyes and may cause damage (Villa Crop Protection, 2008).

2.5.4 Mancozeb 800g/kg

This is a fungicide formulation used for control of fungal diseases including late blight in tomato. The possible adverse effects which can occur as a result of improper use include; severe eye irritation with corneal injury, prolonged skin contact can cause slight irritation with local redness and allergic skin reaction. When this product is inhaled, its respective dusts can cause irritation to upper respiratory tract (nose and throat) and lungs

(Dow AgroSciences, 2004). The product has also reported to cause both cancer and birth defects from the components of 80% mancozeb and 20% ethylene thiourea in laboratory animal test. The product also has been reported to cause systemic (other target organs) effects in animals to specific organs like; thyroid, liver, nervous system and eyes (Dow AgroSciences, 2004).

2.5.5 Chlorpyrifos 50g/kg

This is an insecticide used for control of tomato fruit worms. Proper use and following of the recommended application practices is of paramount. If not properly used, it is harmful and toxic when in contact with skin and when swallowed (Gray and Co, 2000). Further more; ingestion of the concentrate may cause injury or death. If aspirated, it can cause lung damage due to chemical pneumonia caused by petroleum like solvents. NPIC (2009) indicated that, children exposed to chlorpyrifos while in the womb have an increased risk of delays in mental and motor development at the age of 3 years and an increased occurrence of pervasive developmental disorders.

2.5.6 Triadimenol 250g/kg

This is an agricultural fungicide used for control of fungal diseases in tomato. The product has been reported to cause some health effects, including; it is harmful when swallowed or inhaled and irritates the respiratory tract and skin (Bayer Crop Sciences, 2012). In prolonged contact, redness and dermatitis may occur. During eyes exposure, this product irritates and it may cause temporary corneal clouding (Bayer Crop Sciences, 2012).

2.5.7 Chlorothalonil 720g/kg

Chlorothalonil is an aromatic derivative fungicide used for control of fungal diseases in tomato. This product if not properly used and applied, it can cause severe eyes and skin irritation. At very high doses it can cause loss of muscle coordination, rapid breathing, nose bleeding, vomiting, hyperactivity and death (Ospray, 2010). Dermatitis, vaginal bleeding, bright yellow and/or bloody urine, and kidney tumors can also occur. This fungicide is classified by IARC under group 2B, which refer to the possibility of being carcinogenic to humans (Ospray, 2010). It is also reported to be very toxic to aquatic organisms and can cause long-term adverse effects to the aquatic environment

2.5.8 Mancozeb 640g/kg mixed with Metalaxyl 80g/kg

This is a fungicide formulation made from a mixture of 64% Mancozeb and 8% Metalaxyl (Jiangsu Qiaoji Biochem, 2010). It is used for control of fungal infection in tomato. If not properly used/applied, this product can cause irritation to nose, throat and lungs. Prolonged or repeated skin contact may cause possible skin irritation or dermatitis due to skin sensitization (Jiangsu Qiaoji Biochem, 2010).

2.5.9 Sulphur 800g/kg

This product is a fungicide used for control of fungal diseases during tomato growing activities. It has been classified as not hazardous, however regular exposure can result to chronic bronchitis and eye discomfort (Titan Ag Pty, 2009).

2.6 Recommended Practices of Pesticides use in Tomato Growing

The use of pesticides in tomato growing is aimed at controlling pests in order to increase production. However, in order to limit their residues in the harvested tomatoes, recommended practices during application should be followed. Table 2 summarizes the recommended application practices to some of the pesticides registered in Tanzania. The pesticides in Table 2 are purposely used for controlling pests and increase production of tomatoes without bringing any health effects to consumers through proper application practices. Non-recommended practices have been reported by many studies, in Pakistan for example, the indiscriminate use of pesticides particularly at fruiting stage and non adoption of safe waiting period led to accumulation of pesticide residues in consumable vegetables (Madan *et al*., 1996 and Kumari *et al*., 2003).

Table 2: **The recommended application practices of some pesticides used in tomato**

Chemical Name	Mixing Ratio	Application Intervals (days)	Pre-harvest Waiting Time (days from the last spray)
Mancozeb 800g/kg	3 – 3.5 kg/Ha	Repeat 7 – 10	3
Profenofos 720mL/L	10mL in 15L of water	Repeat 10 – 14	21
Chlorpyrifos 240g/L	1L/Ha in 25L of water	Repeat 10 – 12	14
Lambdacyhalothrin 50g/kg	300L in 150L of water	Repeat 7 – 10	3

Source: TPRI (2010)

In Tanzania for example, AGENDA (2006) reported on non-recommended practices that, farmers depend on experience during pesticides dilution rather than the recommended practices available on the containers label, 63% apply pesticides in a short-time interval against recommended, and mix more than one pesticides to increase efficacy which is against recommended practices. The MAFC (2010) also reports that, tomatoes farmers in Tanzania, sometime mixes together more than one pesticides for the purpose of increasing their efficacy and strength, therefore ensuring maximum killing of pests. Further, reports that farmers spray pesticides to ready-harvested tomatoes for the purpose of prolonging shelf-life so as to reach the market undamaged.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location of Kilolo District

Kilolo District Council is among the eight Districts Councils in Iringa Region with an area of 7881 square kilometers of which 6,803 square kilometers are habitable whereas forests, rocky mountains and water, occupy the rest (KDC, 2007). The district extends between Latitudes 7° - 8.3º South and Longitudes 34°-37° East. The main borders are Mpwapwa District (Dodoma Region) to the north, Kilosa District to the northeast and Kilombero District to the east (both of Morogoro Region) Mufindi District to the south, and Iringa District to the West. Administratively, Kilolo District Council is divided into 3 divisions, 12 wards, 83 villages, 415 hamlets and 42 002 households (KDC, 2007).

3.1.2 Selection of the study area

In conducting and for the purpose of this study, the field data and samples for laboratory analysis were collected from six wards which are; Ilula, Mlafu, Ilole, Lugalo, Image and Ibumu. These wards were selected based on the following reasons;

a) They are high potential wards in the production of tomatoes in Kilolo District and Iringa Region in general,
b) Tomatoes production is the main activity for income generation,
c) Pesticides are used intensively,
d) In the previous years, tomatoes from these wards were rejected in the international market with the claim that they contained high levels of pesticides residues, and

e) Tomatoes from these wards have large market share in the city of Dar es Salaam, which has a population of approximately more than 4.5 million.

Figure 1: **Map of Iringa Region showing Kilolo District and some villages covered in the study.**

Source: Majule and Mwalyosi (2003)

3.1.3 Study population

The study population involved small and medium scale tomatoes growers from the 6 wards which have a total number of 584 farmers, distributed in the six wards as follows; Ilula (138), Mlafu (130), Ilole (77), Lugalo (94), Image (95) and Ibumu (50) (KDC, 2010).

3.2 Research Design

A Cross-sectional study design was used during data collection. This design allows data to be collected at single point without repetitions. The design was used because it uses minimum time and resources and it provides quick results as reported by Kothari (2004). It involved field survey, structured interview schedules to identify pesticides application practices, sample collection and laboratory analysis to determine levels of pesticide residues in tomatoes.

3.3 Sampling Techniques

A sampling plan was drawn such that the sample size (n) selected from the study population, was such that n/N represents a figure greater/equal to 5% of the population size which is the minimum sample size to set a representative sample (Boyd *et al.*, 1981). "n" is the sample size and "N" is the population size. Seventy one farmers representing about 12% of the study population were interviewed during the field survey to assess pesticides application practices. On the other hand, 40 (from about 7% of the study population) tomato samples were taken for laboratory analysis to determine pesticide residues levels and their respective distribution pattern within the different tissues of tomatoes. Ten samples were taken from the field and 30 from the markets located in each of the six wards of the study area.

The sampling procedure on the number of respondents from each ward followed the equation, $n_h = (N_h / N)*n$ (Snedecor and Cochran, 1989), whereby; n_h = the sample size of the stratum "h", N_h = the population size for the stratum "h", N = the total population size and n = the total sample size. Random sampling was conducted to select villages and individual farmers, whereby 11 villages and 71 farmers were covered for the field survey to assess application practices. Random sampling was conducted to select villages and individual farmers to sample the 10 tomato samples and purposive sampling to sample the 30 samples from the ward markets for laboratory analysis. The whole unit or package taken to define a single sample was 1kilogramme as described in Codex Alimentarius Commission (2000).

3.4 Data Collection

3.4.1 Data on pesticides application practices

Data on the types of pesticides and application practices was collected using a structured interview schedule composed of open and closed–ended questions for face to face interview provided in Appendix 1.

3.4.2 Chemical analysis

Data on pesticide residues were collected through chemical analysis. The method used for laboratory analysis of tomato samples followed the procedures described by Anastassiades *et al*. (2003). The method is designed for extraction of multiple pesticide residues from fruit, vegetables and other low fat foods and uses Gas Chromatography-Mass Spectrometry (GC/MS) to determine pesticide residues.

Some modifications were made to this method, whereby Ethyl acetate was employed as the extraction media instead of acetonitrile, and florisil was used for cleanup of the supernatant instead of graphite carbon/aminopropylsilanized silica gel layered mini column (500 mg/500 mg) as described below.

3.4.2.1 Materials and equipment

i. Tomato sample; about 1kg per sample
ii. Gas Chromatograph/Mass Spectrometry (GC/MS)

3.4.2.2 Methods: extraction and determination

Of 40 tomato samples; 15 samples were blended before washing, 15 samples were blended after thorough washing with tap water. The remaining 10 samples were blended in two categories, the peel and the pulp after peeling. 15g of the blended sample was measured into 50mL Teflon tube, 100 microlitre (µl) of heptachlor was added as internal standard, 15mL of ethyl Acetate were added as an extracting media. Then 6 gram (g) of anhydrous magnesium sulphate ($MgS0_4$) and sodium acetate (CH_3COONa) were added to remove water. The mixture was shaken gently on the automatic shaker for 3 minutes and then taken to the centrifuge at a speed of 4000 rpm for 3 minutes. Two milllitre (mL) of the supernatant were taken into the 15mL Teflon tube, 300mg of anhydrous magnesium sulphate ($MgS0_4$) and 150mg of florisil was added for further removal of water and cleaning. The mixture was gently shaken and then taken to the centrifuge at a speed of 4000 rpm for 3 minutes. About 1.5 to 2mL of the test solution was taken into a 2mL out sampler screw cap vials. The brief summary of the steps discussed in this section are shown in Fig. 2.

Photo 1: Sample blending process

Photo 2: Separation of components

Photo 3: Separated components for residues determination.

Photo 4: Loading sample in an outosampler GC-MS for residues determination

Figure 2: Photos showing some stages involved in sample extraction and determination.

