

**KNOWLEDGE LEVELS OF FARMERS AND USE OF INTEGRATED PEST
MANAGEMENT PRACTICES IN HOHOE MUNICIPALITY**

BY

PETER HEH

(10443817)

**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF
GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE AWARD OF MASTER OF AGRICULTURAL EXTENSION
DEGREE**

The crest of the University of Ghana is centered behind the text. It features a blue shield with three golden stalks of grain at the top and a golden emblem in the center. Below the shield is a golden banner with the Latin motto "INTEGRI PROCEDES" in blue capital letters.

**DEPARTMENT OF AGRICULTURAL EXTENSION
COLLEGE OF AGRICULTURE AND CONSUMER SCIENCES
UNIVERSITY OF GHANA, LEGON**

AUGUST, 2014

Declaration

I, Peter Heh, author of this dissertation, do I hereby declare that, except for the references to other people's work, which have been duly cited, this work is the result of my own original research and that, this dissertation has neither in whole nor in part, been presented for any degree elsewhere.

.....
PETER HEH

(STUDENT)

.....
DATE

.....
DR. JONATHAN N. ANAGLO

(SUPERVISOR)

.....
DATE



Abstract

Although IPM has been advocated as a means of reducing chemical insecticide application, adoption of IPM practices are however, inadequate in the Hohoe Municipality and this may be attributed to a number of socio-economic and institutional factors. The study therefore sought to determine the knowledge levels and use of IPM practices by rice farmers. Survey research design was used for the study. Multi-stage sampling procedure was used to select 120 rice farmers. Both descriptive and inferential statistical tools were used in the data reduction and interpretation. It was observed that training had a significant influence on the use of IPM by rice farmers. It was also noted that the knowledge level of the rice farmers in IPM had a significant influence on the level of use of IPM. It was however found that majority of the rice farmers have low knowledge levels in IPM practices. It is recommended that in the pursuit of IPM as an agronomic practice, policy makers should include training as a pivotal objective to equip farmers with the requisite skills of using it. This will help increase the level of knowledge on IPM and subsequently enhance its adoption by farmers. It is also recommended that the extension service directorate in the district should endeavour to make IPM information readily available to the rice farmers.

Dedication

This work is dedicated to my dear wife Mrs. Rejoice and children.



Acknowledgement

The development of this thesis has been possible due to the immense contribution, assistance and encouragement of several people. Indeed I am deeply indebted to all my able lectures especially Dr Jonathan Anaglo for his constant advice, brilliant criticisms and encouragement which motivated me to complete the work.

The efforts of Mr. Leonard Heh, Mr. William Afari and the AEA's in the three communities are highly acknowledged. I am very grateful to the WAA Project for sponsoring me to undertake this course and the government of Ghana for granting me study leave. Finally, I acknowledge with much thanks, the encouragement, cooperation and constructive discussions I had with Dr Pascal Atengdem.



TABLE OF CONTENTS

Content	Page
Declaration	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Tables	viii
List of Figures	ix
List of Abbreviations	x
 CHAPTER ONE: OVERVIEW OF INTEGRATED PEST MANAGEMENT PRACTICES	 1
1.0 Introduction	1
1.1 Background of the study	1
1.2 Problem statement	3
1.3 Research questions	5
1.4 Objectives of the study	6
1.5 Justification of the study	6
1.6 Profile of the study area	7
1.7 A conceptual framework for the study	9
1.8 Scope of the study	10
 CHAPTER TWO: LITERATURE REVIEW	 11
2.0 Introduction	11
2.1 Historical development on integrated pest management	11
2.2 The Integrated Pest Management (IPM)	13
2.3 The six IPM program essentials	15

2.4	Farmer knowledge as a predictor of IPM adoption	18
2.5	Concept of farmer knowledge	19
2.6	Diffusion of knowledge	20
2.7	Socio-economic factors influencing knowledge acquisition	21
2.8	Farmer Field Schools (FFS)	25
2.9	Mass media	27
2.10	Community-based groups	29
2.11	Cultural control	29
2.12	Sanitation	30
2.13	Resistant varieties	30
2.14	Biological and natural control	32
2.15	Chemical control	34
2.16	Physical control	34
2.17	IPM decision making threshold levels	35
2.18	Farmer to farmer extension	37
2.19	IPM technology adoption in agricultural production	39
2.20	Summary	42
CHAPTER THREE: METHODOLOGY		43
3.0	Introduction	43
3.1	The research design	43
3.2	Population of the study	43
3.3.	Sampling technique and sample size	44
3.4	Pre-testing	44
3.5	Data collection instrument	45
3.6	Data collection procedures	45
3.7	Method of data analysis	45
3.8	Analytical methods	46
3.9	Summary	47

CHAPTER FOUR: RESULTS AND DISCUSSION	48
4.0 Introduction	48
4.1 Description of respondents	48
4.2 Objective 1: Socio-economic and institutional factors that influence the use of IPM by rice farmers in Hohoe Municipality	50
4.2.1 Influence of age on use of IPM by rice farmers	50
4.2.2 Influence of sex on use of IPM By rice farmers	51
4.2.3 Influence of education on use of IPM by rice farmers	52
4.2.4 Influence of farm size on use of IPM by rice farmers	52
4.2.5 Influence of training on use of IPM by rice farmers	53
4.2.6 Influence of access to information on use of IPM	54
4.3 Objective 2: Assess the relationship between knowledge and use of IPM practices among rice farmers	55
4.3.1 Use of IPM practices by farmers	55
4.3.2 Influence of knowledge of IPM practices on its use	56
4.4 Summary	58
 CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS	 59
5.0 Introduction	59
5.1 Summary	59
5.2 Conclusions	60
5.3 Recommendations	61
 References	 62
Appendix	70

LIST OF TABLES

Table 4.1	Description of respondents	49
Table 4.2	Influence of age on use of IPM	51
Table 4.3	Influence of sex on use of IPM	51
Table 4.4	Influence of level of education on use of IPM	52
Table 4.5	Influence of farm size on use of IPM	53
Table 4.6	Influence of training on use IPM	54
Table 4.7	Influence of access to IPM information on use of IPM	54
Table 4.8	Level of use of IPM practices	56
Table 4.9	Influence of knowledge on use of IPM	57

LIST OF FIGURES/MAPS

		Page
Figure 1.1	Map of Hohoe Municipality	8
Figure 1.2	Conceptual framework	10

LIST OF ABBREVIATIONS

AEA	-	Agriculture Extension Agent
DDT	-	Dichloro-Diphenyl-Trichloroethane
EPA	-	Environmental Protection Agency
FAO	-	Food and Agricultural Organisation
FFS	-	Farmers Field School
HYV	-	High Yield Variety
IPM	-	Integrated Pest Management
MoFA	-	Ministry of Food and Agriculture
PAN	-	Pesticide Action Network
SPSS	-	Statistical Package for Social Scientist
T &V	-	Training and Visits

CHAPTER ONE

OVERVIEW OF INTEGRATED PEST MANAGEMENT PRACTICES

1.0 Introduction

This chapter presents a background of the study, the problem statement, research questions, research objectives, justification of the study of the study, profile of the study area, and conceptual framework of the study and scope of the study.

1.1 Background of the Study

Environmental concerns such as depletion of natural resources, pollution of soil, air, water and chemical residues in foods have become important topics in agricultural production (Patel, Chauhan & Korat, 2007). Rising concern of public health risk of pesticides use as well as its burden on the environment has added momentum to the need to re-evaluate the current chemical-based Pest Management practices (Maumbe and Swinton, 2000). Sonwa, Coulibaly, Adesina, Weise & Tchatat (2004) noted that in most developing countries, the information, training and extension services encourage the use of chemical products for plant protection. The evolution of the IPM concept shows a remarkable change in its technical contents: from threshold theory in the late 1950s to growing a healthy crop in the 1990s (Van Huis and Meerman, 1997).

Integrated Pest Management (IPM) is a holistic way of thinking that improves the ability to mitigate the negative impacts of pests in agricultural production, horticulture, buildings and other situations, while at the same time reducing costs and

improving environmental quality (Maupin & Norton, 2010). Benefits of the IPM approach extend well beyond just the improvement in short term economic return. Potential reduction in the development of insecticide resistance has considerable long-term economic implications (Trumble, 1998). Malone, Herbert & Pheasant (2004) in their studies concluded that lack of familiarity, time, and resources were recurring reasons for non- use of IPM practices; therefore researchers and extension personnel should develop and emphasize IPM programs that are economical and easy to use. Alston & Reding (1998) indicated that lack of knowledge/information; higher cost; higher risk; difficult to use; greater time and labour; lower quantity of yield lower quality of yield; not interested in using; not aware of programs; and lack of confidence in information, are perceived impediments to use of IPM practices.

Both agricultural productivity and pesticide use have increased continuously during the post war period (Robinson and Sutherland, 2002). To reduce crop loss, farmers often spray hazardous insecticides like organophosphates and organochlorine up to five to six times in a cropping season when two applications may be sufficient. Pesticide use in the African agricultural sector is likely to increase as a result of the growing commercialization as well as the growing focus of development agencies on improving yields of small farmers (Nelson et al., 2001).

Pesticide use in Africa accounts for less than 5% of global pesticide use and per hectare averages are low, estimated at around 1 kg/ ha active ingredient applied (compared with 3- 7kg/ ha in Latin America and Asia) (PAN, 2010). Pesticide use in

Africa accounts for only 2–4% of the global pesticide market of US\$31 billion. However, low use volumes do not necessarily equate to low risk, particularly as some of the most toxic pesticides continue to be applied in Africa especially in West Africa, often under extremely dangerous conditions (PAN, 2010). Though, there are differences in the rate of agrochemicals application across the agro ecological zones, pesticide use was high in dry savannah of West Africa (Ephraim, Pender, Kato, Omobowale, Philip, & Ehui, 2010).

IPM was first developed in response to environmental concern about the abuse or overuse of chemicals pesticides associated with intensive input agricultural system in developing countries. The traditional approach was to develop pest and disease control alternative to reduce or eliminate the use of chemical pesticides. The role of extension was to transfer and disseminate those technologies and practices directly to farmers.

1.2 Problem Statement

Rice is a major crop produced in the Hohoe municipality alongside other major crops such as maize, cassava, vegetables and mangoes. Misuse of pesticides such as insecticides and herbicides has been observed to have a negative effect on crops, animals and the general environment. This improper use reduces bio-diversity, creates development of resistance to pesticides and contamination of food and ecosystems (Mauceri, 2004; Birthal and Sharma (2004). Over dosage burn the crops. It also rendered farm workers susceptible to neurological anomalies, respiratory ailments, reproductive and dermal problems.

Although IPM has been advocated as a means of reducing chemical insecticide application, adoption of IPM practices are however, low in the municipality and this may be attributed to a number of socio-economic, institutional and policy constraints. Sometimes, farmers' decisions not to adopt IPM practices were also influenced by their negative perceptions beliefs and attitudes towards the practice (Katti, Pasalu, Rao, Varma & Krishnaiah, 2004). Thus farmers continued to misuse pesticides, continuing to poison the environment, humans and animals.

IPM is a broad concept that is composed of a complete range of control methods including biological, cultural genetic, physical and chemical and the integrated use of these methods (Hoyt, 2001; Rejesus, Palis, Lapitan, Chi & Hossain, 2009). A major method of disseminating IPM information is the use of Farmer Field Schools (FFS) and in some cases, 'No Early Spray' (NES). According to Krishnamurthy and Veerabhadraiah (1999), FFS was originally developed as an extension methodology for IPM in rice in Indonesia in 1990. It is a way of introducing farmers to discovery based learning for dealing with pest management issues in particular and crop management concerns in general. It has therefore been widely used as a valuable extension tool. The success of IPM adoption depends largely on eliminating barriers to its adoption, such as the socio-economic situations of the farmers, knowledge dissemination and acquisition, institutional and policy considerations.

According to Kumari (2012), inadequate usage of IPM was due to lack of, or inadequate IPM knowledge among rice farmers. As pointed out by Bonabana-Wabbi (2002), access to agricultural information and knowledge levels of farmers are important for the implementation of IPM programs. However, Van Mele, Cuc and Van Huis (2001) identified lack of information about farmers' knowledge as a major constraint to establishing an IPM program. For example, there is a variation in the knowledge of pests and pest ecology between farmers working in similar or different ecosystems where pest recognition could be a major problem (van Huis and Meeman, 1997). Generally, it was observed that farmers who attended FFS practised IPM more than farmers who had not attended FFS (Rola, Jamia and Quizon, 2002; Rejesus, Palis & Lapitan, 2009; Kumari, 2012).