The sample components were separated, identified, and measured by injecting 1µl of the concentrated extract into a high resolution fused silica capillary column of a gas chromatography/mass spectrometry (GC/MS) system. Compounds eluting from the GC column were identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a data base. Reference spectra and retention times for analytes were obtained by the measurement of calibration standards under the same conditions used for samples. The concentration of each identified component is measured by relating the MS response of the quantitation ion produced by that compound to the MS response of the quantitation ion produced by a compound that is used as an internal standard.

Furthermore, fortification of tomato samples by 2ml (2.92mg/kg) of profenofos, 2ml (1.84mg/kg) of lambdacyhalothrin and 5.2g of mancozeb in one litre of water was done. The fortification involved two categories; one category involved spraying of tomatoes with a mixture of profenofos and lambdacyhalothrin followed by spraying with mancozeb. The other category involved spraying of tomatoes with profenofos and lambdacyhalothrin individually. profenofos and lambdacyhalothrin were chosen because are mostly used compared to other pesticides, great have health concerns and long recommended pre-harvest waiting periods particularly for profenofos. However, mancozeb was dropped during extraction and determination because of short pre-harvest waiting time required and limitation resulting from the cost of laboratory analysis. Then, the extraction and determination of the profenofos and lambdacyhalothrin residues followed the same procedures stated above. The purposes of this fortification was to assess the, degradation of the two pesticides with time after spraying and the effects of peeling and washing on the concentration of residues in the sprayed tomatoes.

The residues level of each pesticide was then determined using GC-MS results and the calibration curve prepared using the formula below.

$$\text{Residue (mg/kg)} = \left[\frac{(A)(V)(P)}{(C)(W)(CF)(100)}\right] \times 10^6 \quad \ldots\ldots(1)$$

Whereby;

A = the peak area of the analyte in the sample

V = the total volume of concentrated extract (ml)

P = the purity of the standard used

C = the mean calibration factor (Slope), from the calibration curve (Area/ng)

W = the weight of the sample (g)

CF = the correction factor.

The average Limit of Detection (LOD) was 1.0 picogram (pg)/microlitre (µl) and the average Limit of Quantitation (LOQ) was 1.0 nanogram (ng)/ µl.

3.4.2.4 GC-MS measuring conditions

In the GC separation, Injection port temperature was 230^0C and injection mode was splitless. The column temperature programme used was as follows: 50^0C (hold 1 min) and 5^0C/min to 280^0C (hold 10 min). The column was: Durabond, 35 Methyl Silicon (MS), 30m length, 0.250mm internal diameter and 0.25µm film thickness. The solvent used was ethyl acetate and volume injected was 1ul. The carrier gas was helium of more than 99.999% purity and the flow rate was 1.2ml/min. The temperature for the transfer line and the ion source were set at 280 and 230^0C, respectively. The Mass Spectrometer detector was operated in electron impact ionization mode with an ionizing energy of

70 eV. The analysis was performed in the SCAN mode based on the use of one target and two qualifier ions. Chemical compounds were identified according to retention times, target and qualifier ions.

3.4.3 Data analysis

The data from the field survey were subjected to SPSS version 16.0, whereby descriptive statistics was computed, particularly minimum, maximum, means and frequencies of individual variables

3.5 Limitations of the Data

The primary data on pesticides application practices were obtained mainly through interviewing tomato farmers and users of pesticides, whose responses were liable to errors due to inadequate knowledge on proper pesticides applications, or faulty memory. The data were also obtained through laboratory analysis of tomato samples sampled during one of three harvesting seasons.

To overcome some of the primary data limitations further information was collected from pesticides sellers/traders on the pesticides used in the study area particularly correctness of trade names known to farmers against common or chemical names. Also, fortified tomato samples with pesticides used in the study area were analyzed parallel as control samples. However, the fortified samples were kept indoors under room temperatures and therefore the effects of environmental conditions for tomatoes in the field to pesticides residues were not addressed.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Respondents' Area of Residence

Table 3 summarizes the wards, villages and number of individual farmers involved in the data collections.

Table 3: Summary of respondents' area of residence (ward and villages)

Wards	Frequency	Percent	Villages	Frequency	Percent
Ilole	7	9.9	Mbigili	7	9.9
Ibumu	7	9.9	Ibumu	7	9.9
Mlafu			Isagwa	4	5.6
	15	21.1	Mlafu	4	5.6
			Itungi	7	9.9
Image	6	8.5	Image	6	8.5
Ilula			Igunga	7	9.9
	22	31.0	Ikokoto	7	9.9
			Madizini	8	11.3
Lugalo	14	19.7	Mazombe	7	9.9
			Imalutwa	7	9.9
Total	**71**	**100**	**Total**	**71**	**100.0**

The determinant on how many villages to be involved during the field survey was guided by the level of tomato production and the number of farmers in a particular village. Only one village was from Ilore, Ibumu and Image wards. This was because; the selected village from each ward was the one with many tomato farmers and more tomato production than others. Majority of villages with many tomato farmers were concentrated in Ilula and Mlafu wards. Both wards have three villages which were involved in the survey and data collection with respect to the assessment of pesticides application practices and sampling for pesticide residues level laboratory analysis.

4.2 Characteristics of Respondents

Table 4 shows the general characteristics of respondents that include; age, sex, marital status, and level of education. The age of respondents ranged from 22 to 59 years, with a mean of 40 years. Majority of respondents' age were concentrated in ages ranging between 31 to 40 and 41 to 50 years, which made a percentage of 47.9 and 35.2, respectively. Further, 12.7% of respondents' age was between 51 to 60 and only 4.2% between 21 to 30 years. These findings imply that, majority of respondents in the study area were still in the production age with the possibility of increasing tomato production, especially when proper extension services are in place.

The findings also show that, 97.2% of those interviewed tomato farmers were men, only 2.8% were women of whom; one had separated and the other was a widow. These results imply that, tomato growing was a male-dominated activity. Majority, (93%) of the respondents were married and only 4.2% were single. With respect to the level of education, 88.7% of the respondents had primary school level of education. This level of education for the majority of farmers together with inadequate number of extension officers could be the contributing factor towards limited knowledge on best pesticides application practices.

Table 4: **Sex, marital status, actual age and education level of respondents**

Categories assessed	Frequency	Percentage of cases
Sex		
Male	69	97.2
Female	2	2.8
Marital status		
Single	3	4.2
Married	66	93.0
Widowed	2	2.8
Actual age of respondents		
Minimum age (years)	22	
Maximum age (years)	59	
Mean age (years)	40	
21 – 30 Years	3	4.2
31 – 40 Years	34	47.9
41 – 50 Years	25	35.2
51 – 60 Years	9	12.7
Level of education		
No Formal Education	1	1.4
Primary School level	63	88.7
Ordinary Secondary School Level	7	9.9
Total	**71**	**100.0**

4.3 Pesticides Application Practices

4.3.1 Types of pesticides sprayed in tomato in the study area

The assessment of the types of pesticides used was conducted during the field survey, through the structured interview schedule. The types of pesticides used in the study area were based on the intended purposes and type of pests to be controlled. They were either for control of insect pests or fungal diseases.

The results in Fig. 3 showed that, all of the interviewed farmers used pesticides during tomato growing activities.

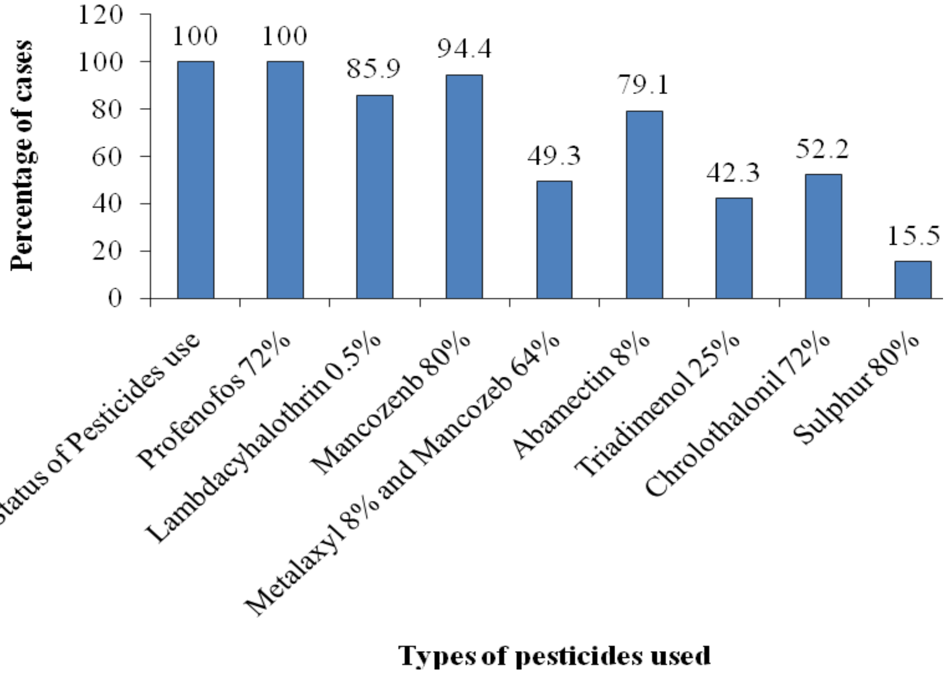


Figure 3: **Types of pesticides used and the percentage of use by respondents**

The level of use for each type of pesticide differed slightly from one pesticide to another. One hundred percent of respondents reported to use profenofos, 85.90% lambdacyhalothrin and 79.10% abamectin for insect pests control in tomatoes. The three pesticides were either used together (mixed) or concurrently for the purpose of controlling or killing specific type of insect pest which attacks tomatoes.

In controlling fungal diseases, 94.40% of respondents reported to use mancozeb, 52.2% used chlorothalonil, 49.3% metalaxyl mixed with mancozeb, 42.30% triadimenol and 15.5% used sulphur. These results showed that, majority of farmers used mancozeb for control of fungal diseases. However, because of limited knowledge with respect to which pesticide was responsible for which diseases, sometime more than one fungicides was mixed with another and used during application. The pesticides (insecticide and fungicide) used in the study area during tomato growing activities were all registered for such purpose (MAFC, 2011). These pesticides were mainly used for the purpose of controlling insect pests and fungal diseases.

Although, profenofos, lambdacyhalothring and abamectin are registered and used insecticides in the study area for control of insect pests, they are associated with various health effects. For example; profenofos inhibits cholinesterase enzyme activity in the nervous tissue, when in contact with skin. Inhalation of spray and when swallowed it is toxic and harmful (Dow AgroSciences LLC, 2002).

Lambdacyhalothrin is harmful and may cause lung damage if swallowed. It is toxic by inhalation, irritates the respiratory system and is very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment (GAT Microencapsulation AG, 2009).

Abamectin is toxic when inhaled and is harmful when swallowed. It is harmful by skin contact and due to its inert nature; it can cause mild to severe irritation to the skin. When there is eyes exposure, the product is a severe irritant to eyes and may cause damage, (Villa Crop Protection, 2008).