Birthal and Sharma (2004) observed that socio-economic factors retarded the acquisition of IPM knowledge and hence farmers' adoption of IPM technologies. This resulted in negative perception of IPM technologies, which then contributed to the farmers' failure to adopt them (Mugisha, Ogwal-O, Ekere and Ekiyar, 2004; Chi, 2008; Borkhani, Fami, Rezvanfar and Pouratachi, 2011).

1.3 Research Questions

The main research question is what are the knowledge levels and use of IPM practices by rice farmers in Hohoe? The specific research questions are as follows:

1. What socio-economic and institutional factors of farmers influence the use of IPM in rice production?

2. What is the relationship between knowledge and use of IPM practices among rice farmers?

1.4 Objectives of the study

The study aimed at assessing the knowledge levels and use of IPM practices of farmers in Hohoe Municipality.

Specific Objectives:

1. To find out the socio-economic and institutional factors that influenced the use of IPM in rice production.
2. To assess the relationship between knowledge and use of IPM practices among rice farmers

1.5 Justification

Agriculture is the main source of livelihood, for over 80% of the population in the Hohoe municipality. The livelihood of these people largely depends on rice, maize and cassava. However, productivity of their farm produce is relatively low due to lack of technical know-how such as excessive use of pesticides on their farms.

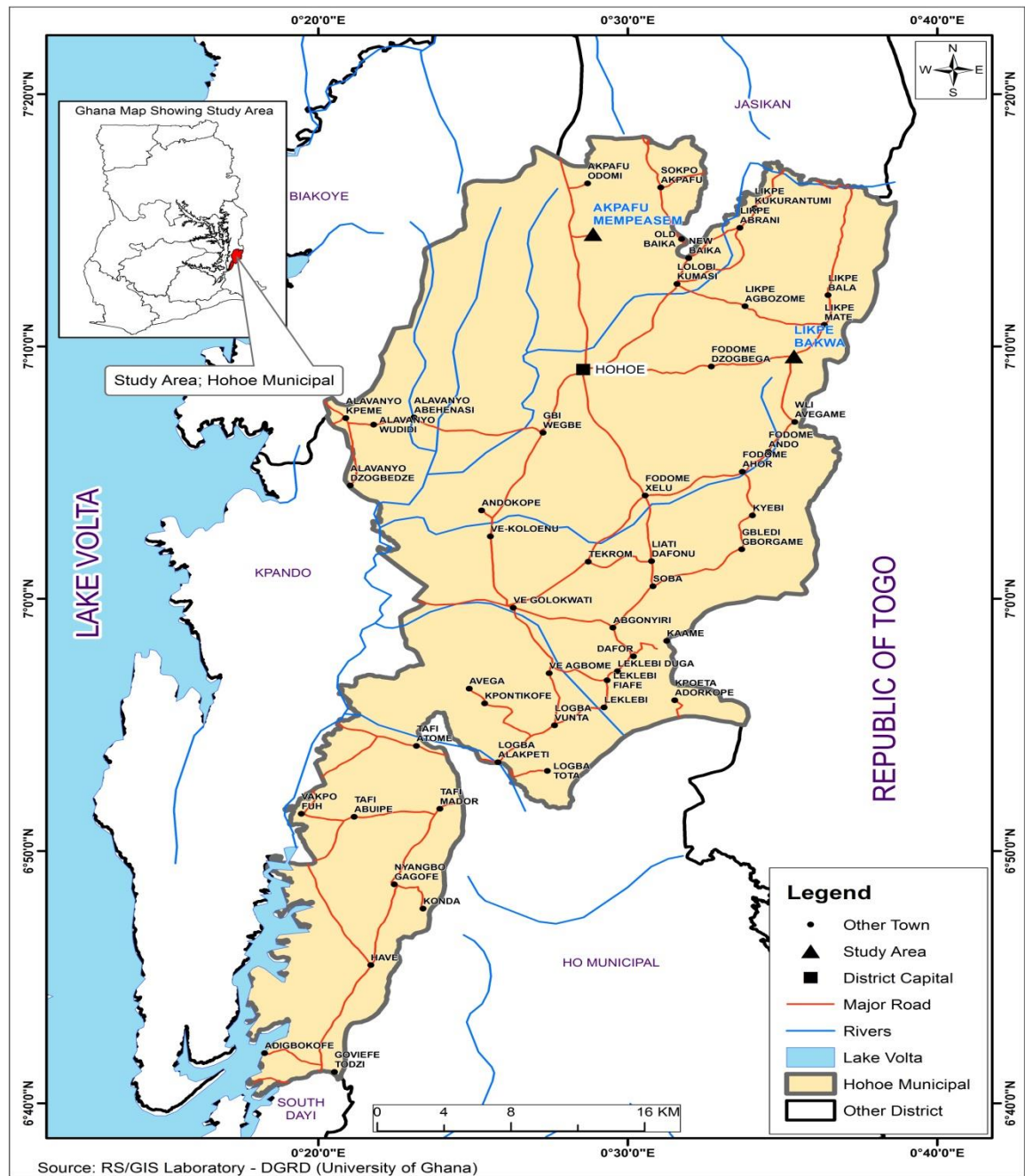
Most of the farmers in the municipality do not follow the guidelines for the use of these pesticides and therefore causing harm to themselves and the crops in over or under use dosage of these chemicals. Some farmers sometimes lost their crops due to over dosage which burned the crops or using the wrong chemical which is undermining the food security in the country. The study is likely to come out with reasons

why farmers are not fully using IPM strategies and still use pesticides excessively. Findings will help policy makers to make new recommendations on the use of pesticides. It will also help them to regulate the distribution and sale of pesticides in the Municipality to get rid of illegal dealers.

1.6 Profile of the Study Area

Hohoe Municipality, (Fig. 1) situated in the centre of the Volta Region, with Hohoe as its capital, was created in 1979. The republic of Togo borders the municipal to the east, whilst to the west is Kpando District. On to the north-west is Jasikan District and to the south is Ho Municipal. The Municipal houses part of the Akwapim-Togo ranges extending beyond the country's eastern boundary all the way to Western Nigeria (MoFA, 2013).

Within these ranges is the Mountain Afadzato, the highest elevation in Ghana (880.3m). River Dayi (a perennial water source) which drains the whole municipality together with other smaller ones make it possible for small irrigation especially for dry season cultivation of vegetables. The municipality has vast suitable land for both upland and lowland rice cultivation and the bimodal rain pattern is an added potential for crop production. Out of the 117,200 ha of land area of the municipality, about 55,000ha (47%) are suitable for crop production and about 10,000 ha, (8.5%) as pasture land. Out of the available land for crop production, only about 22% are under effective cultivation. The first choice crops of importance to the indigenes is rice, maize and cassava.

Figure 1.1 Map of Hohoe Municipality

The Hohoe Municipality has a very good road network within the municipal, which facilitates movement from the rural areas to the municipal capital. There are 390km of road network in all, made up mainly of feeder roads. The Municipal capital is

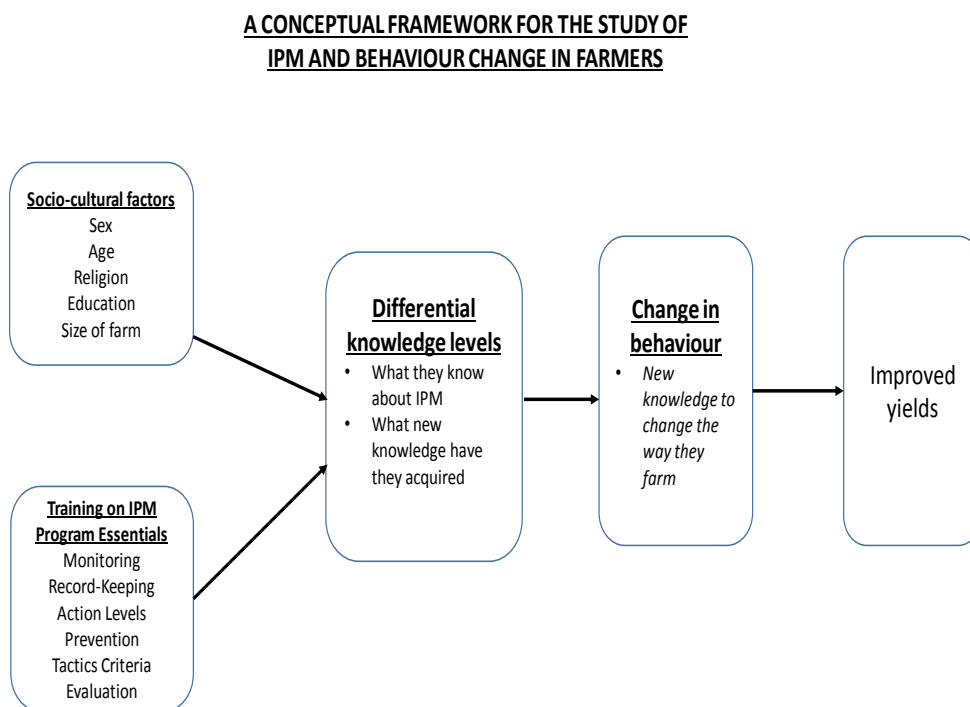
however linked up to the regional capital, Ho and Accra, the National capital by first class roads (MoFA, 2013).

1.7 A Conceptual framework for the study

The socio-cultural factors such as sex, age, religion and education can affect the knowledge levels of farmers concerning IPM practices and knowledge acquisition. Leeuwis (2004) refer to knowledge as basic means through which we understand and give meaning to the world around us. Training on IPM program essentials like monitoring, record-keeping, action level, prevention and tactics criteria can also affect knowledge level of farmers because this can safe guard their production and attitude toward IPM practices.

This difference in knowledge can lead to change in behaviour, new knowledge and new way of farming which would lead to increase in yield and sustainability of the environment for continuous production and less poisoning of our food crops.

The researcher conceptualised that socio-economic and institutional factors including age, sex of farmers, level of formal education attained, farm size, access to information on IPM, training on IPM will all have influence on the knowledge level of the farmers on IPM practices. This will all influence the level of use of IPM in the study area and also on rice production in the study area.

Figure 1.2 Conceptual framework

Source: Author's construct, 2014

1.8 Scope of the study

Chapter one was devoted to background of the study, problem statement, research questions, objectives of the study, justification of the study, conceptual framework of the study, profile of the study area and scope of the study. The rest of the chapters are as follows. Chapter two is devoted to review of relevant literature that spans the concepts in this study, chapter three presents the methodology of the study, chapter four presents the results and discussions of findings and chapter five finally presents the summary, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter consists of a definition of IPM, outline of its importance, benefit to human beings and the environment. The chapter also looks at the practices of the farmers, (the methods that they are using to combat weeds and pests in their farms), knowledge acquisition, and diffusion of knowledge among farmers, training and education.

2.1 Historical Development of Integrated Pest Management

There were constant threats from severe food shortages and famines in the ancient times. These threats were posed by outbreak of insects like locusts, armyworms, stem borers and plant hoppers. Weeds and vertebrate pests also accounted for the food loss. Over the past two hundred years, major developments in the knowledge of insect pests and diseases occurred and the current advancements in molecular biology promised further revolutionized pest control tactics. The early twentieth century marked the discovery of DDT (Dichloro-Diphenyl-Trichloroethane) that evolved the era of insecticide use. Rapid development of chemically based control as “silver bullet” thinking occurred. Not until the realization of some insects becoming resistant to insecticides, killing of insects was the preoccupation rather than producing crops or maintaining the environment. The changes in the mind-set of the people in the late twentieth century that chemicals did not solve all insect problems led to general

concerns about the pest resistance problems posed by indiscriminate use of chemicals (Robert, Claire, Tyler & Douglas, 2004).

Integrated Pest Management (IPM) is a program of prevention, monitoring, and control which offers the opportunity to eliminate or drastically reduce the use of pesticides, and to minimize the toxicity of and exposure to any products which are used. IPM does this by utilizing a variety of methods and techniques, including cultural, biological and structural strategies to control a multitude of pest problems (Maupin & Norton, 2010).

The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options, but not limited to, the judicious use of pesticides. In contrast, organic food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals (Maupin & Norton, 2010).

This led to thinking more on balanced ecological view of pest control that called for conserving non-target organisms and beneficial insects. Thereafter, biological and ecological information were mapped to design a pest control strategy which is now universally known as IPM. The concept encompassed the use of insecticides in a manner that was compatible with biological control of insects integrated with other control tactics. Gradually, the paradigm of IPM techniques opened new avenues for

pest management on an ecological basis taking into consideration environmental conservation in the wake of producing more rice for the explosive populations of the world.

The scientific basis of “Integrated Pest Control” evolved over a period of about 10 years, mainly among researchers at the University of California, Berkeley and Riverside campuses. The concept was explicitly defined in 1965 at a symposium sponsored by the Food and Agriculture Organization (FAO) of the United Nations, held in Rome, Italy. The concept of “Integrated Control”, originally limited to the combination of chemical and biological control methods was greatly expanded in that symposium, and redefined to become synonymous with what we presently consider IPM. Thus the concept of “integration” stemmed from foundations established in the U.S.A. Concurrently, however, the concept of “Pest Management” that had been proposed by Australian ecologists in 1961, started receiving greater recognition in the U.S.A. Publication of Geyer’s Annual Review of Entomology article in 1966, a report by the US National Academy of Sciences, and the proceedings of a conference held in North Carolina which included participation by the original proponents of pest management from Australia (Rabb and Guthrie 1970 cited in Bajwa and Kogan, 2002), provided the impetus for that recognition.

2.2 The Integrated Pest Management (IPM)

The IPM programs use the most economical combination of cultural, physical, and least hazardous chemical controls to manage pest infestations and minimize damage (Brenner et al., 2003). Based on an assessment of the problem, the treatment options

range from “no action taken” to the use of an effective, least-toxic pesticide. Non-chemical methods that include tolerance, sanitation, and exclusion are preferred, and least-toxic pesticides are used when non-chemical treatments are ineffective. Least-toxic pesticides are defined as those labelled “CAUTION” or those exempt from EPA registration (Brenner et al., 2003). Exceptions are made when pest related medical risks are high and current IPM options have previously been deemed ineffective. Pesticide treatments are conducted during appropriate times to maximize the efficacy of the products and minimize the potential for human exposure. All pesticides are handled according to state and federal laws. Species-specific plans to prevent and expeditiously manage pest problems need to be developed. These plans should accomplish the following objectives to maintain a safe and healthy environment (Altman, 2007).

Some of the method of IPM practices is to protect residents by suppressing pests that threaten public health and safety and also to minimize exposure of residents to pesticides by responsibly applying least-toxic pesticides only when needed. Secondly by preventing or reducing any pest damage to properties through accurate pest identification and actions based on knowledge of the pest’s biology, this can be followed by reducing environmental pollution through the careful selection and proper placement of pesticides. This would enhance the quality of life for the people who work or reside in the structures by maintaining a safe and sustainable environment.

2.3 The Six IPM program essentials

This section reviews literature on the six IPM essentials namely; monitoring, record keeping, action threshold, prevention, tactics criteria and control. There is also evaluation.

Monitoring

This includes regular site inspections and trapping to determine the types and infestation levels of pests at each site. Monitoring is a major component of an IPM program. It is essential for detecting and locating the source of an infestation (Wang and Bennett, 2006). Monitoring is also helpful for determining the success of the treatment options (Rust, 1994). Monitors, which are various kinds of traps, are placed throughout structures during the initial inspection. The monitors are then checked for insects during routine service. Monitor placement is important to get an accurate assessment of the pest problem (Wang and Bennett, 2006). Monitors should be placed in locations where insects are commonly observed. Not all insects, weeds, and other living organisms require control. Many organisms are innocuous, and some are even beneficial. IPM programs work to monitor for pests and identify them accurately, so that appropriate control decisions can be made in conjunction with action thresholds. The monitors should be placed where they are not disturbed or affected by factors that may hinder their performance, including under sinks, behind the stove or refrigerator, in cabinets, and in closets (Hollingsworth, Coli, Murray, & Ferro, 2002). If a pest is detected during an inspection, the proper IPM option should be taken.

Record Keeping

A record-keeping system is essential in IPM programs in order to gather data about types of pest outbreaks, establish trends and patterns in pest outbreaks and hence attempt to predict future pest outbreaks. Information recorded at every inspection or treatment should be recorded in a logbook. This would include pest identification, population size, distribution, recommendations for future prevention, and complete information on the treatment action. A section of each logbook is reserved for use by staff to alert the pest management technician of pest sightings between scheduled services.

Action Threshold

IPM first sets an action threshold, before taking any pest control action; pests are virtually never eradicated but reduced to minimum level. An action level is the population size which requires remedial action for human health, economic, or aesthetic reasons. It is a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

Prevention

As a first line of pest control, preventive measures must be incorporated into the existing structures and designs for new structures. IPM prevention is and should be the primary means of pest control in an IPM program. In rice-farming, this means

using cultural methods, such as rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

Tactics Criteria

Under IPM, the last resort method for farmers should be chemicals, but when used, the least-toxic materials should be applied to minimize exposure to humans and all non-target organisms.

Control

Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective less risky pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding. If further monitoring, identifications and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides.

Evaluation

In IPM a regular evaluation program is very essential to determine the success of the pest management strategies. Observation and monitoring of data are periodically summarized and reviewed to evaluate the program effectiveness and sustainability.

IPM practices and procedures are continually adopted and modified based on past experience and results, and knowledge, gained over time, of the problems associated with each facility. Evaluating farmer's knowledge and perception of pests and natural enemies is especially useful to set research agendas, for planning campaign strategies and developing messages for communication (Fujisaka, 1992; Escalada and Heong, 1993).

2.4 Farmer Knowledge as a Predictor of IPM Adoption

The knowledge intensive nature of IPM means that it is widely assumed that improved knowledge (defined as the outcome of an active learning process) is a key prerequisite for the adoption of IPM practices. Similarly, the literature on agricultural innovation, starting with Rogers (1995), asserts that awareness and knowledge of a new technology is the first step in the adoption process. The agricultural innovation literature suggests that knowledge only translates into adoption if a set of enabling factors and conditions exist, including farmers' positive perception of the technology's benefits (Adesina and Zinnah, 1993), access to complementary inputs (e.g. seed, fertilizer) (David, Mukandala & Mafuru, 2002), tender arrangements and labour availability (Feder, Just, & Zilberman, 1985).

Farmer Field Schools (FFS) impact studies typically investigate both farmers' adoption and knowledge of IPM practices and most document superior technical knowledge among FFS graduates compared with non-FFS farmers. A few studies go further to assess the relationship between IPM knowledge and adoption or increased productivity. While increased appreciation of natural enemies among Sri Lankan

farmers did not translate into reduced insecticide application, a change in knowledge about leaf feeding insects was correlated with reduced insecticide use (Tripp, Mahinda & Hiroshini, 2005). Regression results from a study of cowpea IPM in Uganda showed IPM knowledge was the most important variable in explaining the adoption of five IPM strategies (Erbaugh, Donnermeyer & Amujal, 2007). Godtland, Sadoulet, de Janvry, Murgai & Ortiz (2004) report that improved knowledge about IPM practices significantly impacted potato productivity positively. These results suggest that technical knowledge among FFS graduates is not only valuable as an outcome impact indicator, but could also serve as a reasonable way to reliable predictor of the adoption of management practices, particularly for crops and technologies where there is a relatively long time lag between adoption and impact.

2.5 Concept of Farmer Knowledge

Concept such as meaning', 'interpretation and perception 'are largely synonymous to knowledge. They refer to the outcome of applying knowledge to a particular situation. Leeuwis (2004) referred to knowledge as basic means through which we understand and give meaning to the world around us.

He further described knowledge as collection of interconnected schemes of interpretation that we have available in our heads which can be mobilized to give meaning to particular situation. Therefore knowledge remains essentially in people's heads which can be made tangible as information. Thus is knowledge that has been

captured and stored in a physical or electronic form such as books, files, newspapers, pictures, sound, and websites among others (Leeuwis, 2004).

Knowledge can therefore be regarded as the body of mental inferences and conclusions that people build from different elements of information, and which allow them to take action on a given context. In many ways human actions and practices, as well as technologies and other material artefacts such as machines, seed and varieties, roads and bridges for example can be seen as tangible expression of knowledge. There is increasingly, a growing realization that knowledge is an important resource that can contribute to poverty alleviation among resource poor farmers. Knowledge is now if not more, an important factor for development and this trend is to intensify, and farmers in many countries have been able to increase their productivity mainly by using more knowledge in the production process. Different types of knowledge are needed in agriculture for developing solution to different development problems. Different groups of people or institutions can develop a specific type of knowledge or a specific type of knowledge can be developed jointly by different actors through a process of social learning (Van de Ben, 2002)

2.6 Diffusion of Knowledge

The effectiveness of the diffusion process is of great practical importance in the design of farmer knowledge enhancement strategies, as it affects the cost effectiveness and financial sustainability of publicly funded farmer information services such as extension and adult education. If information diffuses extensively from farmer to farmer through informal communication, then a relatively small effort, focused on a

nucleus of farmers trained (or contacted regularly) by knowledge agents, could achieve a large impact at a reasonable cost. If, however, the knowledge that is expected to be diffused is complex, or otherwise deals with technology that is costly, the diffusion process among farmers may be slow and limited. The number of farmers who will need to be trained directly will have to be large if a significant impact is to be achieved. This implies higher program costs, and a greater challenge to economic viability and financial sustainability. These are indeed matters of great concern, as financial issues have afflicted many agricultural knowledge systems in both developed and developing countries (Hanson and Just, 2001).

2.7 Socio-economic factors influencing knowledge acquisition

Variables reviewed under this category include; sex, age, religion, educational level, household size, and farm size.

Sex

Sex of the household head is a factor that limits access to and use of agricultural information. Women are traditionally occupied by household chores while the man has the liberty of mobility, participate in different meetings and trainings consequently have greater access to agricultural information which subsequently help them in acquisition of new knowledge on farm practices. Also male-headed households tend to build and maintain larger network ties with relatives and friends than female-headed households (Katungi, 2006). Nambiro, Omiti & Mugunieri (2006) in assessing access to agricultural extension in SSA found out that sex is an important determinant in the seeking of

Agricultural information. Male farmers sought for agricultural information than their female counterpart. A positively significant relationship was established between sex of household head and adoption of improved agricultural technologies in Irish potatoes (Namwata, Lwelamira & Mzirai, 2010). On the other hand, Doss & Morris (2001) found out that there was no significant relationship between sex and access to agricultural information.

Age

Age is also one of demographic characteristics which describe how long a person has been in existence. Young farmers are ardent to get knowledge and information than older farmers. It might also be that older farmers want to avoid risk and are not likely to be flexible than younger farmers and thus have a lesser likelihood of information utilization. But several studies report different results; Nkamleu, Coulibaly, Tamo & Ngeve (1998) reports of older farmers being more experience and have accumulated more capital as a result they are more likely to invest in innovation. Similarly, Yenealem (2006) reported positive relationship between age and adoption behaviour of farmers.

However, Haba (2004) suggest that older people were unwilling to pay for agricultural information delivery technologies such as print, radio, farmer-to-farmer, expert visit, and television. He revealed that, as age increased, the willingness to pay for these agricultural information delivery technologies decreased, meaning that older farmers were less willing to get information than younger ones. Old age also increases with conservativeness and negatively impact on adoption while young farmers tend to be more innovative and risk adverse (Zhang, Li, Xiong & Xia, 2012; Adesina, Mbila, Nkamleu & Endamana, 2000).

A study conducted by Deribe (2007) on diary women farmers proved that age has a negative influence on agricultural information network of farm women. The study is that older women do not seek many new ideas, since they try to conform to practices they have followed for a long time in their life. Ayele and Bosire (2011) also found out that both younger and old tried new things introduced to them thus there was no significant relationship between age and the use of improved inputs and practices.

Educational level

Education generally is associated with receiving and absorbing of agricultural information and use of the information. Because education is believed to increase farmers' ability to obtain, process and analyze information disseminated by different sources and helps him/her to make appropriate decision to utilize agricultural information through reading and analyzing in a better way. The ability to read and understand sophisticated information that may be contained in a technological package is an important aspect of access to agricultural information. Hence the educational level of an individual will play a significant role in knowledge acquisition (Zeta, 2009).

Rehman et al. (2013) found out that education of respondent had a significant relationship with their access to agricultural information; an increase in the educational level of the respondents increased their access to agricultural information.

Better education according to Okoye et al. (2008) would lead to improved access to knowledge and tools that enhance productivity. However, Julius, (2013) established that

irrespective of farmers educational level it had no influence on their access to agricultural extension services.

With regard to the use of agricultural information, Ofuoku et al. (2008) posit a positive significant relationship between level of formal education of fish farmers and information use. According to Waller, Hoy & Henderson (1998), education is expected to create a favourable mental attitude for the acceptance of new practices especially of information-intensive and management intensive practices.

Farm Size

Rehman et al. (2013) in studying effects of farmers' socio-economic characteristics found a highly significant relationship between respondent size of land holding and their access to agricultural information. Similarly, Saadi, Mahdei & Movahedi (2008) who also found a highly significant relationship between land holdings of the respondents and their access to information. This means that the quest for new knowledge by farmers is partly influenced by their farm sizes. It implicitly suggests that farmers with large farm sizes will strive to acquire more knowledge in order to improve on their current agronomic practices in order to maximize output.