Mancozeb, chlorothalonil, triadimenol and sulphur are fungicides used for control of fungal diseases in the study area. These fungicides are also associated with a number of health effects. Mancozeb if not properly used and applied can cause severe eye irritation with corneal injury, and allergic skin reaction. When this product is inhaled, it’s respective dusts can cause irritation to upper respiratory tract (nose and throat) and lungs (Dow AgroSciences, 2004). This product can also cause both cancer and birth defects as per the conducted laboratory animal tests (Dow AgroSciences, 2004).

Chlorothalonil can cause severe eye and skin irritation and loss of muscle coordination, rapid breathing, nose bleeding, vomiting, hyperactivity and death at very high doses (Ospray, 2010). It is also classified with possibility of being carcinogenic to humans and reported to be very toxic to aquatic organisms causing long-term adverse effects to the aquatic environment (Ospray, 2010).

The associated health effects of these pesticides can affect health and safety of famers and consumers if not properly used and applied. Inadequate protection and application of safety measures during pesticides application might lead to the fore mentioned health effects to farmers or other users. Tomato consumers can be affected by the residues of these pesticides, especially when the recommended application practices such as applying the right dosage and following the recommended pre-harvest waiting time after the last spray are not followed.

4.3.2 Training on pesticides application

The proper pesticides application and use requires special training. The results from this study show that, only 18.3% of respondents attended training. The minimum time of the training was 1 day and the maximum was 180 days, with the mean of about 21 days as shown in Table 5. The standard deviation was very large (48.6 days) because only one person attended training for a long period (180 days). The rest of respondents (12) attended this training for less than 30 days. The average number of seasons for tomato growing was 2, with a minimum of 1 and maximum of 3 days.

Table 5: **Special training on pesticides use and applications and number of tomato growing seasons**

	Frequency	Percentage	Minimum	Maximum	Mean	Standard deviation
Total days of training	13	18.3	1	180	20.77	48.599
Number of grown seasons	71		1	3	2.11	0.622

Training is one of the vital aspects to ensure safe pesticides use and applications for protection of farmers and consumers health from their respective hazardous effects. However, as pointed out, only 18.3% of respondents attended training on pesticides use and applications. These findings imply that, majority of farmers had limited knowledge on safe use and application of pesticides. As a result farmers are likely to practice non recommended application practices, which can lead to pesticides residues in the ready to use or harvested tomatoes. Waswa and Kiremire (2004) reported that, tomatoes were sprayed and immediately sold for consumption. This results to relatively high pesticide residues which remain in fruits and vegetables.

4.3.3 Source of information on pesticides use and applications

Fig. 4 summarizes the source of information for farmers to use and apply pesticides during tomato growing. The results show that, 74.60% of respondents got information on pesticides use and application from fellow farmers and 52.10% and 50.70% from labels provided on the package/containers and pesticides vendors, respectively.

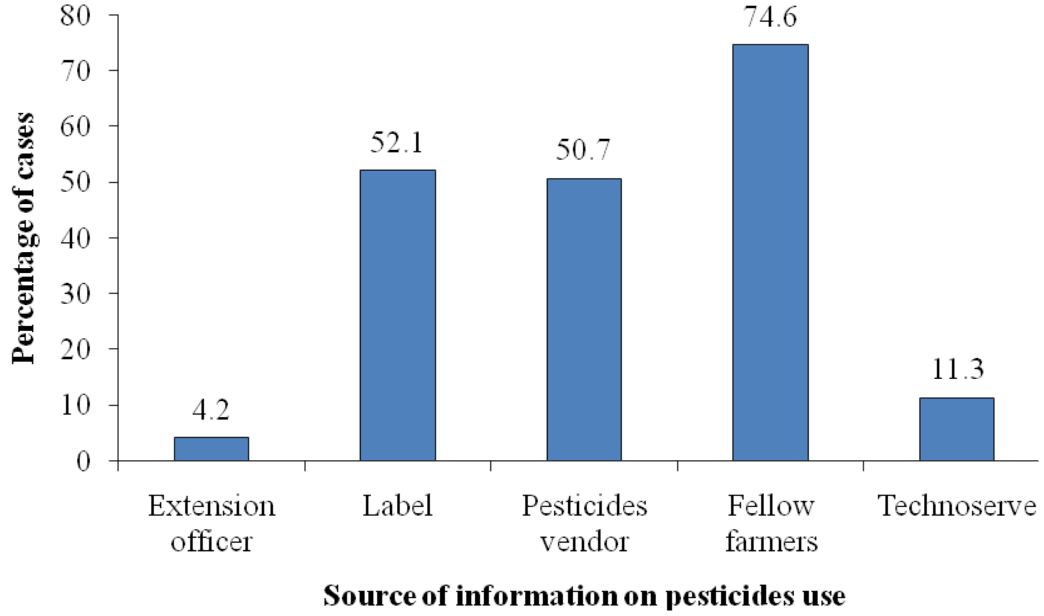


Figure 4: Source of information on pesticides use and application

These results show that, majority of tomato farmers get information on pesticides use from fellow farmers and pesticides vendors. However, as revealed from this study, majority of them have not attended any special training on pesticides use and application. Also their respective level of formal education is standard seven (88.7% reported) which does not provide much knowledge on safe pesticides use, their respective health effects and the need to follow the recommended practices. These results also show to the extent of effectiveness of extension officers in providing proper guidance to farmers with respect to proper use and application of pesticides, as only 4.2% of respondents reported to get such information from extension officers. Furthermore, it was reported that, in most cases these officers were also not available, as out of 6 wards visited only one ward had an extension officer apart from the Head of Agriculture and Livestock division level. This circumstances leads to the situation where farmers depended much on fellow farmers, pesticides vendors, labels or all possibility at a time as source of information rather than relying on extension officers.

4.3.4 Individual application of pesticides

The proper use and application of pesticides requires each pesticide to be applied individually. The finding from this study shows that, abamectin is the only pesticide mostly (81.60%) applied individually during spraying, the rest are mixed together. The recommended normal practice was to spray each pesticide individually. However, this is not the case, as also reported by the MAFC (2010) that farmers do mix more than one pesticides when spraying in order to increase the killing capacity.

It has also been revealed from this study that, even if mixing increases the killing capacity, it also increases the production costs and possibly the concentration of the pesticides active ingredients, leading to pesticide residues in the ready to use or harvested tomatoes. This is because in most cases farmers mix pesticides of the same active ingredients, same efficacy and safe target pests or fungal diseases.

4.3.5 Mixing of pesticides while spraying in tomato

The results show that, 50.70% of the interviewed respondents mixed three pesticides, 29.90% mixed four pesticides and 19.40% mixed two pesticides. Few farmers (7.50%) go to the extent of mixing five pesticides together as summarized in Fig. 5.

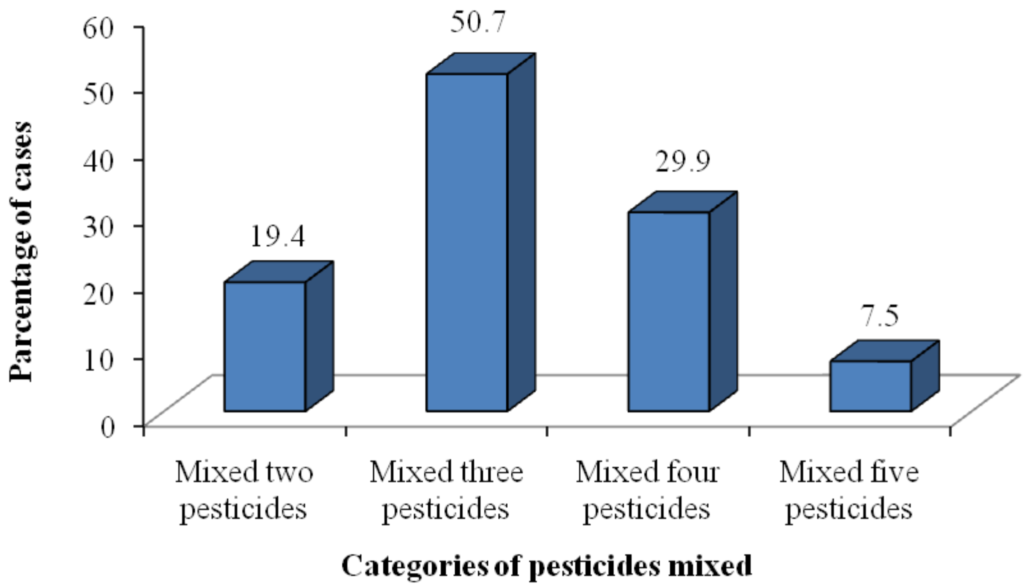


Figure 5: Categories of pesticides mixing during application

The practices of mixing more than one pesticides as reported in various literatures were also found in the study area. These findings coincide with those reported by the MAFC (2010) that tomato farmers in Tanzania, sometime mix together more than one pesticide for the purpose of increasing their efficacy and strength, therefore ensuring maximum killing of pests. However, this practice could lead to possibility of two responses; one could be an increase of the killing capacity while also increasing the dosage than the recommended or a decrease in the killing capacity as a result of possible reactions of components in the mixture. When high dosage is used, there is also possibility of pesticide residues in the harvested tomatoes especially when the pre-harvest waiting time interval is too short compared to recommended time interval.

4.3.6 Types of pesticides mixed together while spraying in tomato

The most mixing category involved three pesticides as shown and discussed in section 4.3.5. The possible combinations of the three mixed pesticides are summarized in Table 6. The finding from this study shows that, when three pesticides are mixed, it involves either of the following combinations; Profenofos, Lambdacyhalothrin and Mancozeb (32.50%); Profenofos, Mancozeb and Triadimenol (22.50%); Profenofos, Mancozeb and Abamectin; or Profenofos, Mancozeb and Cholorothalonil (10.00%) respectively, as shown in Table 6.

Table 6: **Combinations when three pesticides are mixed together**

	Frequency	**Percentage of Cases**
Profenofos, Lambdacyhalothrin and Mancozeb	13	32.5
Profenofos, lambdacyhalothrin and Abamectin	1	2.5
Profenofos, lambdacyhalothrin and tridimenol	2	5.0
Profenofos, Lambdacyhalothrin and Mancozeb and Metalaxyl	1	2.5
Profenofos, Mancozeb and Abamectin	4	10.0
Profenofos, Mancozeb and Cholorothalonil	4	10.0
Profenofos, Mancozeb and Triadimenol	9	22.5
Profenofos, Mancozeb and Sulphur	1	2.5
Profenofos, Mancozeb and Metalaxyl, and Chlorothalonil	2	5.0
Lambdacyhalothrin, Mancozeb and Sulphur	2	5.0
Mancozeb, Chlorothalonil and Triadimenol	1	2.5
Total	**40**	**100.0**

In most cases, the mixing involves either two insecticides and one fungicide or two fungicides and one insecticide. For example, from the first combination (which include profenofos, lambdacyhalothrin and mancozeb); both profenofos and lambdacy-halothrin are insecticide which under recommended practice have to be used either alone or separately at different time intervals (Dow AgroSciences LLC, 2002, and Syngenta Crop Protection AG, 2010). In the second combination (which include profenofos, mancozeb and triadimenol); both mancozeb and triadimenol are fungicides and mainly applied for control of fungus as reported by Dow AgroSciences LLC, (2004) and Bayer Crop Sciences (2012) respectively, either one can be used or they have to be used separately.