Cocoa farmers with large farm sizes are usually wealthy and there is more likelihood that they would readily adopt any high inputs innovation. Large farm size facilitates easy realization of the benefits due to economy of scale (Zhang et al., 2012).

Akudugu, Guo & Dadzie (2012) found farm size a significant positive relationship farm size and farmers' adoption of modern agricultural production technologies, the bigger the size of a farm, the higher the probability for adoption of current ideas by farmers.

2.8 Farmer Field Schools (FFS)

Farmer Field Schools (FFS) is an adult education program used to disseminate information and technology to farmers (Van den Berg 2004). It is an interactive and participatory model used for IPM methods that is present around the world, but is especially common in many developing countries. FFS began in 1989 in Indonesia with the aim to correct the over usage of insecticides in rice farming. Today the program covers a variety of farming practices and focuses on the major crops of Sub-Saharan Africa, Asia, and Latin America. The model is also used to spread information on non-agricultural topics such as HIV/AIDS, water conservation, food security, and nutrition (Braun, Jiggins, & Roling, 2006).

A case in point is the Farmer Field School (FFS) approach to knowledge enhancement, which is gaining prominence in many developing countries. In recent years, a number of development agencies, including the World Bank, have promoted FFS as a more effective approach to extend science-based knowledge and practices to farmers. FFS is an educational/training approach to IPM information dissemination that is experience and participatory in nature, it is holistic and also information-

intensive approach that aims to strengthen farmer's capacity to address his / her own pest problems through the judicious use of different agronomic practices.

Though pioneered and first promoted by the Food and Agriculture Organization (FAO) as a practical way of diffusing knowledge intensive integrated pest management (IPM) concepts and practices for East Asian rice-based systems, the concept quickly spread all over the world. The training program utilizes participatory methods "to help farmers develop their analytical skills, critical thinking, and creativity, and help them learn to make better decisions. In this approach, the trainer is more of a facilitator, rather than an instructor, reflecting a paradigm shift in extension work (Roling and van de Fliert, 1994). The typical FFS conveys to farmer participants knowledge on agro-ecosystems analysis, within a framework of integrated pest and crop management. A great emphasis of the program has been on sensible pest management, safety with regards to chemical pesticides, and understanding of the interactions between pest insects and beneficial insects that limit the numbers and the impact of pests. With the knowledge gained in the FFS training, it is expected that farmers would practice a lower and safer use of chemical pesticides. In recent years, a number of development agencies have promoted farmer field schools (FFS) as a potentially more effective approach to extend knowledge to farmers. FFS programs were first introduced in East Asia, in the late eighties, as a way of diffusing knowledge-intensive integrated pest management (IPM) practices for rice. FFS have since been adapted to work with other crops and diseases, and have spread rapidly across Asia, Africa, and Latin America (Nelson et al., 2001).

The FFS approach represents a paradigm shift in agricultural extension: the training program utilizes participatory methods “to help farmers develop their analytical skills, critical thinking, and creativity, and help them learn to make better decisions” (Kenmore, 2002). Extension agents, who are viewed as facilitators rather than instructors, conduct learning activities in the field on relevant agricultural practices. Through interactive learning and field-experimentation, FFS programs teach farmers how to experiment and problem-solve independently, with the expectation that they will thus require fewer extension services and will be able to adapt the

2.9 Mass Media

“IPM is not for farmers but is by farmers” is often noted in IPM programmes. Getting IPM into the hands of farmers, however, is not always easy. Several methods have been developed with various levels of information and completeness. Most agricultural extension services now recognize the importance of natural enemies and are quick to point out the need to conserve them –although their promotion of various insecticides, fungicides and herbicides is often at odds with their awareness of natural enemies. Work by Heong and others from the Rice IPM Network (Huan, Mai, Escalada & Heong, 1999) includes the development of a number of interesting radio messages to spread the word on a large scale that early spraying of insecticides during the first 40 days of the crop is not necessary and in fact increases the risk of higher pest populations later in the crop season. In many cases these radio messages are accompanied by field-based plant compensation participatory research groups (Heong

and Escalada, 1998). This programme has been very effective in increasing awareness of the negative impact of insecticides on natural enemies and the role of plant compensation in recovering without yield loss from early season pest damage, and has resulted in a reduction of early insecticide spraying where it has been implemented.

Furthermore, these mass media programmes are complementary to community study groups necessary for learning ecological principles or community organizing for community-level pests. Study groups of various types, focusing on the overall production and pest management, are now common in many rice systems, including organic agriculture, rice- duck groups, Australian rice farmer associations and many others. The FAO Community IPM Programme in Asia has promoted study groups called “farmer field schools” under which structured learning exercises in fields (“schools without walls”) are used to study both ecosystem-level dynamics transferable to other crops (e.g. predation, parasitism and plant compensation) and specific rice IPM methods. More than 1.5million farmers have graduated from field schools of one or more season’s duration in Asia over the past ten years. The field schools have proved themselves very cost-effective as an extension methodology, and many continue in some type of participatory research programme (Ooi, Warsiyah & Nguyen, 2001). In Mali, work under the Global IPM Facility and the Office du Niger with farmer groups using few pesticides has expanded the IPM methods to arrive at “IPPM” (integrated production and pest management) based on experiences from Zimbabwe and focusing on improved production methods balanced with pest management practices.

2.10 Community-based Groups

Community-based study groups, study circles, field schools and other approaches are now being integrated with sustainable funding approaches through greater reliance on community-based organizations such as IPM clubs, water-user groups, women's organizations and local farmers' unions (Ooi et al., 2001). With the large-scale World Bank-type extension programmes (T&V) generally being phased out in most countries, it will be necessary for local communities to organize themselves in such a way that they can increasingly cover the costs of expert inputs. Primary school programmes on IPM are also emerging in Cambodia, Indonesia, Thailand and other countries as part of an environmental education curriculum related to the Asian rice-culture (Ooi et al., 2001).

2.11 Cultural control

Cultural control is a method of crop protection using careful timing and a combination of agronomic practices to make the environment less favourable for the increase of certain pests or diseases (Robert et al., 2004). It includes practices such as tillage, planting/ transplanting, irrigation, sanitation, mixed cropping and crop rotation. A principle of IPM is to "grow a healthy crop". Cultural practices should therefore be adapted in such a way that the crop is in optimum condition.

Since rice production has a very long history in most Asian countries, traditional cultural practices are those that have achieved the greatest yield stability over time and that have been passed on from generation to generation. Some cultural practices also seriously affect natural enemies. These include: burning of rice stubble and/or

straw, burning of rice husk on the field prior to onion cultivation (in the Philippines), trimming of non-rice vegetation from rice bunds prior to tillage (puddling), destruction of vegetation on the field during fallow periods, and strictly synchronous rice planting over a large area. But, from plant nutrient and natural enemy conservation points of view, it is better to incorporate crop residues into the soil rather than burn them. If burning is essential, then it should be done in heaps rather than burning residue spread all over the field (Robert et al., 2004).

2.12 Sanitation

Use of clean planting material is important in IPM. Any infected plants are to be roughed and destroyed by burning in order to avoid further spread of the diseases. But, when removing dead plant parts from the field, the farmer is removing nutrients and reducing the fertility of the soil. By using the leaves and branches from king compost, the farmer can compensate for this loss. Another aspect of clean cultivation is the destruction of crop residues (Robert et al., 2004).

2.13 Resistant varieties

Certain rice varieties, such as Togo-Marshall which is more resistant to particular insect pests or diseases than others, bring about reduction in the development of the insect pest or disease populations. Sometimes, breeding for high-yielding varieties can be at the expense of pest susceptibility. The potential of using host-plant resistance as a pest control method was not fully appreciated until the mid-1960s. Considerable progress in breeding plants for resistance to pests has been made thereafter. These

were done through breeding programs by incorporating resistant genes to other screened varieties. Resistant varieties are one important part of an IPM program for rice for several reasons.

They do not increase farmers' costs, limit damage at all levels of pest population throughout the season, require less pesticide than susceptible varieties do and can be integrated effectively with other control methods in a pest management program. The "resistance" of rice to insects can be divided into three basic categories. The first of it is tolerance, in which case the rice variety can survive heavy infestations without a significant yield loss. Pest numbers on a tolerant variety are equal to those on a susceptible variety.

The other category is non-preference where the insects do not feed upon, oviposit in, or use a resistant variety for shelter while in case of antibiosis, the insects do not grow, survive, or reproduce well on the variety. In practice, it is often difficult to identify the type of resistance that a given rice variety has to an insect pest. Some varieties may have only one type of resistance, but others may have a combination of all three. For example, varietal resistance to the yellow stem borer is primarily antibiosis where larvae feeding on a resistant variety are smaller and their survival is reduced. On the other hand, resistance to the striped stem borer is due to both non-preference and antibiosis (Robert et al., 2004).

2.14 Biological and Natural control

Biological control is one of the oldest, most effective means of achieving insect control. The pest management tactic involving purposeful natural enemy manipulation to obtain a reduction in pest's status is called biological control, while natural control refers to the control involving agents other than natural enemies, such as weather or food and no purposeful manipulation is involved (Pedigo, 1999). Biological control may be defined as the action of predators, parasitoids and pathogens to suppress a pest population, making it less abundant and less it would otherwise be. In other words, biological control is a population-levelling process in which one species' population lowers the numbers of another species by mechanisms such as predation, parasitism, or competition. Biological control has proven relatively successful and safe. It can be an economical and environmentally being solution to severe pest problems.

There are natural control factors that limit the increase in numbers of an organism in an ecosystem. These naturally occurring limiting factors prevent most organisms from becoming pests. This process is known as natural control. It consists of two major components, environmental factors (biotic) and natural enemies (biotic). When natural enemies are killed by man's actions in any habitat or when the pests are introduced to new habitats without their natural enemies, natural control often fails and results in pest outbreaks. To remedy the situation caused by his own actions, man can play an active role in reintroducing the natural enemies to control pests. So, the use of natural enemies by man to control pests is biological control. Thus the difference between

biological control and natural control is that the former is brought about through man's action while the latter is not.

Biological control use natural enemies such as predators, parasites, and pathogenic microorganisms or antagonists to control pests or diseases. This can be achieved by conserving indigenous natural enemies or by mass introduction of exotic natural enemies or rearing them. Spiders for example are very active predators that feed on a variety of pests. Some of the more desirable characteristics of natural enemies are good searching ability; attacking only the target pest; having high rate of increase in reproduction; having shorter life cycle than host; adapting well to host habitats; well adapted to different stages of life cycle of target host; and able to maintain itself after reducing host population. Thus, there are lots of advantages in deploying biological control because it has no side effects, safe to handle, occurs naturally, self-perpetuating and has high degree of host specificity with good searching ability, cost effective, and survive at low host density. Although, it possesses more of advantages, it is still not widely practiced owing to the farmers' need for a quick fix solution to pest related problems supplemented by their impatience to wait for the slow results from the biological control actions. Besides, potent pesticides being readily available in the market blended with industry advocates have circumscribed the efforts on biological control entities.

2.15 Chemical control

In IPM, chemical control is recommended as the last resort option for combating pest menaces. Many synthetic chemical products are available that can be used to control insects or diseases. It is noted that chemical application does not help increase yields rather it helps to minimize the insects' populations. To protect the natural enemies, chemical applications should be discouraged and its application should be avoided as much as possible. Pesticides can even create pests. For example, outbreaks of brown plant hopper are usually the result of pesticide use. In a pesticide free environment, many beneficial spiders and insects are present, which keep this pest population under control. If these beneficial insects are destroyed, its population will quickly build up and cause hopper burn. It is, therefore, often said that brown plant hopper is a man-made pest. Besides, insecticides have detrimental effects to the environment and are hazardous to human beings and other living beings.

2.16 Physical controls

Physical controls are tangible materials and devices used to control pests. They involve routine maintenance, exclusion, and use of mechanical devices such as traps and flyswatters. Maintenance personnel are essential partners in an IPM program (Hollingsworth et al., 2002). Whenever a pest control technician or resident discovers a maintenance problem, e.g. leaking pipes, cracks in walls, etc., the building manager should be notified so the problem can be addressed. Structural maintenance is also important to keep pests from entering the buildings. Windows and doors should seal tightly and any holes or cracks should be fixed immediately. Sealing around pipes and

electrical conduits can prevent the spread of infestations (Hollingsworth et al., 2002). It is helpful if pest control technicians keep a caulk gun with them so they can fill any cracks or crevices during routine inspections.