It should be noted that, when more than one pesticide are mixed, there is a possibility of either increasing or decreasing the efficacy towards the intended pests or fungus depending on the chemical reactions which might occurs when mixed together. Also there might be a possibility of increasing pesticide residues especially when spraying is done to ready to harvest tomatoes and pre-harvest waiting time not followed.

4.3.7 Average pesticides application intervals between last spray and harvest

The mean pre-harvest waiting time intervals as reported by respondents were approximately; 8, 8, 6 and 7 days for two, three, four and five pesticides mixed together, respectively as shown in Table 7. The standard deviation for mixing two and three pesticides is high (approximately 4 and 5 days, respectively), because majority of respondents reported less than 21 days as maximum pre-harvest waiting time interval with the minimum of 5 and 2 days (Table 7) and also that, the mean deviation from the reported individual values is very large.

The recommended use and application of pesticides among others provides for pre-harvest waiting time between last spray and harvest of tomatoes. As revealed from this study, pesticides are mixed during application, and that in every mixture profenofos is compulsory. The average pre-harvest waiting time for profenofos is 21 days as per the TPRI (2010).

Table 7: **Pesticides application intervals (in days) between last spray and harvest (pre-harvest waiting time)**

Category of Pesticides	Frequency	Minimum	Maximum	Mean	Standard Deviation
When two pesticides mixed	19.4	5	21	7.92	4.209
When three pesticides mixed	50.7	2	21	8.21	4.742
When four pesticides mixed	29.9	2	14	6.47	2.601
When five pesticides mixed	7.5	5	7	6.50	1.000

However, the finding from this study showed that; in every mixture profenofos has been compulsory and the reported average pre-harvest waiting time ranged from 6 to 8 days only. This implies that, if the required dosage is applied and if the practices of mixing do not affect the concentration of each component in the mixture, there is a possibility of harvested tomatoes to contain residues particularly of profenofos.

These findings are in line with other studies conducted on pesticides application practices. Madan *et al*. (1996) and Kumari *et al*. (2003) reported that, the indiscriminate use of pesticides particularly at fruiting stage and non adoption of safe waiting period led to accumulation of pesticide residues in consumable vegetables. AGENDA (2006) also reported that, farmers depend on experience during pesticides dilution rather than the recommended practices available on the containers label. Sixty three percent apply pesticides in a short-time interval against recommended and mix more than one pesticides to increase efficacy, which is against recommended practices.

4.3.8 Source of information on mixing pesticides during applications

The findings from this study showed that, farmers mixed more than one pesticide during application, and it was of interest to know the source of information for mixing. The results showed that, 94% of respondents reported to get information from fellow farmers and 31.30% from sellers/wholesalers or pesticides vendors as shown in Fig. 6. The results also showed that, 4.5 and 9.0% of farmers reported to get information from a Non-Governmental Organization called Technoserve and labels, respectively.

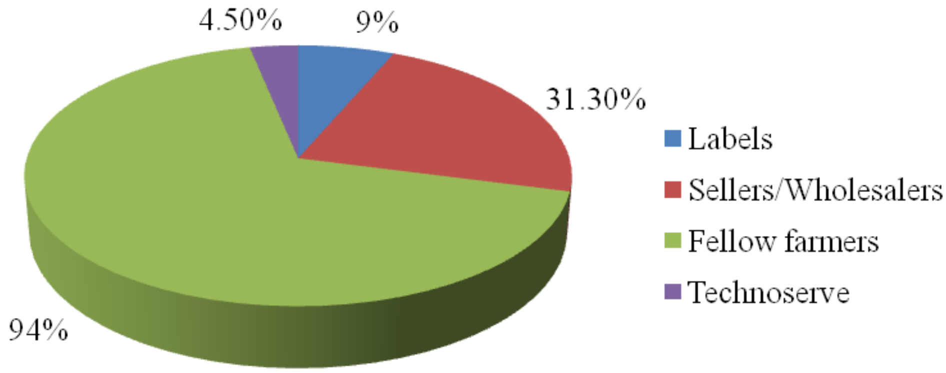


Figure 6: **Source of information on mixing more than one pesticides**

The findings in respect to source of information for mixing more than one pesticides pointed out that, majority of farmers (94%) get information from fellow farmers and 31.30% from sellers/pesticide vendor who are also farmers. These results concur with the earlier reported findings in Fig. 4 that, the knowledge on pesticide use and application is through sharing or learning experience from one farmer to another.

4.3.9 Reported health effects resulting from pesticides application

The health effects resulting from the use of pesticides during tomato growing were also assessed. The responses from respondents reported 14 health effects as shown in Table 8. It was reported that, 85.30% and 41.20% of respondents reported skin and eye irritation, respectively, while 58.80% both reported chest pain and flu as a result of pesticides use/application, symptoms being seen immediately after spray. Some 22.10%

reported to feel fatigue while 20.60% reported skin burn and irritation and dryness of the respiratory tract as the effects.

Table 8: Reported health effects as a result of pesticides application

Health Effects	Number	Percentage of Cases
Stomach ache	3	4.4
Fatigue	15	22.1
Skin irritation	58	85.3
Chest pain	40	58.8
Flu	40	58.8
Eye irritation	28	41.2
Headache	21	30.9
Death	8	11.8
Irritation and dryness of the respiratory tract	14	20.6
Skin burn	14	20.6
Possibility of Cancer	8	11.8
Feel dizzy	10	14.7
Destruction of nervous system	8	11.8
Effects on reproductive system	4	5.9

The health effects reported in Table 8 were related to hazardous health effects of the pesticides used in the study area. These findings are supported by various literatures. GAT Microencapsulation AG, (2009) reports that, lambda-cyhalothrin can cause lung damage if swallowed; it is toxic by inhalation, causes irritation to the respiratory system and skin and has risk of serious damage to eyes. Also, when a mixture of mancozeb 64% and metalaxyl 8% is not properly applied it can cause irritation to nose, throat and lungs and prolonged or repeated skin contact can cause possible skin irritation (Jiangsu Qiaoji Biochem, 2012).

Villa Crop Protection (2008) also reported that, abamectin is harmful by skin contact and it can cause mild to severe skin irritation, an exposure to eyes can cause severe irritation and damage. Bayer Crop Sciences (2012) reports that, triadimenol can cause irritation to the respiratory tract and skin, during eyes exposure. This product irritates and it may cause temporary corneal clouding.

4.3.10 Protection measures against pesticides health effects during application

The recommended use of pesticides involves the use of proper and relevant protection equipment like masks, gloves, overall coats and others as protection measures against hazardous health effects of pesticides. The result in Fig. 7 shows that; 48.30% of respondents wear a piece of cloth or dust masks, 43.10% wear normal coats, while 19.00% and 3.40% wear gloves and goggles, respectively when applying pesticides. Majority of respondents (70.70%), wear gumboots and 22.40% spray against wind flow as protection measures against pesticides health effects.

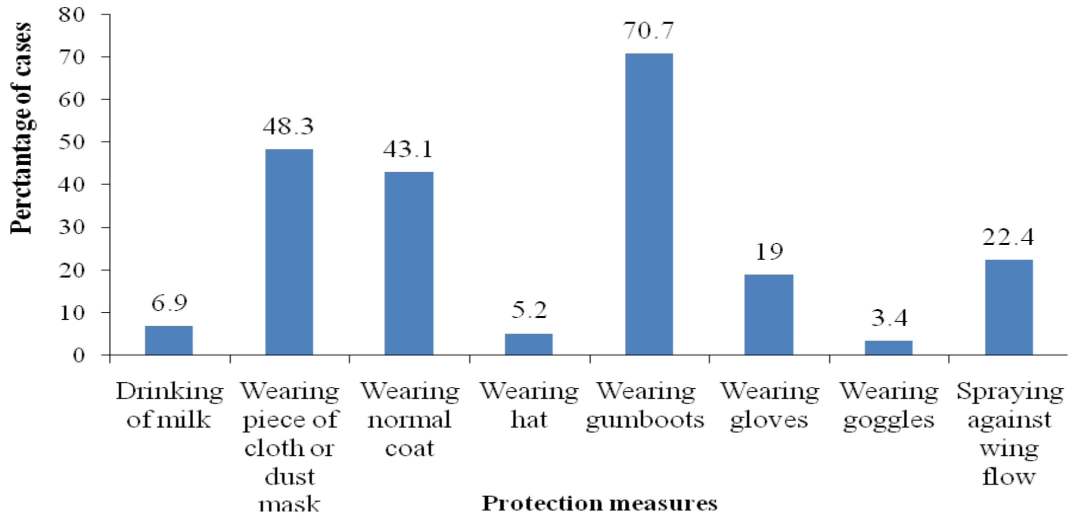


Figure 7: **Protection measures against pesticides health effects during application**

These results revealed the inadequate protection measures taken by farmers when spraying/applying pesticides. The recommended best practice and proper application is to use relevant and appropriate protective gears. However, majority of the used protective gears are not relevant and appropriate.

For example, a piece of cloth or dust mask is used instead of recommended chemical masks. Also, wearing of normal coat instead of chemical resistant coat and spraying against wind movement are all inappropriate gears and practices and cannot protect the farmers from the health effects associated with the pesticides used.

The finding from this study show that, farmers in the study area are exposed to health effects resulting from the inappropriate protection measures employed during pesticides application in tomato growing activities. The reported health effects by farmers support this conclusion. As observed from this study that, 85.30% and 41.20% of farmers reported skin and eye irritation respectively, 58.80% both chest pain and flu, 20.60% dryness and irritation of the respiratory tract, 30.90% headache, 22.10% fatigue, 20.60% skin burn and many other health effects. All of these reported health effects are associated with the pesticides used in the study area.

4.3.11 Estimated annual gross income from tomato growing activities

Table 9 summarizes the estimated annual gross income from tomatoes growing activities. The result shows that, the minimum and maximum annual gross incomes are Tanzania Shillings 0.5 million and 40 million, respectively. Majority (48.00%) of farmers get an average annual gross income ranging between 0.5 million to 5 million and 25.00% between 5.1 million to 10 million. Only 7.00% of respondents had an average annual gross income above 10 million Tanzanian Shillings.