2.17 IPM Decision-Making on threshold levels

IPM decision-making has traditionally depended heavily on economic threshold levels that are based on three factors (management cost, commodity price and damage coefficients) that are highly variable and thus have not been found useful under most conditions where economic and ecological considerations are of equal importance for stable production (Weber and Paruda, 1994). Decision-making is therefore based on weighing potential management costs against potential losses. Costs and losses, however, can include not only economic costs and losses but can also have an impact on natural enemies, health and the environment while taking into consideration the general condition of the crop. Obviously, a crop under drought or flood stress is going to require a different decision from that for one under optimal conditions. The first level of decision-making therefore begins with the first principle of IPM or IPPM, which is to create a healthy soil and crop through proper soil fertility management, healthy seed and appropriate varieties, strong seedling management, proper soil preparation, correct time of planting.

A robust healthy crop has fewer pests in most cases and can recover from pest damage. This principle applies throughout the cropping season and even beyond, when issues such as crop rotation, cover cropping and green manuring are taken into consideration. Latin American rice production, which has few problems relating to

arthropods and many problems relating to weeds, depends primarily on many of these first-level methods (Weber and Paruda, 1994) while rice yields and profitability in Africa and Asia benefit greatly by ensuring proper growth conditions. The second level of decision-making is based not on traditional pest-scouting but on whole-field observation including soil, water, plant, pests, natural enemies and weather patterns. Potential losses are weighed against potential management costs – a traditional aspect of farming that becomes refined with improved observation skills and ecological understanding gained during IPM training courses. The time required for observation and decision-making is typically short because most rice pests do not have clumped distributions and most fields are relatively small (because of water-levelling technical issues) and uniform. IPM training programmes for extension officers and farmers therefore focus on economically sound decision-making taking into account ecological and toxicological factors.

Pesticide application may occasionally be one decision outcome, especially in higher fertilizer input systems, but is by no means the only possibility. Decisions taken may include soil, water and plant management actions such as increasing or reducing fertilizer usage in response to pest or weather damage. Decision processes take into account the impact of activities on natural enemies and plant compensation factors (e.g. will a spray remove natural enemies and actually cause greater pest populations?). Selecting the least toxic solutions in order to prevent health problems is also a factor in decision making. Of course, because there is a possibility of pesticide application, topics related to reducing exposure during mixing and spraying, proper

protective gear, equipment maintenance and calibration, and storage and disposal of pesticides are also included even in organic agriculture, which also uses organic pest-management methods that include spraying (e.g. *Bacillus thuringiensis*, viruses and soaps).

It is generally necessary to include topics related to growing a healthy crop alongside traditional pest management topics because agronomic considerations and practices such as varieties, mulching, water status and plant nutrient status have an impact on pest status. Furthermore, topics such as basic ecological processes– including soil regeneration, predation, parasitism and pollination are central to the training process using field studies and hands-on learning methods (Weber and Paruda, 1994).

2.18 Farmer to farmer Extension

Informal dissemination or social learning occurs when farmers learn from each other's experiences, decisions, and outcomes (Munshi, 2004). Although proponents of farmer field schools and other intensive extension methods rely on the notion that trained farmers will share the information with friends, many studies have shown that informal dissemination is inadequate to reach the majority of the population. Several hypotheses have been proposed as to why this informal diffusion fails.

Copp, Sill, and Brown raise concern about informal diffusion by suggesting that farmers receiving innovation information from peers are more likely to receive negative information about other farmers' failed attempts to successfully implement the new technology. An IPM study in Ecuador by Mauceri, Alwang, Norton &

Barrera, (2007) concluded that farmer-to-farmer diffusion is less effective than other dissemination strategies based on lower knowledge scores and adoption rates (Mauceri et al., 2007).

The study found that FFS graduates share IPM information with 11 other farmers. Of these 11 individuals, some shared the information with peers however dissemination did not proceed further. Non-FFS farmers may lack the expertise to effectively transfer IPM knowledge. In addition, trust may play a vital role, as the study found that recipient farmers prefer to learn from knowledgeable trainers instead of neighbouring farm operators (Mauceri et al., 2007).

An Indonesian study concluded that IPM knowledge did not significantly diffuse to members of other villages through informal diffusion (Feder, Murgai & Quizon, 2004). Many reasons have been cited for the failure of informal diffusion. Having a diverse, heterogeneous population may lower the level of social learning because people cannot assume that a technique that worked for their neighbour will also prove profitable for their farm (Munshi, 2004). Additionally, the high complexity of some IPM techniques may account for lower diffusion because they are not easily communicated in informal farmer-to-farmer discussion. One study concluded that simple technologies may be successfully disseminated through farmer-to-farmer diffusion, whereas, information about more complex technologies must be transferred via formal training (Ricker-Gilbert, Norton, Alwang, Miah, & Feder, 2008). The economic impacts of these conclusions are critical as they dramatically affect the cost-

effectiveness of high input diffusion strategies and may threaten the sustainability of IPM dissemination efforts that rely on informal diffusion.

2.19 IPM and Technology adoptions in Agricultural Production

Technology adoption has been studied extensively over the years, and different authors have defined technology differently. In general a new technology can be defined as a new way of production. New technologies are usually associated with risk, uncertainty and distrust in the minds of farmers, which are obstacles to adoption.

The constraints to adoption of innovative technologies are the “lack of credit, limited access to information, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortages (thus preventing timeliness of operations), chaotic supply of complementary inputs (such as seed, chemicals, and water), and inappropriate transportation infrastructure.” Economists often associate technology improvement within crease of productivity, decrease of labour and increase of leisure. In agriculture, technologies have been introduced as packages containing several components such high yield varieties (HYV), such as Togo-Marshall, fertilizer and corresponding land preparation.

Feder et al. (1985) also point out that before defining adoption it is important to distinguish between individual (farm-level) and aggregate adoption, defining final adoption at the level of the individual farmer as the “degree of use of a new

technology in long-run equilibrium when the farmer has full information about the new technology and its potential” while the aggregate level of adoption is measured by the aggregate use of technology within a specific geographic area. Mauceri (2004) analysed the adoption of IPM technologies in the case of potato production in Carchi, Ecuador, using an ordered probity model. The variables used in the adoption analysis were: age, farm size, education, family size, number of family members 14 years and older, landholdings per capita, pesticide health impact on the farmer and the family, FFS attendance, information access through field days, pamphlets and exposure to FFS participants.

The study found that, apart from information factors the only socioeconomic factor that was significant was household size, and it impacted IPM adoption negatively. The data were obtained through a farmers’ survey, however the sample was non-random and small which limited the analysis. Mauceri (2004) also looked at the cost-benefit of various information diffusion methods, and the extent of adoption in addition to analyzing the determinants and constraints to adoption. The study found that FFSs are cost-effective and require little if any additional capital but do not have the most cost effective dissemination techniques.

Bonabana-Wabi (2002) analysed the factors affecting adoption of IPM technologies in the Kumi district, Eastern Uganda. In addition, she also analysed the relative contribution of each factor affecting IPM adoption and the level of adoption of eight IPM technologies. The study analysed the adoption of eight IPM technologies on

cowpea, sorghum and groundnuts in Kumi. Low adoption ($< 25\%$) was found with five technologies, while high adoption ($> 75\%$) was found with three technologies. Using univariate and multivariate logit models, the eight practices were analysed and it was found that information access positively affects adoption of IPM technologies. It was also found that social factors do not affect sorghum technology adoption, except celosia (an exotic legume that reduces striga) which was positively affected, and in that case males were more likely to adopt the technique of intercropping sorghum with celosia than females. Farm experience was found to positively affect timely planting of cowpea. Some of the significant economic factors found by the study to affect adoption were the farm labour availability and disease incidence, which affect adoption of celosia and other Striga chasers, negatively (Striga chasers such Celosia reduce Striga emergence in sorghum). In the sorghum crop rotation model, adoption of crop rotation was found to reduce weed problems. In the cowpea case, it was found that intercropping was used as both a land saving technology and a pest management strategy (Bonabana-Wabbi, 2002).

De Souza-Filho, Young & Burton (1999) analysed the factors influencing adoption of sustainable agricultural technologies in Espitito Santo, Brazil, using an alternative approach called discrete econometric framework (duration analysis). The study found that access to information (through membership in farmers organizations, NGO presentations, pamphlets etc.) positively affects adoption, and also increases the awareness of negative effects due to pesticide use. In this study farm size was found to affect adoption negatively. It was also found that an increase in output prices and rural

wages relative to prices of external inputs decreases the speed of diffusion of sustainable agricultural technologies.

Another study by Chaves and Riley (2001) determined the factors influencing integrated pest management adoption to combat coffee berry borer on Colombian farms. The factors affecting adoption were said to be social, economic, environmental and institutional. A logistic regression analysis was used to determine the impact of different factors, but first some standard non-linear curves were fitted and contrasted to the uptake data for each of the four chosen IPM recommendations for coffee berry borer control. Since the different factors were analysed at different times upon the uptake of the recommendations singly and in combination, there were different scenarios. The study found education to be an important influential factor positively affecting adoption under all scenarios, while the size of coffee plots was found to be important in all cases in most of the years, and wealth was also found to be an influential factor affecting adoption.

2.20 Summary

The chapter reviewed literature on the historical development of IPM, the concept of IPM, the six essentials of IPM, farmers' knowledge as a predictor of IPM adoption, concept of farmer knowledge, diffusion of knowledge, farmer field schools, IPM practices, IPM decision making on threshold levels, farmer to farmer extension and IPM and technology adoption in agricultural production.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter gives a description of the study area, research design, and population of the study, the sampling techniques adopted and the sample size. In addition, it describes the method of data collection and its analysis as well as the statistical tool used to analyse the data collected. It also includes the challenges encountered in the course of data collection and analysis. A case study method was used in carrying out the study.

3.1 The Research Design

A research design according to Sarantakos (2005) is a plan and structure of research. It entails the conceptualization and structuring of the research problem to serve as a practical guide to the researcher for data collection and analysis. The survey research design was used employing both quantitative and qualitative methods (Creswell, 2003).

3.2 Population of the Study

The target population consists of the “complete group relevant to the research project” (Zikmund, 2003, p. 373). For the purpose of this study, the research target population comprises of all rice farmers in the Hohoe Municipality. The number of rice farmers in the Municipality is over 1,150.

3.3 Sampling Technique and Size

A multi-stage sampling procedure was used in this study. At the first stage, two communities out of nine from the Hohoe Municipality were purposely selected. The communities are Akpafu-Mempeasem and Likpe-Bakwa. These communities were selected because they are the two major rice growing communities in the study area and happen to have IPM programme implemented. In selecting the farmers, that is the second stage of the sampling procedure, proportionate systematic random sampling was employed. In all 120 rice farmers were interviewed with 70 from Akpafu-Mempeasem and 50 from Likpe-Bakwa.

3.4 Pre- testing

In order to evaluate the clarity and comprehensiveness of the questionnaire, as well as the feasibility of the survey as a whole, a pilot survey was conducted. As argued by several researchers, such test run surveys are necessary to demonstrate the methodological rigor of a survey. The sample used in this survey was drawn primarily from a database of rice farmers from the Ministry of Food and Agriculture at Hohoe. A total of 20 rice farmers outside the sample population were interviewed using designed questionnaires. The response indicated that farmers in Municipality have heard of IPM programs but have little knowledge about it and its benefits to them and the environment. The pre testing also indicated that farmers can only be available in the morning and evening for the interview because they are engaged in other work in the afternoon section.

3.5 Data collection instrument

The main research instrument for this study was a standardized questionnaire written in English. The research instrument involved both closed-ended and open-ended questions. The open-ended questions sought to encourage respondents to share as much information as possible in an unconstrained manner. The closed-ended questions, on the other hand, were questions that could be answered by simply checking a box or circling the proper response from a set provided by the researcher. Whilst this method allowed for easier analysis of the data due to standardized questions, its limitation was that it allowed the researcher to determine only what the respondents were doing, not how or why they were doing it.

3.6 Data collection procedures

Data from both primary and secondary sources were collected. Primary data was obtained from face-to-face interviews carried out by the researcher with the aid of a structured questionnaire. The researcher made contacts with MoFA Hohoe Municipal office and Rice Farmer Associations within the municipality in order to inform them and also receive permission to interview the rice farmers.

3.7 Methods of data analysis

Following data collection, the data was coded and entered into SPSS Version 20 computer software. SPSS was chosen because of its appropriateness for coding and entering of quantitative data for analysis as well as its ability to handle large data sets. Descriptive statistics such as frequency tables were used for the interpretation of the

data. Chi-Square analysis were used to determine the influence of socio-economic and institutional factors on the use of IPM in rice production and the relationship between knowledge and use of IPM practices among rice farmers in Hohoe Municipality.

3.8 Analytical method

Three concepts were used for the study namely socio-economic and institutional factors, knowledge in IPM practices and level of use of IPM practices. Socio-economic and institutional factors included age, sex, level of education, farm size, access to IPM information and training in IPM.

The farmers knowledge in IPM practices were tested using five IPM practices, namely crop rotation, crop scouting, conventional tillage, use of resistance varieties and multiple cropping. The farmers were tested for their knowledge on these practices on Likert scale of 1 to 5. Where 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high. A maximum total score of 25 was expected. The farmers who scored a total score of 5-12 were categorised as having low knowledge in IPM practices, those who had total score of 13-18 were categorised as farmers with average knowledge in IPM and those who scored 19-25 were categorised as having high knowledge in IPM.

The extent to which the famers made use of the IPM practices was used to measure their level of use of IPM. Level of use of each practice was measured on a Likert scale of 1 to 5. Where 1 = very low, 2 = low 3 = moderate, 4 = high and 5 = very high. All farmers who scored 5-12 were categorised as low users of IPM, those who scored 13-

18 were categorised as moderate users and those who scored 19-25 were categorised as high users.

3.9 Summary

The chapter was used to describe the methodology of the study. The study employed survey as the research design. The population of study was rice farmers in the Hohoe Municipality. Multi-stage sampling procedure was used to select 120 farmers for the study. The chapter was also used to describe the data collection procedure and method of data analysis and the analytical method used. Data collected were entered and analysed using SPSS Version 20 Software. Main statistical tools employed included frequency tables and chi-square test of independence.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter provides a description of the sampled farmers in respect of the socio-economic variables considered in the study, the relationship between knowledge and use of IPM practices among rice farmers and the observed effects of the use of IPM on rice production by farmers who are using the practices.

4.1 Description of respondents

The characteristics considered in the study included; age, sex, educational level, farm size. From Table 4.1 the sex distribution of rice farmers shows that there are more females engaged in rice production in the study area. Females accounted for 51.7% of the total respondents and males and accounted for 48.3% of the total respondents.

The age distribution shows that majority of the respondents were in the middle aged group of 37-55 years and they accounted for 61.7% of the respondents. 20.8% of the respondents were above 55 years. The remaining respondents were youths in the age bracket of 18-36 years and they represent 17.5%. It means the youths are less engaged in rice production in the study area.

Most of the respondents had basic education which accounted for 81 respondents; the least was tertiary which accounted for 9 respondents. From the Table 4.1 it can be observed that those who did not have any form of education were 11.

Table 4.1 Description of respondents

Variable	Categories	(n=120)	%
Sex	Male	58	48.3
	Female	62	51.7
Age	18-36 (Youths)	67	55.8
	37-55 (middle age)	40	33.4
	>55 (old)	13	10.8
Education	No education	11	9.2
	Basic	81	67.5
	SHS/Technical	19	15.8
	Tertiary	9	7.5
Farm size	< 5 acres (small)	88	73.3
	>5 acres (large)	32	26.7

Source: Field Data, 2014.

From Table 4.1 above it can be seen that majority i.e. 73.3% of the farmers have small farm sizes of less than five acres with only few with farm size greater than five acres categorised in this study as large farm size.

4.2 Objective 1: Socio-economic and institutional factors that influence the use of IPM by rice farmers in Hohoe Municipality.

4.2.1 Influence of age on use of IPM by rice farmers

The age of a farmer is a necessary factor which can contribute to the use of IPM practices. The farmers have been categorised into youth (18-36yrs), middle age (37-55yrs) and old age (55+). From Table 4.2, the statistical analysis shows that there was no significant influence of age on the use of IPM practices ($\chi^2 = 4.108$, $df = 4$, $p = 0.392$). Thus irrespective of age, any farmer can use or not use IPM practices. This finding is consistent with findings of Atry, Rezvanfar and Faham (2009) who found no relationship between age and adoption of IPM among wheat growers in Iran. However Patel, Chauhan and Korat (2007) observed a negative significant relationship between age of the farmers and their use of IPM strategies in India. Thus the issue of age and the use of IPM strategies are therefore not certain and have to be investigated more.

Table 4.2 Influence of age on use of IPM

Use of IPM Age of respondents	Use of IPM			Total
	Low (5-12)	Moderate (13-18)	High (19-25)	
18-36 (Y)	15 (12.5)	39 (32.5)	13 (10.8)	67 (55.8)
37-55 (M)	6 (5.0)	25 (20.8)	9 (7.5)	40 (33.4)
>55 (old)	0(0.0)	10 (8.3)	3 (2.5)	13 (10.8)
Total	21 (17.5)	74 (61.7)	25(20.8)	120 (100)

Source: Field Data, 2014 $\chi^2 = 4.108$, df = 4, p = 0.392, not significant. NB percentages are reported in parenthesis.

4.2.2 Influence of sex on use of IPM by rice farmers

The Chi-square of ($\chi^2 = 0.359$, df = 2, p = 0.836) shows that use of IPM is not significantly different across the categories of the sexes. It means that use of IPM is the same for both men and women. In other words sex of the farmers has no influence on their use of IPM. This finding contradicts studies by Kellyn (2011) who noted differences in use of IPM between men and women. The result of the cross-tabulation is shown in Table 4.3 below.

Table 4.3 Influence of sex on use of IPM

Use of IPM	Sex of farmers		Total
	Male	Female	
Low (5-12)	33 (27.5)	34 (28.3)	67 (55.8)
Moderate (13-18)	18 (15.0)	22 (18.3)	40 (33.3)
High (19-25)	7 (5.8)	6 (5.0)	13 (10.8)
Total	58 (48.3)	62 (51.7)	120 (100)

Source: Field Data, 2014. $\chi^2 = 0.359$, df = 2, p = 0.836, not significant.
NB: Percentages are reported in parenthesis

4.2.3 Influence of education on use of IPM by rice farmers

The use of IPM was found to be the same across the categories of level of education of the respondents. It can therefore be said that level of formal education attained by rice farmers in this study do not have significant influence on their level of use of IPM. This contradicts previous findings by David and Asamoah (2011) who found that use of IPM increases as level of education increases. The cross-tabulation result is shown in Table 4.4 below.

Table 4.4 Influence of level of education on use of IPM by rice farmers

Use of IPM	Level of education respondents				Total
	No edu.	Basic	SHS/Tec h	Tertiar y	
Low (5-12)	5 (4.2)	51 (42.5)	8 (6.7)	3(2.5)	67 (55.8)
Moderate (13-18)	5 (4.2)	22 (18.3)	8 (6.7)	5(4.2)	40 (33.3)
High (19-25)	1 (0.8)	8 (6.7)	3 (2.5)	1 (0.8)	13 (10.8)
Total	11 (9.2)	81 (67.5)	19 (15.8)	9 (7.5)	120 (100)

Source: Field Data, 2014. $\chi^2 = 0.359$, $df = 2$, $p = 0.836$, not significant. NB: Percentages are reported in parenthesis

4.2.4 Influence of farm size on use of IPM by rice farmers

The researcher investigated influence of farm size categorization of the respondents on their level of use of IPM in the study area. The Chi-statistics ($\chi^2 = 4.576$, $df = 2$, $p = 0.101$) obtained have shown that use of IPM in the study area is not different across the categories of farm sizes of the respondents. It can therefore be inferred that the use of IPM by rice farmers is not influenced by their farm sizes. This is not in line with findings by Sonwa et al. (2004) who found that farmers with large farms use IPM

more than those with small farm sizes. The result of the cross-tabulation is shown in Table 4.5 below.

Table 4.5 Influence of farm size on use of IPM

Use of IPM	Farm size (acres)		Total
	< 5 acres	>5 acres	
Low (5-12)	44 (36.7)	23 (19.2)	67 (55.8)
Moderate (13-18)	33 (27.5)	7 (5.8)	40 (33.3)
High (19-25)	11 (9.2)	2 (1.7)	13 (10.8)
Total	88 (73.3)	32 (26.7)	120 (100)

Source: Field Data, 2014. $\chi^2 = 4.576$, $df = 2$, $p = 0.101$, not significant. NB: Percentages are reported in parenthesis.

4.2.5 Influence of training on use of IPM by rice farmers

Half of the respondents (50%) of the rice farmers interviewed had training in the use of IPM, the other 50% were not trained in any IPM programme. From Table 4.6 it can be observed that out of the 60 farmers who had training in IPM 11 of them are high users of IPM as compared with the untrained farmers with only two of the respondents who are high users of IPM in that category. The Chi-square result ($\chi^2 = 11.504$, $df = 2$, $p = 0.003$) obtained from the cross-tabulation shows that there is a significant difference in the use of IPM across the categories of trained and untrained farmers in IPM. It means that training in IPM has significant influence on the use of IPM by rice farmers in the study area. This finding is consistent with previous studies by Ricker-Gilber et al. (2008) who found that training enhances the use of agricultural innovation by farmers.

Table 4.6 Influence of training on use of IPM

Use of IPM	Training in IPM		Total
	Trained	Untrained	
Low (5-12)	36 (30.)	31 (25.8)	67 (55.8)
Moderate (13-18)	13 (10.8)	27 (22.5)	40 (33.3)
High (19-25)	11 (9.2)	2 (1.7)	13 (10.8)
Total	60 (50.0)	60 (50)	120 (100)

Source: Field Data, 2014. $\chi^2 = 11.504$, df = 2, p = 0.003, significant. NB: Percentages are reported in parenthesis.

4.2.6 Influence of access to information on use of IPM by rice farmers

From Table 4.7 it can be deduced that majority i.e. 63.3% of the respondents have no access to information on IPM. Only 36.7% of the respondents have access to information on IPM in the study area. The chi-square result had shown that there is no significant difference between the levels of use of IPM with respect to access to information on IPM. It connotes that the mere access to IPM information does not necessarily influence the use of IPM in the study area. The result of the cross-tabulation is shown in Table 4.7 below.

Table 4.7 Influence of access to IPM information on use of IPM

Use of IPM	Access to IPM information		Total
	NO	YES	
Low (5-12)	41 (34.2)	26 (21.7)	67 (55.8)
Moderate (13-18)	27 (22.5)	13 (10.8)	40 (33.3)
High (19-25)	8 (6.7)	5 (4.2)	13(10.8)
Total	76 (63.3)	44(36.7)	120 (100)

Field Data, 2014. $\chi^2 = .449$, df = 2, p = 0.799, not significant.

S
o
u
r
c
e
:

4.3 Objective 2: Assess the relationship between knowledge and use of IPM practices among rice farmers

4.3.1 Use of IPM practices by farmers

The rice farmers' use of the five IPM practices identified for the study is presented in Table 4.8 below. It can be observed that 54.2% in the area use crop rotation as IPM practice very low or low, 29.2% of the respondents use crop rotation as an IPM practice moderately while 16.7% uses crop rotation very high or high. It was also determined that majority of the farmers representing 50% made use of crop scout as an IPM practice very low or low in the study area, 29.2% used crop scout moderately and 15.9% were high or very high users of crop scout as an IPM practice in Hohoe Municipality.

It was also found that 50% of the respondents used resistance varieties as IPM practice on their rice farms at very low or low level in the Hohoe Municipality. It was also noted that 32.5% of the rice farmers in the municipality moderately used resistance varieties while only 17.5% of the respondents used resistance varieties as IPM practice in the study area at high or very high level. On the whole 46.7% of the respondents were low or very low users of conventional tillage as an IPM practice, 35.8% of them moderately made use of conventional tillage as IPM practice and only 17.5% of them made use of conventional tillage at high or very high level in the study area.

The study further revealed that the use of multiple cropping as an IPM practice in the study area is very low. It was also noted that 47.5% of the rice farmers were very low or low users of multiple cropping as an IPM practice. The analysis further revealed that 36.7% of the farmers interviewed used multiple cropping moderately in the study area, while only 4.2% of the respondents were high or very high users of this IPM practice on their rice farms. It can therefore be inferred that the use of IPM practices is low in the study area.

Table 4.8 Level of use of IPM practices by rice farmers.

IPM Practice	Level of use of IPM practices by the rice farmers (n=120)				
	Very low	Low	Moderate	High	Very high
Crop rotation	15 (12.5)	50 (41.7)	35 (29.2)	18 (15.0)	2 (1.7)
Crop scout	20 (16.7)	46 (38.3)	35 (29.2)	17 (14.2)	2 (1.7)
Resistant varieties	14 (11.7)	46 (38.3)	39 (32.5)	18 (15.0)	3 (2.5)
Conventional tillage	15 (12)	41 (34.2)	43 (35.8)	16 (13.3)	5 (4.2)
Multiple cropping	15 (12.5)	42 (35.0)	44 (36.7)	14 (11.7)	5 (4.2)

Source: Field Data, 2014.

Percentages are reported in parenthesis.