Table 9: Gross annual income from tomato

Amount (TZS in Millions)	Frequency	Percentage
0.1 – 5	48	68
5.1 – 10	18	25
1.1 – 15	2	2.8
15.1 – 20	1	1.4
20.1 – 25	0	0
25.1 – 30	1	1.4
30.1 – 35	0	0
35.1 – 40	1	1.4
Minimum income 0.5		
Maximum income 40		
Mean income 5.1		
Standard deviation 6.2		

The finding shows the importance of tomato growing activities towards contribution to the individual and national economy. The average annual gross income of 5.1 million with the minimum of 0.5 million and maximum of 40 Million shows the huge contribution of tomato growing activities to farmers and the national economy. These findings are supported by the finding reported by KDC (2007) that, Kilolo District alone had an average annual tomato production of 200 000 Metric tonnes, which accounted for 54.6% of the total cash crops earning in Iringa. Therefore, it is important for farmers to be given proper knowledge and education related to pesticide application, in order to increase tomatoes production and maximize profit while protecting their health and that of tomato consumers.

4.4 Pesticide Residues in Tomato Samples

The laboratory analysis to assess pesticide residues from tomatoes grown in the study area involved 40 tomato samples. The categories of analysis were; 15 samples unwashed, another 15 samples washed with tap water, and 10 samples peeled then the peels and pulp analyzed separately. Only 14.00% (7 samples) were detected to contain residues of endrin as shown in Fig. 8. Pulp of the peeled tomato from the two samples were detected to contain 0.9 and 2.2 mg/kg, peels of the three tomatoes samples detected to contain 0.5, 0.9 and 1.1 mg/kg, and that of two unwashed tomato samples detected to contain 1.7 and 1.9 mg/kg (Table 10).

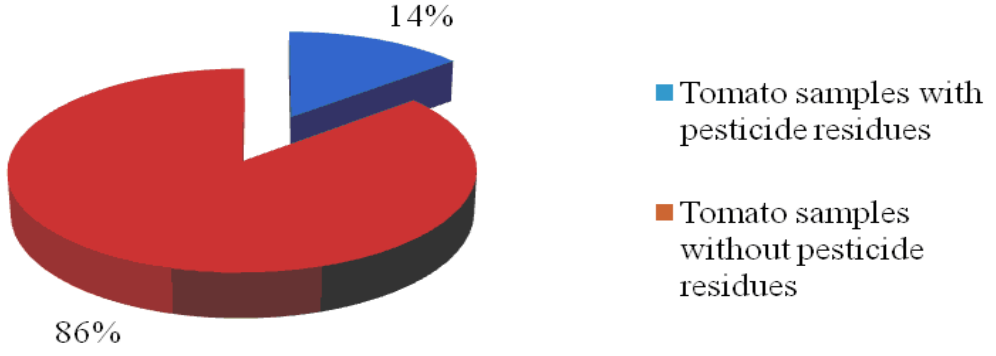


Figure 8: **Pesticide residues in tomato samples**

Table 10: **Pesticide residues in tomato samples, analyzed using GC-MS**

Categories of tomato samples	Endrin (mg/kg)	Percentage recovery of internal standard
Pulp of peeled tomatoes	2.2	82
Peels of tomatoes	0.5	36
Unwashed whole tomatoes	1.7	195
Unwashed whole tomatoes	1.9	67
Peels of tomatoes	1.1	60
Pulp of peeled tomatoes	0.9	99
Peels of tomatoes	0.9	110

The residues were expected to be of the pesticides used at the study area. However, none of the samples were found to contain residues of pesticides used at the study area. Instead, the detected pesticide residues were of endrin. Endrin is an organochlorine pesticide in a form of either aldehyde or ketone. It is a Persistent Organic Pollutant (POP) and therefore its use is banned to all Parties to the Stockholm Convention on POPs. Endrin is a systemic insecticide, non-biodegradable with low solubility in water but highly soluble in body fats and therefore causing bioaccumulation in the human body (URT-NIP, 2005). These distinct properties are of great concern to wildlife and human, being at high level in the food chain and thus are at higher risks due to biomagnifications tendency.

This pesticide is associated with various health effects; the long term exposure may produce cumulative health effects involving organs or biochemical systems, irritability, drowsiness, loss of appetite, reduction of blood cell numbers, leukemia and anemia (Santa Cruz Biotechnology, 2008). It causes concerns for human fertility on the basis that similar materials provide some evidence of impaired fertility in the absence of toxic effects, or evidence of impaired fertility occurring at around the same dose levels as other toxic effects, but which are not secondary non-specific consequences of other toxic effects. The long term exposure to high dust concentrations may cause changes in lung function i.e. pneumoconiosis; caused by particles less than 0.5 micron penetrating and remaining in the lung.

Endrin like other organochlorine and POP pesticides in long period of exposure can cause multiple nervous system infections and disorders involving the brain and autonomic nerves with headache, dizziness, "pins and needles", tremor in the limbs, disturbances in nerves supplying blood vessels, pain in the bowel and stiffening of the bile duct, rapid heartbeat, hollow heart sounds and a tight pain in the chest (Santa Cruz Biotechnology, 2008). There can also be blood problems with loss of platelets and white blood cells, change in blood cell distribution, anaemia and loss of appetite and weight.

The health concerns and systemic effects associated with this pesticide, led to inclusion in the Stockholm Convention and ban of its use in all Parties. Tanzania being a Party to the convention had also banned its use in all related applications just after ratification of the convention in the year 2004, and therefore no residue of this pesticide at any concentration level is supposed to be found in food chain (URT-NIP, 2005). The URT-NIP (2005) further reports that, there is no documented evidence that endrin as insecticide have ever been used in Tanzania. Therefore, these findings raise concerns for further study to assess whether endrin is imported and used illegally, or because it is a systemic insecticide it might have been used previously particularly in the early 1990's and therefore is still being up-taken from the contaminated soil, or during the laboratory analysis some components of the samples revealed the same properties like that of endrin particularly retention time.

The recovery from the internal standard for majority of the sample was in a recommendable range as it ranged from 60 – 110%, only one reading was below the range which read 36%. These findings are in accordance with Herrmann and Smedsgaard (2011) who reported that, the recoveries for a single analysis should be within the range of 60-140%. The recoveries from the internal standard being in a recommended range assures for the method validation and correctness of the results.

4.5 Pesticide Residues for Fortified Samples

4.5.1 Tomato samples fortified with a mixture of profenofos and lambdacyhalothrin

Table 11 shows the result of Tomato samples fortified with the mixture of profenofos and lambdacyhalothrin at 1 and after 6 days. The result shows that, no residues of lambdacyhalothrin were detected in the peels or pulp of tomato after 1 day. However, after 6 days, 0.70mg/kg (38% recovery) residues of lambdacyhalothrin were detected in the peels. The two results contradicts one another, it was expected to find residues of lambdacyhalothrin in the peels of tomato analysed after 1 day and not after in the peels of tomatoes analysed after 6 days. This contradiction could be caused by unequal distribution of pesticides concentration during spraying from one tomato to another within the same batch of sprayed tomatoes. Generally, ten tomatoes were sprayed together as one batch, then peels of five tomatoes were analysed after 1 day and peels of the remaining five tomatoes were analysed after 6 days. On the other hand 2.10 (71.9% recovery) and 1.40 mg/kg (48.0% recovery) residues of profenofos were detected in the peels of tomatoes after 1 and 6 days, respectively and 0.29mg/kg (9.9% recovery) in the pulp after 1day.

Table 11: **Pesticide residues (in mg/kg) following fortification of tomato with profenofos and lambdacyhalothrin mixed together as applied by farmers**

Types of Pesticides	Tomato Constituents	1 Day	%RC	ISTD %RC	6 Day	%RC	ISTD %RC
Lambdacyhalothrin	Peels	ND		49	0.70	38.0	84
	Pulp	ND		97	ND		95
Profenofos	Peels	2.10	71.9	49	1.40	48.0	84
	Pulp	0.29	9.9	97	ND		95

ND – Not Detected % RC – Percentage Recovery from fortified samples with 2.92mg/kg (2ml/L) Profenofos and 1.84mg/kg (2ml/L) Lambdacyhalothrin.
ISTD % RC – Internal Standard Percentage Recovery

The purpose of mixing two pesticides together before fortification and spraying was to reflect the practices done by farmers during applications and thereafter assess the level of pesticide residues and its degradation with time. The percentage recovery and distribution of residues for profenofos was 71.9% and 9.9% in the peels and pulp, respectively after 1 day, and 48.0% in the peels at the sixth day. These results reveal the vital role of peeling as one of the important processes in the reduction of pesticide residues in tomatoes as also reported by Abou-Arab (1999), who reported that, the efficient role of the peeling process in elimination of pesticide residues of profenofos lead to a residues loss of 83.3%. If the tomatoes as per these findings have to be peeled on the sixth day, it ensures safety of consumers because no residue was detected in the pulp of the peeled tomatoes.

The level of profenofos residues in the peels decreased with time by 33.30% loss from 2.10mg/kg at the first day to 1.40mg/kg after 6 days. This shows the importance of following the recommended pre-harvest waiting time for profenofos, which is 21 days as reported and recommended by TPRI (2010). If the recommended pre-harvest waiting time particularly for profenofos is not followed, there is a possibility of harvested tomatoes to contain residues, which in turn might affect health of consumers, especially when eaten without peeling. This is because, the Maximum Residues Limits (MRLs) for profenofos ranged from 0 to 0.03 mg/kg bw per day (FAO/WHO, 2007).

4.5.2 Tomato samples fortified with profenofos and lambdacyhalothrin applied individually.

Table 12 summarizes the result of tomato samples fortified with profenofos and lambdacyhalothrin, whereby each pesticide was applied individually as recommended, then the residues level analyzed at 0 and 5 days after spraying. Table 12 also summarizes the results on the distribution of residues and their respective percentage recovery in the whole tomatoes, peels and pulp for the two pesticides. The result shows that, the residues of lambdacyhalothrin were only detected in the peels with a slight decrease from 0 day (0.90mg/kg) to the 5th day (0.70mg/kg) with respective recovery of 49.5% and 38.0%.

The residues of profenofos were found to be distributed in all categories of tomato parts whereby, 0.5mg/kg (17.1% recovery) in both washed and unwashed whole tomatoes at the fifth day. There was much high concentration in the peels (2.82mg/kg) and low concentration in the pulp (0.70mg/kg) at 0 day with recovery of 97.0% and 24.0%, respectively. The residues levels were found to be almost equally distributed in both peels (1.20mg/kg) and pulp (1.30mg/kg) at the fifth day after fortification with the respective recovery of 41.1% and 44.5%.

Table 12: **Pesticide residues (in mg/kg) in tomato samples following fortification by profenofos and lambdacyhalothrin applied individually.**

Types of Pesticides	Tomato constituents	0 Day	%RC	ISTD %RC	5 Day	%RC	ISTD %RC
Lambdacyhalothrin	Whole				ND		88
	Peels	0.90	49.5	100	0.70	38.0	79
	Pulp	ND		96	ND		101
Profenofos	Whole washed				0.50	17.1	107
	Whole unwashed				0.50	17.1	109
	Peels	2.82	97.0	101	1.20	41.1	93
	Pulp	0.70	24.0	100	1.30	44.5	87

ND – Not Detected % RC – Percentage Recovery from fortified samples with 2.92mg/kg profenofos and 1.84mg/kg lambdacyhalothrin ISTD % RC – Internal Standard Percentage Recovery

The results summarized in Table 12 show the residues of lambdacyhalothrin to be concentrated only in the peels with a slight decrease from 0 to 5 days, the recoveries being 49.5% and 38.0%, respectively. This finding implies that the combination of both peeling of tomatoes and following of the recommended pre-harvest waiting time will ensure safety of consumers. These results concur with those obtained by Powell *et al*. (1970) and Chirila and Florll (1985), who reported that much of the pesticide residues, were removed by peeling.

The reduction of profenofos residues as a result of washing with tap water showed no significant difference between washed and unwashed whole tomato samples, with recoveries of 17.1% and 0% loss as a result of washing. This findings concur with those of Abou-Arab (1999) who reported that, washing with tap water proved the least effective in the reduction of profenofos residues showing only 22.7% loss. Under normal practices at domestic level, tomatoes are normally washed with tap water. However, from these findings; consumers should not depend only on this process. In addition other process like peeling should be employed in order to ensure safety.

The distribution of profenofos residues was much higher in the peels with the recoveries of 97.0% than in the pulp which was 9.9% at day 0. However, the residues were almost equally distributed between the peels and pulp with recoveries of 41.1% and 44.5%, respectively after 5 days. The findings at 0 day agree with those of Abou-Arab (1999), who reported that, the efficient role of the peeling process in elimination of pesticide residues of profenofos lead to residues loss of 83.3%. However, these findings do not agree after 5 days, which might imply that, profenofos tends to be equally distributed in all parts of the tomato tissue and therefore bring to the attention of farmers to follow the recommended pre-harvest waiting time of 21 days in order to ensure safety of consumers. The current practices from the study area show that the average pre-harvest waiting time for profenofos ranges from 6 to 8 days depending on whether two, three, four or five pesticides were mixed together, profenofos being compulsory. The results of profenofos residues from the fortified samples in comparison with the observed pre-harvest waiting time, is likely to lead to unsafe harvested tomatoes and therefore affect health of tomato consumers. Although no residues of profenofos were detected in the samples from the study area, these results from the fortified samples and average short pre-harvest waiting time revealed from this study, bring concern of whether the tomatoes from the study area were 100% safe.

The results from the fortified samples during this study could not assess the effects of environmental conditions as samples were fortified and stored indoor under room temperature. A study, covering all the three tomato growing seasons and an experimental control farm will provide additional findings, which will support, provide further information or disagree with the findings of this study.

The percentage recovery for the internal standard ranged from 79 – 109%, this shows the good performance of the equipment and the method and therefore the correctness of the results. This recovery was in line with that reported by Herrmann and Smedsgaard (2011) who reported that, the recoveries for a single analysis should be within the range of 60-140%.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The findings of this study observed eight pesticides used in the study area for control of insect pests and fungal diseases. Majority of the used pesticides have possible health effects to farmers during application and to consumers of tomatoes if the recommended application practices are not followed. This in turn results in residues in the harvested tomatoes. The study revealed various non-recommended pesticide application practices including; mixing of more than one pesticide, short pre-harvest waiting time, short time application intervals between the last and next spray and limited protection measures of farmers when applying pesticides. This study also observed that, farmers have very limited knowledge on the safe use of pesticides on which majority depend on fellow farmers rather than extension officers when it comes to various aspects of pesticides applications. Because of the limited protection measures while applying pesticides, farmers reported various health effects, which directly link with the pesticides that had been used in the study area.

No residues of the pesticides used in the study area were detected; instead the detected pesticide residues were of endrin. Endrin is an organochlorine pesticide, a systemic insecticide, non-biodegradable with low solubility in water but highly soluble in body fats and therefore causing bioaccumulation in the human body. Because of these distinct properties endrin is of great concern to wildlife and human, being at high level in the food chain and therefore it is banned by all Parties to the Stockholm Convention on Persistent Organic Pollutant (POP).

5.2 Recommendations

It is recommended from this study that, education and awareness raising campaign related to health effects and the importance of following recommended pesticides application practices should be provided to farmers. This will assist in protecting farmers and consumers of tomatoes from the hazardous health effects of the pesticides used in the study area. This can be achieved through involvement of both Non-Governmental Organizations (NGOs) in providing awareness on pesticides health effects and the need for safe application. By creating good environment for NGOs to work smoothly and employing adequate number and qualified extension officers for the same purposes, can also be of help to farmers, tomato consumers and the Government.

The laboratory analysis of samples sampled from the study area revealed no residues from the pesticides used in the study area. Instead, endrin residues were detected. However, there is no documented evidence that endrin as an insecticide has ever been used in Tanzania. Therefore, a further study is recommended to assess whether endrin was imported and used illegally, or because it is a systemic insecticide it was previously used and therefore up-taken from the contaminated soil. Although no residues of the pesticides used in the study area were detected, this study covered only one growing seasons. Therefore further study is recommended to cut across all the three seasons. This is because non-recommended application practices, which can lead to pesticide residues in the harvested tomatoes, have been observed from this study.

The fortification of tomato samples was done to assess the degradation of profenofos and lambdacyhalothrin with time after spraying and the effects of peeling and washing on the residue levels in the sprayed tomatoes. The residue levels of both pesticides were shown to decrease with time, which shows the importance of following the recommended pre-harvest waiting time for each pesticide. The peeling of tomatoes showed to be an effective process in reducing the residues. It is therefore recommended that, consumers should always peel the tomatoes in order to ensure safety. Washing with tap water was not effective process and therefore it is not recommended to be among the processes of leading to reduction of pesticide residues in tomatoes.

The results from the fortified samples in this study could not assess the effects of environmental conditions as samples were fortified and stored indoors under room temperature. Therefore, further studies should also include an experimental tomato control farm following the recommended pesticide application practices. The control farm will assist in addressing the effects of environmental conditions like temperature, light, wind, humidity and others with respect to degradation of the pesticides used in the study area.

REFERENCES

Abou-Arab, A. A. K. (1999). Behavior of pesticides in tomatoes during commercial and home preparation. *Food Chemistry* 65: 509 – 514.

ANCAP (2004). *Analysis of Pesticides for a Better Environment, Public Health and Competitive Agriculture and Aquatic Exports.* Inaugural Conference Proceedings, Arusha Tanzania. 106pp.

AGENDA for Environment and Responsible Development and Pesticides Action Network UK, (2006). *Final Report for the Study on Trade and Utilization of Pesticides in Tanzania:* Implication to Stockpiling. 113pp.

Ak'habuhaya, J. and Lodenious, M. (1988). *Pesticides in Tanzania.* Publications of the Department of Environmental Conservation at the University of Helsinki. 10pp.

Amoah, P., Drechsel, P., Abaidoo, R. C., and Ntow, W. J. (2006). Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Archives of Environmental Contamination and Toxicology* 50: 1 – 6.

Anastassiades, M., Lehotay, S. J., Stajnbaher, D. and Schenck, F. (2003). Fast and easy multiresidue method employing acetonitrile extraction/partitioning and dispersive solid phase extraction for the determination of pesticide residues in produce (QuEChERS method). *Journal AOAC International* 8(2): 412 – 431.

Bayer Crop Sciences (2012). *Material Safety Data Sheet for Triadimenol 250 EC.* Tooronga Road, East Hawthorn, Victoria, Australia. 6pp.

Boyd, H. K. R., Westfall, E. and Stasch, S. F. (1981). *Marketing Research, Text and Cases.* Richard, D. Publisher, Illinois. 813pp.

Chirila, R. and Florll, S. (1985). Absorption, translocation,metabolization and accumulation of methidathion in cucumber and tomato plants. *Analele Institutului de Cercetari Pentru Protectia Plantelor* 18*:* 221 – 227.

Codex Alimentarius Commission (2000). *Pesticides Residues in Food, Methods of Analysis and Sampling. (*Second Edition), The Codex Alimentarius Commission, Rome, Italy. 91pp.

Dow AgroSciences LLC (2002). *Material Safety Data Sheet for Profenofos.* Zionsville Road Indianapolis, Indiana, USA. 5pp.

Dow AgroSciences LLC (2004). *Material Safety Data Sheet for Mancozeb 80%.* Zionsville Road Indianapolis, Indiana, USA. 5pp.

FAO/WHO (2006). *Pesticides Residues in Food.* Joint Meeting of Pesticide Residues *Report.* FAO Plant Production and Protection Paper No. 191.

FAO/WHO (2007). *Pesticides Residues in Food. Joint Meeting of Pesticide Residues Report.* FAO Plant Production and Protection Paper No. 191**.**

FAO (2005). Production of Fruits and Vegetable and Share in world. Rome Italy. [Http://www.faostat.fao.org] site visited on 15/07/2012.

GAT Microencapsulation AG (2009). *Material Safety Data Sheet for Lambda-Cyhalothrin 5EC*. Gewerbezone, Ebenfurth. 8pp.

Gray, D. (2000). *Material Safety Data Sheet for Chlorpyrifos.* 2 Rawlinson Street, O'Connor Palmyra DC, Western Australia. 5pp.

Herrmann, S. S. and Smedsgaard, J. (2011). *Determination of Pesticide Residues Using GC-MS (MS) and LC-MS/MS Following Acetonitrile Extraction/Partitioning and Cleanup by Dispersive SPE – QuEChERS – Method.* DTU National Food Institute, Moerkhoej Bygade 19, Soeborg. 47pp.

Jiangsu Qiaoji Biochem Co. (2010*). Material Safety Data Sheet for Metalaxyl 8% and Mancozeb 64% WP.* No. 168, Qiuhu Road (S), Duntou Town, Hai an County, Jiangsu, China, 5pp.

Kilolo District Council (2007). *Investment Profile Report*, *Kilolo District.* Kilolo, Iringa. Tanzania. 24pp.

Kilolo District Council (2010). *List of Medium and Large Scale Farmers using Pesticides.* Fertilizers and herbicides in tomato production. Kilolo, Iringa, Tanzania. 2pp.

Knezevic, Z. and Serdar, M. (2009). Screening of fresh fruit and vegetables for pesticide residues on Croatian market. *Food Control* 20: 419 – 422.

Kothari, C. R. (2004). *Research Methodology, Methods and Techniques. (*Second Edition), Published by New Age International, New Delhi. 418pp.

Kumar, M., Gupta, S. K., Garg, S. K. and Kumar, A. (2006). Biodegradation of hexachlorocyclohexane-isomers in contaminated soils. *Soil Biology and Biochemistry, 38:* 2318 – 2327.