4.3.2 Influence of knowledge of IPM practices on its use

Majority i.e. 60.0% of the rice farmers interviewed in Hohoe Municipality have low knowledge in IPM and this could be attributed to their low access to IPM information in the study area. It can also be inferred from Table 4.9 that majority of the respondent

representing 55.8% are low users of IPM. This could also be due to the low knowledge of the farmers on IPM in the study area.

The Chi-square of ($\chi^2 = 11.739$ df = 4, p = 0.019) obtained from cross-tabulating knowledge of the farmers in IPM with their use of IPM have shown that knowledge in IPM has a significant influence on its use. The low knowledge of the rice farmers on IPM might have accounted for its low use in the study area. This is consistent with conclusion drawn by Malone et al. (2004) who found that the lack of familiarity with IPM was the major reason for its low usage by farmers. It therefore means that increasing rice farmers' knowledge on IPM may possibly lead to an increase in the use of IPM.

Table 4.9 Influence of knowledge and use of IPM

Use of IPM	Knowledge of IPM			Total
	5-12 (Low)	13-18 (Average)	19-25 (High)	
Low (5-12)	45 (37.5)	19 (15.8)	3 (2.5)	67 (55.8)
Moderate (13-18)	20 (5.0)	9 (7.5)	11 (9.2)	40 (33.3)
High (19-25)	7(5.8)	4 (3.3)	2 (1.7)	13 (10.8)
Total	72 (60.0)	32 (26.7)	16(13.3)	120 (100)

Source: Field Data, 2014. $\chi^2 = 11.739$, df = 4, p = 0.019), significant.

4.4 Summary

In summary, it was found that use of IPM did not differ across the categories of age, sex, level of education, farm size and access to information on IPM. There was however a significant difference between the use of IPM by farmers who had training in IPM and those who did not have training in IPM. It can be concluded that training in IPM have significant influence on its use. The results also revealed that level of knowledge of rice farmers on IPM has a significant influence on use of IPM.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents summary of the study, the key findings and the conclusions that were drawn as a result of the study. Recommendations are then suggested for policy makers.

5.1 Summary

Although IPM has been advocated as a means of reducing chemical insecticide application, adoption of IPM practices are however, inadequate in the Hohoe Municipality and this may be attributed to a number of socio-economic, institutional factors.

The study therefore sought to determine the knowledge levels and use of IPM practices of farmers on the six essentials of IPM and its effect on rice production. The following specific objectives were therefore carried out.

- 1 To find out the socio-economic characteristics and institutional factors of rice farmers that influenced the use of IPM in rice production
- 2 To assess the relationship between knowledge and use of IPM practices among rice farmers

Survey research design was used for the study. Multi-stage sampling procedure was used to select 120 rice farmers in the Hohoe Municipality for the study. The data collected were entered and analysed using SPSS version 20. Both descriptive and inferential statistical tools were used in the data reduction and interpretation. The descriptive statistical tools included; frequency tables and means. The chi-square test of independence was the main inferential statistical tool that was used to explore the relationship between the dependent variables and the independent variables.

The study established the following;

Objective 1

It was found that use of IPM did not differ across the categories of age, sex, level of education, farm size and access to information on IPM. There was however a significant difference between the use of IPM by farmers who had training in IPM and those who did not have training in IPM. It can be inferred that training in IPM has significant influence on its use.

Objective 2

The level of knowledge of rice farmers on IPM had a significant influence on their use of IPM in the Hohoe Municipality. The study however determined that majority of rice farmers have low knowledge in IPM.

5.2 Conclusion

The study found that there was a significant difference between the use of IPM by farmers who had training in IPM and those who did not have training in IPM. It can be inferred that training in IPM has significant influence on its use.

The study also discovered that the level of knowledge of rice farmers on IPM have a significant influence on their use of IPM. But majority of rice farmers in the municipality have low knowledge in IPM.

5.3 Recommendations

The study noted that the category of farmers who had training in IPM were high users of IPM relative to those without any training. Moreover the study identified that training had a significant influence in the use of IPM. It is therefore recommended that in the pursuit of IPM as an agronomic practice, policy makers should have training as a core objective to equip farmers with the requisite skills of using it. This will increase the level of knowledge on IPM and subsequently enhance its adoption by farmers.

Access to information on IPM by rice farmers in the Hohoe Municipality was found to be low. It is recommended that the extension service directorate should endeavour to make this information readily available to the farmers.

References

- Adesina, A. A. Mbila, D., Nkamleu, G. B., & Endamana, D. (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of Southwest Cameroon. *Agr. Ecosyst. Environ.* 80:255-265.
- Adesina, A. A. & Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone. *Agricultural Economics*, 9(4), 297-311.
- Akudugu, M. A., Guo, E., & Dadzie, S. K. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? *Journal of Biology, Agriculture and Healthcare*, 2(3).1-13
- Altman, S. (2007). *Integrated pest management: a guide for managers and owners of affordable housing*. Boston Public Health Commission. Boston, MA.
- Alston, D. G., Reding, M. E. (1998). Factors influencing adoption and educational Outreach of integrated pest management. *Journal of extension*, 36(3), 131-142.
- Altry, S., Ahmad, R. & Elham, F. (2009). Factors influencing the adoption of integrated pest management (IPM) by wheat growers in Varamin County, Iran. *African Journal of Agricultural Research*, 4(5), 491-497.
- Ayele, S., & Bosire, C. (2011). *Farmers' use of improved agricultural inputs and practices: Review and synthesis of research in Ethiopia, IPMS*.
- Birthal, P. S. & Sharma, O. P. (2004). *Integrated Pest Management in Indian Agriculture*. Proceedings 11.
- Bonabana-Wabbi, J. (2002). *Assessing factors affecting adoption of agricultural technologies: The case of integrated pest management (IPM) in Kumi district, Eastern Uganda*. Doctoral dissertation, Virginia Polytechnic Institute and State University.
- Borkhani, F. R., Fami, H. S., Rezvanfar, A. & Pouratachi, M. (2011). Application of integrated pest management (IPM) practices by paddy farmers in Sari County of Mazandaran province, Iran. *African Journal of Agricultural Research*. 6(21), 4884-4892.
- Brenner, B. L., Markowitz, S., Rivera, M., Romero, H., Weeks, M., Sanchez, E., et al. (2003). Integrated pest management in an urban community: A successful partnership for prevention. *Environ. Health Persp*, 111, 1649-1653.

- Braun, A., Jiggins, J., Roling, N., Den Berg, V. & Snijders, P. (2006). *A global survey and review of farmer field school experience*. International Livestock Research Institute, Nairobi, Kenya.
- Calberg, E., Kostandini, G. & Dankyi, A. (2012). *The effect of IPM farmer field school on groundnut productivity: evidence from Ghana*. Selected paper prepared for presentation at the Agricultural and Applied Economics Association's 2012 AAEA Annual meeting, Seattle, Washington, August 12-14, 2012.
- Carson, R. (1962). *Silent spring*. Boston, MA. Houghton Mifflin.
- Chaves, B., & Riley, J. (2001). Determination of factors influencing integrated pest management adoption in coffee berry borer in Colombian farms. *Agriculture, Ecosystems & Environment*, 87(2), 159-177.
- Chi, T. T. N. (2008). Factors affecting technology adoption among rice farmers in Mekong Delta through the lens of the local authorial managers: An analysis of qualitative data. *Omonrice*, 16, 107-112.
- Creswell, J. W. (2003). *Research design. Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: Sage.
- David, S. & Asamoah, C. (2011). Farmer's knowledge as an early indicator of IPM adoption: a case study of cocoa farmer field school in Ghana. *Journal of Sustainable Development in Africa*, 13(4), 213-224.
- David, S., Mukandala, L. & Mafuru, J. (2002). Seed availability, an ignored factor in crop varietal adoption studies: a case study of beans in Tanzania. *Journal of Sustainable Agriculture*, 21(2), 5-20.
- De Souza-Filho, H. M., Young, T., & Burton, M. P. (1999). Factors influencing the adoption of sustainable agricultural technologies. Evidence from the State of Espírito Santo, Brazil. *Technological Forecasting and Social Change*, 60, 97-112.
- Deribe, K. (2007). *Agricultural information networks of farm women and role of agricultural extension: The Case of Dale Woreda, Southern Nations, Nationalities & Peoples' Region*. M. Sc. Thesis, Alemaya University.
- Doss, C. R., & Morris, M. L. (2001). How does gender affect the adoption of agricultural innovation? The case of improved maize technology in Ghana. *Journal of Agricultural Economics*, 25(1): 27 – 29.

- Ephraim, N., Pender, E., Kato, O., Omobowale, D., Philip, D. & Ehui, S. (2010). *Nigeria strategy program*. International Food Policy Research Institute, Washington DC. USA.
- Erbaugh, J. M., Donnermeyer, J. & Amujal, M. (2007). Assessing the impact of Farmer Field School participation on IPM adoption in Uganda. In: *AIAEE 2007 Proceedings of the 23rd Annual Conference "Internationalizing with Cultural Leadership*, 20-24 May 2007, Montana, USA.
- Feder, G., Murgai, R., & Quizon, J.B., (2004). Sending farmers back to school: the impact of farmer field schools in Indonesia. *Review of Agricultural Economics*, 26, 314-314.
- Feder, G., Just, R. & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: a survey. *Economic Development and Cultural Change*. 33(2) 255-298.
- Geier, P. W., & Clark, L. R. (1961). An ecological approach to pest control, In *Proc. Tech. Meeting Intern. Union Conservation Nature and Natural Resources*, Warsaw, Poland.
- Godtland, E. M., Sadoulet, E., de Janvry, A., Murgai, R. & Ortiz, O. (2004). The impact of farmer field schools on knowledge and productivity: A study of potato farmers in the Peruvian Andes. *Economic Development and Cultural Change*, 53, (1) 63–92.
- Haba, S. (2004). *Factors influencing the willingness to pay for agricultural information delivery technologies by cooperative-oriented agribusinesses in Rwanda: evidence from the Abahuzamugambi Coffee Growers Cooperative of Maraba*. Master's thesis, Texas A&M University. Available on <http://handle.tamu.edu/1969.1/2414>
- Hanson, J. & Just, R. (2001). The potential for transition to paid extension: some guiding economic principles, *American Journal of Agricultural Economics* 83(3), 774-784.
- Heong, K. L. & Escalada, M.M. (1998). Changing rice farmers' pest management practices through participation in a small scale experiment. *Int. J. Pest Management*, 44(4), 191-197.
- Hollingsworth, C. S., Coli, W. M., Murray, K. D. & Ferro, D. N. (2002). *Integrated pest management for northeast schools*. Natural Resource, Agriculture, and Engineering Service. Ithaca, NY.
- Hoyt, B. (2001). Integrated pest management and food production. Accessed on 25th July, 2014. On <http://www.epa.gov/pesticides/food/ipm.htm>.

- Huan, N. H., Mai, V., Escalada, M. M. & Heong, K. L. (1999). Changes in rice farmers' pest management in the Mekong Delta, Vietnam. *Crop Protection*, 18, 557–563.
- Julius, A. (2013). Impacts of gender and farmers' level of education on access to agricultural extension services in Abuja, Nigeria. *International Journal of Agricultural Economics and Extension*, 1 (7), 055-060.
- Katti, G, Pasalu, I. C., Rao, P. R. M., Varma, N. R. G. & Krishnaiah, K. (2000). Integrated pest management in Indian agriculture. An overview. In: Birthal, P. S. and Sharma, O. P. *Integrated Pest Management in Indian agriculture*. Proceedings 11.
- Katungi, E. (2006). *Gender, Social Capital and Information Exchange in Rural Uganda IFPRI and Melinda Smale*, IFPRI. CAPRI Working Paper No. 59, University of Pretoria. Uganda. Available on <http://www.capri.cgiar.org/pdf/capriwp59.pdf>.
- Kellyn, P. M. (2011). *Spatial and gender dimensions of IPM adoption in Uganda*. Thesis submitted Virginia State University in partial fulfilment of the requirement for the degree of Master of Science in Geography.
- Kenmore, P. (2002). Integrated pest management. *International Journal of Occupational and Environmental Health*, 8(3), 173-174.
- Kumari, G. (2012). Constraints in adoption of Integrated Pest Management practices by rice growing farmers in Jammu Division. *Indian Research Journal of Extension Education*. Special Issue (2).
- Leeuwis, C. (2004). *Communication for rural innovation: rethinking agricultural extension 3rd edition*. Annes, Iowa, Blackwell.
- Malone, S, Herbert D. A. & Pheasant, S. (2004). Determining adoption of integrated pest management practices by grains farmers in Virginia. *Journal of Extension*, 4(4), 34-43.
- Maumbe, B. M. & Swinton, S. M. (2000). *Why do smallholder cotton growers in Zimbabwe adopt IPM? The role of pesticide-related health risks and technology awareness*. Selected paper for presentation at annual meeting of American Agricultural Economics association, Tampa, FL, July 30-August2, 2000.
- Mauceri, M. (2004). *Adoption of integrated pest management technologies: A case study of potato farmers in Carchi, Ecuador*. Thesis: Master of Science in Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.
- Mauceri, M., Alwang, J., Norton, G. W. & Barrera, V. (2007). "Effectiveness of Integrated Pest Management Dissemination Techniques: A Case Study of Potato

Farmers in Carchi, Ecuador." *Journal of Agricultural and Applied Economics*, 39(3), 765-780.