Kumari, B., Kumar, R., Madan, V. K., Singh, R.V., Singh, J. and Kathpal, T. S. (2003). Magnitude of pesticidal contamination in winter vegetables from Hisar, Haryana. *Journal for Environmental Monitoring and Assessment* 87: 311 – 318.

Madan, V. K., Kumari, B., Singh R. V., Kumar, R. and Kathpal, T. S. (1996). Monitoring of pesticide from farmgate samples of vegetables in Haryana. *Pesticides Residues* 8(1): 56 – 60.

MAFC (2010). *Report on the Tomatoes Growing and Application of Pesticides*. Kilolo District, Iringa, Tanzania. 3pp.

MAFC (2011). *The List of Registered Pesticides*. Tanzania. 43pp.

Majule, A.E. and Mwalyosi, R. B. B. (2003). *Enhnancing Agricultural Porudctivity through Sustainable Irrigation*. A case of Vinyungu farming system in selected Zones of Iringa. research report submitted to University of Dar es Salaam, Tanzania. 17pp.

MPEE (2007). *Iringa Regional Socio - Economic Profile.* (Second Edition), Iringa Tanzania. 264pp.

NPIC (2009). In a chlorpyrifos technical facts sheet. [http://npic.orst.edu/factsheets/chlorptech.pdf] site visited on 26/7/2011.

Ospray (2010). *Material Safety Data Sheet for Ospray Chlorothalonil 720 Fungicide.* 50 Middleton Rd Freecall 1800 624 597 Cottonvale Qld 4375, Australia, 6pp.

Powell, A. J. B., Stevens, T. and McCully, K. A. (1970). Effect of commercial processing on residues of Aldrin and Dieldrin in tomatoes and residues in subsequent crops grown on the treated plots. *Journal of Agriculture and Food Chemistry*, 18(2): 224 – 227.

Rajkumar, P., Kulanthaisami, S., Raghavan G. S. V., Gariepy Y. and Orsat M. V. (2006). *Vacuum Assisted Solar Drying of Tomatoes Slices, Paper Number 066207.* In the American Society of Agricultural and Biological Engineers (ASABE), Annual International Meeting Proceedings, and 9 - 12 July 2006. 7153 – 7163.

Sajjad, A. B., Niaz A. A., Muhammad, A. and Muhammad, R. A. (2009). Determination of the Organophosphorus pesticide in vegetables by high-performance liquid chromatography. *American-Eurasian Journal, Agriculture and Environmental Science* 6(5): 513 – 519.

Santa Cruz Biotechnology (2008). *Material Safety Data Sheet for Endrin Aldehyde.* 2145 Delaware Avenue, Santa Cruz, California. 7pp.

Snedecor**,** G. W. and Cochran, W. G. (1989). *Statistical Methods* (8th Edition). The Iowa State University Press, USA. 503pp.

Syngenta Crop Protection AG (2010). *Material Safety Data Sheet According to Regulation (EC) No. 1907/2006 for Lambdacyhalothrin 5EC (Karate 5EC).* Postfach CH-4002 Basel, Switzerland. 8pp.

Titan Ag. Pty (2009). *Material Safety Data Sheet for Titan Sulphur 800GW Fungicide/Miticide.* 15/16 Princies Street, Newport, New South Wailes, Australia. 5pp.

TPRI **(**2010). *Pesticides Registration Procedure.* Arusha, Tanzania. 2pp.

TPRI Act (1979). *The Tropical Pesticides Research Institute Act.* United Republic of Tanzania. 30pp.

URT (2005). *National Implementation Plan (NIP) for the Stockholm Convention on Persistent Organic Pollutants.* Vice President's Office Division of Environment, Dar es Salaam, Tanzania. 308pp.

University of Georgia (2008). *Economic Impact of Georgia Tomato Production Value Losses due to the US.* Salmonella Outbreak Report. Center for Agribusiness and Economic Development College of Agricultural and Environmental Sciences. Archie Flanders Center. 7pp.

Villa Crop Protection (2008). *Material Safety Data Sheet for Abamectin.* Aston Manor, South Africa. 4pp.

Waswa, J. and Kiremire, B. T. (2004). Pesticide Residue Distribution in Sediment and Fish Samples from the Ugandan Side of Lake Victoria. *In the Inaugural Conference Proceedings of the African Network for Chemical Analysis of Pesticides* (ANCAP), 8^{th} – 11^{th} August 2004, Arusha International Conference Centre, Arusha, Tanzania. pp. 7 – 15.

Wener, Z. H. (2000). Agriculture support online vegetables consultant. [www.agrisupportonline.com] site visited on 15/4/2011.

.

APPENDICES

Appendix 1: An Interview Schedule for Research on pesticide Application Practices

SOKOINE UNIVERSITY OF AGRICULTURE

FUCULTY OF AGRICULTURE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

AN INTERVIEW SCHEDULE FOR RESEARCH ON

PESTICIDE RESIDUES IN SPRAYED TOMATOES AND THEIR SAFETY TO CONSUMERS: A CASE STUDY OF KILOLO DISTRICT IRINGA, TANZANIA

BY

DANIEL W. NDIYO

M. Sc. FOOD SCIENCE

-

A: Personal information

1. Name of

   Respondent:…………………………………………………………………...

2. Name of Village:……………………….……………………..

   …………………………….……

3. Name of Ward

   ……………………………………….…..……………………………….

4. Year of Birth ……………………………….……………………….………………………

5. Sex: 1 = Male, 2 = Female

6. Marital status

   1 = Single, 2 = Married, 3 = Widowed, 4 = Divorced, 5 = Separated

7. Highest education attained by the respondent

   1 = Uneducated 2 = Primary, 3 = O-level, 4 = A-level, 5 = College

8. Years of Schooling…………………………………………………………………..

9. Having attended any special training on pesticides use and application: 1=Yes, 2= No.

   a) If Yes, where was the training undertaken

   b) How long did the training take

B: Questionnaire for Pesticides Application Practices

10. Do you use pesticides in tomatoes growing? 1= Yes, 2 = No

   a) If yes, list the types of pesticides used at fruiting stage of tomatoes.

      i. ………………………………………………………………………………………

      …

      ii. ………………………………………………………………………………………

      …

      iii. ………………………………………………………………………………………

      …

      iv. ………………………………………………………………………………………

      …

v. …………………………………………………………………………………………

…

vi. …………………………………………………………………………………………

…

b) If no, what are the alternative methods used to control pests?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

11. If yes in (10) above, where do you get the information on the application of pesticides? 1= TPRI, 2 = Extension Officer, 3 = Label, 4 = sellers/wholesaler or retailers,

12. 5= fellow farmers, 6 = Others Specify……………………………….…………………

12 If yes in (10) above, are the pesticides applied individually? 1= yes, 2= no.

13. If yes in (12) what are the intervals between first and next spray?

a) Name of pesticide. ……………………., application intervals………………...days

b) Name of pesticide..……………….……….., application intervals……………...days

c) Name of pesticide..………..………….., application intervals……..…………...days

d) Name of pesticide..…………..……….., application intervals………………...days

e) Name of pesticide…………………..….., application intervals..………………days

14. When pesticides are applied individually, what are the application intervals between last spray and harvesting?

a) Name of pesticide……………….……., application intervals…………….. days

b) Name of pesticide.…………………….., application intervals…………… ..days

c) Name of pesticide…………………..…, application intervals……………...days

d) Name of pesticide…………… ………, application intervals………….…. days

e) Name of pesticide….……………………, application intervals……………. days

15. If the answer in question (3) above is No;

a) List the pesticides mixed together and their respective formulation ratio.

i. 1= two pesticides mixed ……………….…………………………………….....

ii. 2= three pesticides mixed………………………………………………..…...

iii. 3= four pesticides mixed……………………………………………………..

iv. 4= five pesticides mixed……………...…………………………………………

b) Where did you get the information on mixing more than one pesticide? 1= TPR1, 2 = Extension Officer, 3 = Label, 4 = sellers/wholesaler or retailers, 5= fellow farmers.

c) How did you get the knowledge on mixing? 1= attended training, 2 = depend on experience, 3 = Fellow farmers.

d) Does the killing of pests increases when pesticides are mixed as opposed to individually applied?1 = yes, 2= no.

16. When pesticides are mixed, what are the application intervals between last spray and harvesting?

a) 1= Name of 2 pesticides mixed……..………., application intervals………….days

b) 2= Name of 3 pesticides mixed……… ……..., application intervals; ……..….days

c) 3= Name of 4 pesticides mixed………………, application intervals; ……….. days

d) 4= Name of 5 pesticides mixed..……………., application intervals…..…..….days

C: Information of Health Effects of Pesticides Sprayed in Tomatoes

17. Are you aware of any health effects resulting from pesticides use? 1 = Yes, 2 = No

18. If the answer is yes in question 17 above, mention some of the health effects you know.

a) …………………………………………………………………………………………

…

b) …………………………………………………………………………………………

…

c) ………………………………………………………………………………..…………

d) …………………………………………………………………………………………

…

e) …………………………………………………………………………………………

…

19. If the answer is yes in question 1 above, what protection measures do you take when applying pesticides?

a) …………………………………………………………………………………………

…

b) …………………………………………………………………………………………

…

c) …………………………………………………………………………………………

…

d) …………………………………………………………………………………………

…

20. Is pesticides also applied to tomatoes after harvesting? 1 = Yes, 2 = No.

21. If the answer is Yes in 20 above, name the type of pesticides used?

a) …………………………………………………………………………………………

…

b) ………………………………………………………………………………………

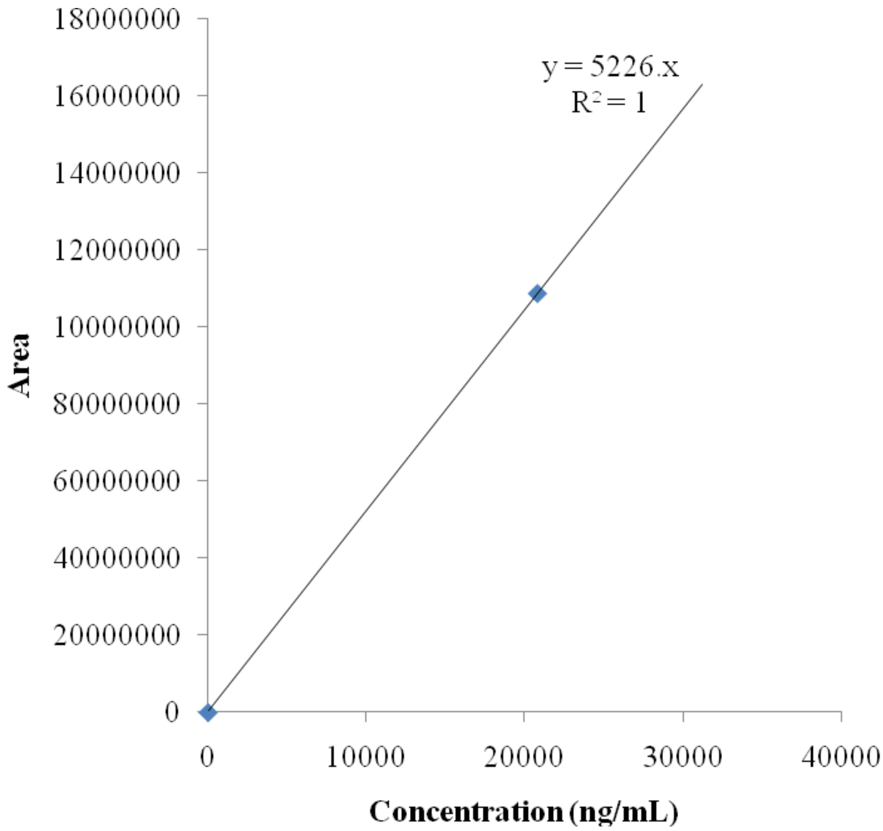
…

22. How many growing seasons do you grow tomatoes? ……………………….……………

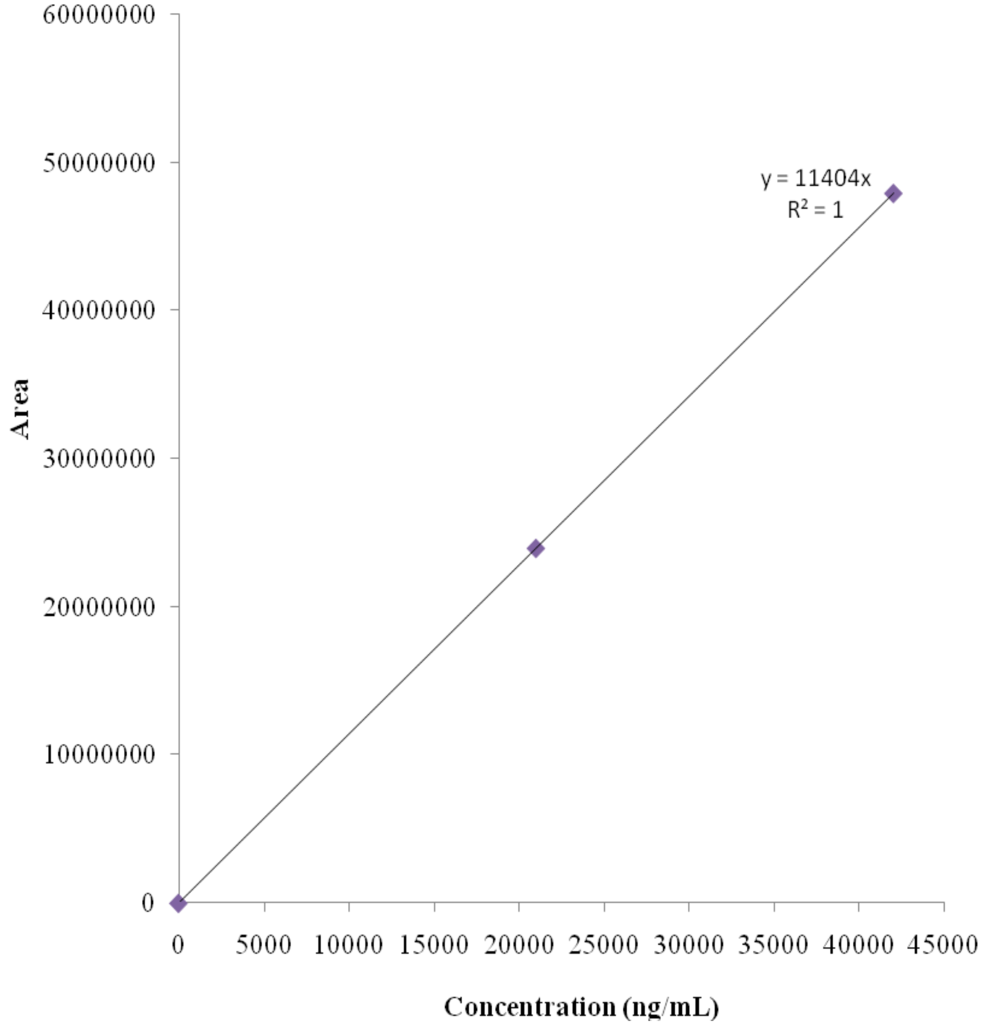
23. What is the average annual gross income from tomatoes growing activities?................

Appendix 2: **Calibration curves for profenofos, heptachlor, endrin and lambcyhalothrin**

Profenofos	
Concentration (ng/mL)	**Area**
0	**0**
20800	108717763

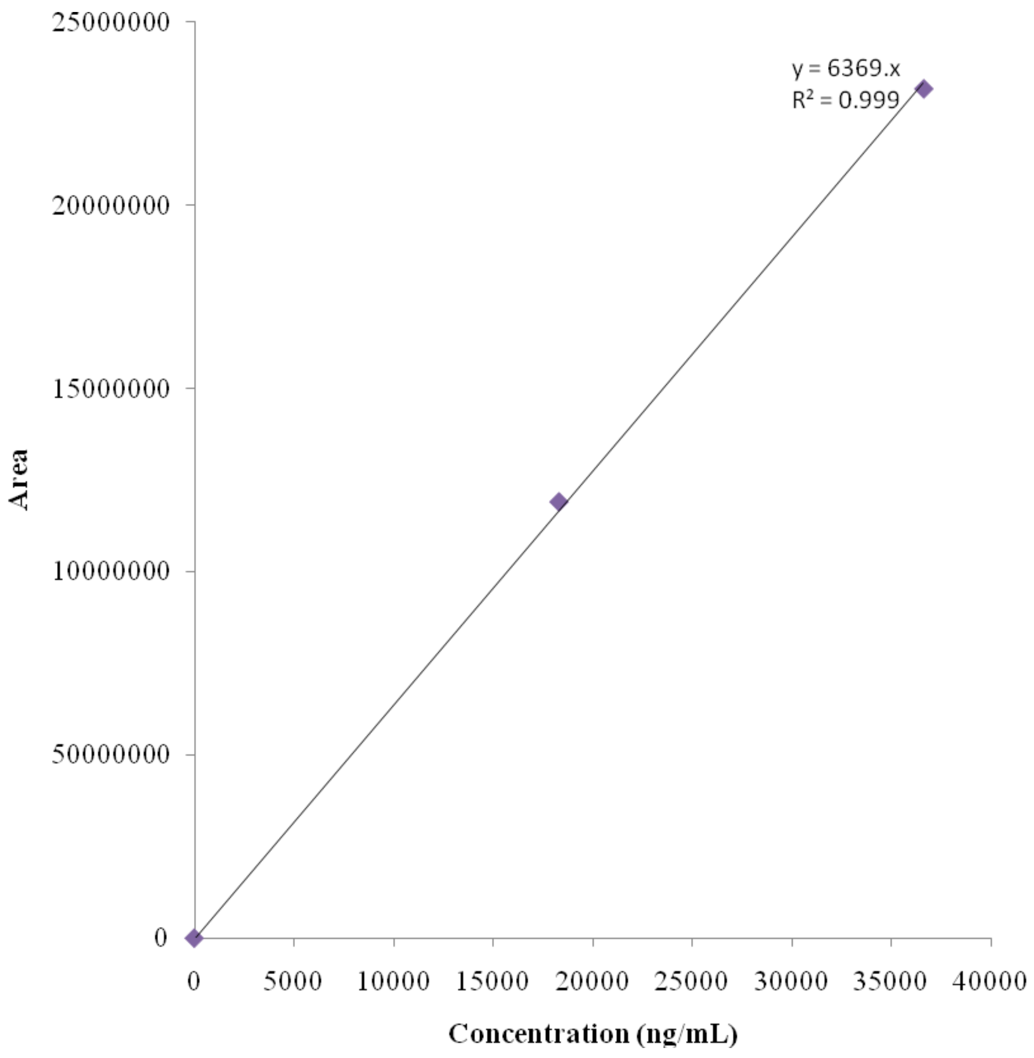


Heptachlor	
Concentration (ng/mL)	**Area**
0	**0**
21000	239479553
42000	478959106



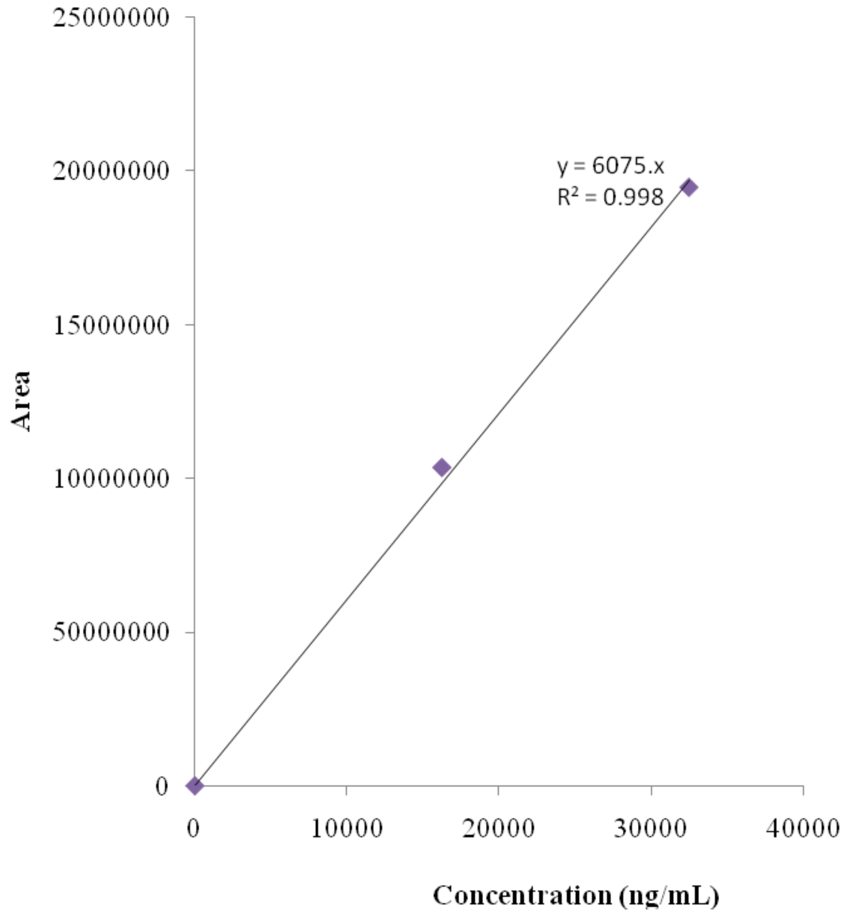
Endrin Concentration (ng/mL)	**Area**
0	0
36600	231852455

18300	119090599



Lambda Cyhalothrin	
Concentration (ng/mL)	**Area**
0	0
32437.5	194588280

16218.75	103488862



Appendix 3: **Chromatograms showing the peak areas against retention time of pesticide residues.**