- Maupin, J. & Norton, G. (2010). *Pesticide use and IPM adoption: Does IPM reduce Pesticide use in the United States?* Selected paper prepared for presentation at the Agricultural and Applied Economics Association. AAEA, CAES, &WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010.
- MoFA (2013). Online profile of Districts in Ghana: Hohoe Municipality, Assessed on June 12, 2014. http://mofa.gov.gh/site/?page_id=1707
- Mugisha, J., Ogwal-O, R., Ekere, W. & Ekiyar, V. (2004). Adoption of IPM groundnut production technologies in Eastern Uganda. *African Crop Science Journal*. 12(4), 383-391.
- Munshi, K. (2004). Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of Development Economics*, 73(1), 185-213.
- Nambiro E, Omiti J, Mugunieri, L. (2006). *Decentralization and access to agricultural extension services in Kenya*. Paper presented at the international association of agricultural economics conference, Gold Coast, Australia, August 12- 18: 1 – 12.
- Namwata, B. M. L., Lwelamira, J., & Mzirai, O.B. (2010). Adoption of improved agricultural technologies for Irish potatoes (*Solanum tuberosum*) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences*, 8(1): 927-935.
- Nkamleu, G. B., Coulibaly, O. Tamo, M., & Ngeve, J. M. (1998). *Adoption of storage pest control technologies by Cowpeas' Taders in Western Cameroun: Probit Model Application Monograph*. International institute of Tropical Agriculture.
- Nelson, R., Orrego, R., Ortiz, O., Tenorio, J., Mundt, C., Fredrix, M. et al. (2001). Working with resource-poor farmers to manage plant diseases. *Plant Disease*, 85(7), 684–695.
- Ofuoku, A. U., Emah, G..N., & Itedjere, B. E. (2008). Information Utilization among Rural Fish Farmers in Central Agricultural Zone of Delta State, Nigeria. *World Journal of Agricultural Sciences*, 4(5): 558-564.
- Okoye, B. C., Onyenwaku, C.E., Ukoha, O. O., & Asumugha, O. C. (2008). Determinants of Labour Productivity on Smallholder Cocoyam Farm in Anambra State, Niger. *Acad. J. Sci. Res.* 3 (11): 559 – 561.
- Ooi, P. A. C., Warsiyah, N. B. & Nguyen V. S. (2001). Farmer scientists in IPM: a case of technology diffusion. In T.W. Mew, E. Borromeo & B. Hardy, (eds).

Exploiting biodiversity for sustainable pest management. pp.207–215. Proceedings of the Impact Symposium on Exploiting Biodiversity for Sustainable Pest Management, 21–23 August 2000, Kunming, China. Los Baños, Laguna, the Philippines.

- PAN (2010): *Communities in Peril* – Global Report on Health Impacts of Pesticide Use in Agriculture, Manila.
- Patel M. C., Chauhan N. B., & Korat, D. M. (2007). Consequence of farmers' attributes on their attitude towards integrated pest management strategy. *Karnataka J. Agric. Sci.*, 20(4), 797-799.
- Pedigo, L. P. (1999). Introduction to sampling arthropods populations. In . Pedigo, L. P., & Buntin, G. D. ed. *Handbook of sampling methods for arthropods in agriculture*. Boca Raton, FL. CRC Press.
- Rehman, F., Muhammad, S., Ashraf, I., Mahmood, K., Ruby, T., & Bibi, I. (2013). Effect of farmers' socioeconomic characteristics on access to agricultural information: empirical evidence from Pakistan. *The Journal of Animal & Plant Sciences*, 23(1): 324-329.
- Rejesus, R. M., Palis, F. G., Lapitan, A. V., Chi, T. T. N. & Hossain, M. (2009). The impact of integrated pest management information dissemination methods on insecticide use and efficiency: evidence from rice producers in South Vietnam. *Review of Agricultural Economics*. 31(4), 814-833.
- Ricker-Gilbert, J., Norton, G.W. Alwang, J. Miah, M. & Feder, G. (2008). Cost-effectiveness of alternative integrated pest management extension methods: an Example from Bangladesh." *Appl. Econ. Perspect. Pol.*, 30(2), 252-269.
- Robert, J. O., Claire, E. R., Tyler, B. F. & Douglas, A. L. (2004). Soybean aphid predators and their use in integrated pest management. *Ann. Entomol. Soc. Am*, 97(2), 240-248.
- Robinson, A. R. & Sutherland, W. J. (2002). Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology* 39, 157-176.
- Rogers, E. (1995). *Diffusion of innovations*. 3rd Edition. New York, NY, The Free Press.
- Rola, A. C., Jamias, S. B. & Quizon, J. B. (2002). Do farmer field school graduates retain and share what they learn? An investigation in Iloilo, Philippines. *Journal of International Agricultural and Extension Education*, 9(1), 65-76.
- Röling, N., & van de Fliert, E. (1994). Transforming extension for sustainable agriculture: the case of integrated pest management in rice in Indonesia. *Agriculture and Human Values*, 11(2/3), 96-108.

- Saadi, H., Mahdei, K. N., & Movahedi, R. (2008). Surveying on wheat farmers' access and confidence to Information and Communication Channels (ICCs) about controlling *Eurygaster integriceps* in Hamedan province, Iran. *American Journal of Agriculture and Biological Science*, (2): 497-501.
- Sarantakos, S. (2005). *Social research (3rd ed.)*. New York, NY. Palgrave Macmillan.
- Sonwa, D. J., Coulibaly, O., Adesina, A. A., Weise, S. F., & Tchatat, M. (2004). Integrated Pest Management in cocoa agro-forests in southern Cameroon: constraints and overview. *Journal of Integrated Pest Management Reviews* 7, 191-199.
- Tripp, R., Mahinda, W. & Hiroshini, P. V. (2005). What should we expect from farmer field schools? A Sri Lanka case study. *World Development*, 33(10), 1705-1720.
- Trumble, J. T. (1998). IPM: overcoming conflicts in adoption. *Journal of Integrated Pest Management Reviews*, 3, 195-207.
- van den Berg, H. & Jiggins, J. (2007). Investing in farmers: the impacts of farmer field schools in relation to integrated pest management. *World Development* 35(4), 663-686.
- Van Huis, A. & Meerman, F. (1997). Can we make IPM work for resource-poor farmers in sub-Saharan Africa? *International Journal of Pest Management*, 43(4), 313-320.
- Van Mele, P., Cuc, N. T. T. & Van Huis, A. (2001). Farmers' knowledge, perception and practices in mango pest management in the Mekong Delta, Vietnam. *International Journal of Pest Management*, 47(1), 7-16.
- Waller, B. E., Hoy, C. W., & Henderson, J. L. (1998). Matching innovations with potential users: a case study of potato IPM practices. *Agriculture, Ecosystem and Environment*, 70, 203 – 215.
- Wang, C., & Bennett, G. W. (2006). Comparative Study of Integrated Pest Management and Baiting for German Cockroach Management in Public Housing. *J. Econ. Entomol*, 99, 879-885.
- Way, M.L. (1977). Integrated control-practical realities. *Outlook on Agriculture*, 9, 127-135.
- Weber, G. & Paruda, O. (1994). Development of an integrated pest management strategy for rice in Latin America. In E. A. Heinrichs, ed. *Biology and management of rice insects*, (pp. 733-747). Wiley Eastern, New Delhi.

- Williamson, S., Ball, A. & Pretty, J. (2008). Trends in pesticides use and drivers for safer pest management in four African countries. *Journal of crop protection* 27(10), 1327-1334.
- Zhang, W. Li, F. Xiong, Y., & Xia, Q. (2012). Econometric analysis of the determinant of adoption of raising sheep in folds by farmers in the semiarid Loess Plateau. *Ecol. Econ*, 74:145-152.
- Zikmund, W. (2003). *Business Research Methods* (6th ed.). United States of America: HarcourtCollege Publishers.
- Zuta, J. K. (2009). Adoption of integrated pest management practices by vegetable farmers in the Greater Accra Region, Ghana. Unpublished Mphil Thesis. Department of Agricultural Extension, University of Ghana, Legon.

Appendix

QUESTIONNAIRE

Integrated Pest Management in the Hohoe Municipality, Ghana

Declaration of purpose and the usage of the information

Dear Respondent,

The information to be collected through the administration of this questionnaire will be used to develop a common dataset without any mention to the identity of the respondents (personal and/or corporate).

The information will be used purely for the academic purpose e.g. writing masters' dissertation and scientific articles. These outputs may be published in printed or virtual forms and may be presented at scientific conferences, workshops, and lectures and also used as learning materials. Thank you in advance for your contribution.

Section A: Socio-economic characteristics of Farmers

Please tick (✓) where applicable.

Questionnaire No.: _ _ _ _ _

1. What is your age (in years)?
2. Sex 1. Male ☐ 2. Female ☐
3. What is your Religion?
 1. Traditional ☐
 2. Christianity ☐
 3. Islam ☐

4. What is your highest level of education?
1. No education []
 2. Basic []
 3. Secondary []
 4. Tertiary []
5. What are your main sources of income apart from farming?
-
6. If agriculture is part of your livelihood for how long have you been involved?
1. 1 - 5 years []
 2. 6 – 10 years[]
 3. 11 - 15 years[]
 4. 15 years +[]
7. Marital status
1. Never married[]
 2. Married[]
 3. Divorced[]
 4. Widowed[]
8. What is your household size?
9. What is the size of your Rice farm (s) in acres.....
10. Years of experience with Rice cultivation.....
11. How many tonnes of rice did you obtained after drying and winnowing in both major and minor seasons last year?

Section B: Perception and Knowledge of the farmer concerning IPM

Please tick (✓) where applicable.

12. What are your main sources of IPM information?

1. Own experience[]
2. Fellow farmers[]
3. Rice or Maize traders[]
4. Agric extension officers[]
5. Researchers[]
6. Radio/TV[]

13. Have you received any training in IPM? 1. NO [] 2. YES []

14. Do you have access to IPM information? 1. NO [] 2. YES []

15. Frequency of meeting extension personnel on IPM

1. Never [] 2. Rarely [] 3. Sometimes [] 4. Often [] 5. Always []

16. Apart from extension visits, have you attended any IPM training before?

1. Yes [] 2. No[]

17. If yes, how many times have you attended the IPM trainings?

18. Which institution organized the IPM training?

.....

19. What criteria have you been using to determine the threshold of IPM?

.....

20. Which of these best describe the level of pest infestation on your farm?

1. High [] 2. Moderate[] 3. Low []

Section C: Effects of the use of IPM on Rice production**Please tick (✓) where applicable.**

21. How many years have you been practicing IPM?

22. IPM practice use by farmers

1. Cultural []

3. Biological []

2. Mechanical []

4. Chemical []

23. Which of the following do you normally practice as IPM? (Multiple answers)

1. Crop rotation []

2. Scout crops []

3. Use beneficial insects []

4. Conventional tillage []

5. Multiple cropping []

24. In the table provided below indicate your level of use of each of the IPM practice on a scale of 1 to 5. Where 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high

Use of IPM	Very low	low	moderate	High	Very high
Crop rotation					
Scout crops					
Use of beneficial insects					
Conventional tillage					
Multiple cropping					

25. Name some of the harmful effects you experienced when practicing IPM

.....

26. Select the appropriate preventive measures used during pesticide applications

1. Washing body ☐
2. Following instruction of containers ☐
3. Protecting domestic animals ☐
4. Disposing empty containers ☐
5. Protecting mouth ☐
6. Covering head ☐
7. Using gloves ☐

27. What is your knowledge level of the following? Answer by ticking the appropriate box by the questions

Program essentials	Low	Moderate	High
Monitoring of site			
Record-Keeping (inspection or treatment)			
Action levels			
Preventive measures			
Tactics criteria			
Regular evaluation			

28. To what extent have you been using the following IPM program essentials? Answer by ticking the appropriate box by the questions

Program essentials	Low	Moderate	High
Monitoring of site			
Record-Keeping (inspection or			

treatment)			
Action levels			
Preventive measures			
Tactics criteria			
Regular evaluation			

29. What are the difficulties faced when using the IPM methodology?

.....

30. What are the benefits derived from using the IPM on yields of rice?

.....

31. What are the effects of using the IPM on the environment?

.....